Original research article

Imagining renewable energy: Towards a Social Energy Systems approach to community renewable energy projects in the Global South

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\begin{abstract}
Rural community energy projects in the Global South have too frequently been framed within a top-down technologically-driven framework that limits their ability to provide sustainable solutions to energy poverty and improving livelihoods. This framing is linked to how energy interventions are being imagined and constructed by key actors in the sector, via particular sociotechnical imaginaries through which a set of increasingly universalised energy futures for rural communities is prescribed. Projects are too frequently reverse-engineered through the lens of particular combinations of technologies, financial models and delivery mechanisms, rather than by attending to the particular energy needs/aspirations of individual communities. Assumptions over the association between energy access and livelihood enhancement have also reinforced a technocratic determination of appropriate system scale and a search for universalised ‘scaleable’ delivery models. There is, however, no necessary causation between scaleability and outcomes – appropriate implementation scales are not purely determined by technical or financial considerations, rather it is the social scale via which optimum forms of local participation and ownership can be achieved. To operationalise this concern for social space we propose a Social Energy Systems (SES) approach that is advanced via exploration of the interactions between three distinct but mutually edifying variants of energy literacy – energy systems literacy, project community literacy and political literacy.\

\end{abstract}

\section{Introduction}

The emergence of the ‘energy trilemma’ as a concept\textsuperscript{1} and framework for global action has captured the imagination of political elites the world over. The trilemma heralds a new ‘energy era’ characterised by the need to address simultaneously three key policy drivers: energy security, climate change mitigation and energy access/equity to ensure long-term sustainability of global energy systems [1–4]. Addressing the trilemma is undoubtedly challenging and will require deep structural changes to energy systems such that technology, infrastructure, policy, scientific knowledge and social and cultural practices all become increasingly aligned towards achieving the same goals. With anthropogenic climate change becoming rapidly more evident and poorer Southern communities the most vulnerable to its effects, the focus on renewable energy technologies (RETs) as a suite of instruments with the potential to address all three (ostensibly contradictory) forces constituting the trilemma is becoming more and more acute. In the last two decades, where energy poverty alleviation in particular is concerned, a veritable industry has matured to address the tripartite constituents of appropriate technology, scale and financing that collectively form the substance for energy access for the world’s poorest communities.\textsuperscript{2}

But the linear, top-down techno-logic that tends to shape the design, development and implementation of RETs the world over encounters numerous obstacles and limitations. Projects implemented without an in-depth understanding of the sociocultural context in which the projects are to be embedded often fail to engage with the ways in which local communities envision their own futures and the role of energy in delivering and sustaining such visions. Watson et al. [5], p. 2] suggest

\textsuperscript{1} There are a plethora of slightly different definitions of the energy trilemma concept but, as and Sovacool argue, they all fundamentally agree on the fact that the contemporary energy trilemma revolves around the contradictory dynamics of “economic, security and environmental concerns” [4].

\textsuperscript{2} It is through the lens of the growing global commitments towards addressing energy poverty that our own entry into these debates has been structured. Our approach towards energy poverty connects closely to that advanced within Practical Action’s Poor People’s Energy Outlook series (http://policy.practicalaction.org/policy-themes/energy/poor-people-energy-outlook). Indeed, one of us contributed towards the initial debates surrounding the measurement of energy poverty that fed into this series although we recognise the complexities and inconsistencies that still exist within discussions over the measurement of the concept [9,10]. The evolution of our thinking on this issue has been influenced heavily by our involvement in a project exploring the applicability of the nano-grid concept to community energy development in Kenya and Bangladesh alongside colleagues in both countries.
that the academic literature on the barriers affecting the increased use of modern energy services is similarly weak on understanding the social, cultural and political dimensions to such barriers in contrast to that relating to economic and technical barriers. While there is a wealth of empirical evidence to suggest that projects often achieve developmental benefits in terms of health, education, security and social integration to varying degrees, the degree to which RET projects address the poverty of household members and their ability to generate income is less clear. In fact, evidence suggests that they do not [6–8] and in some cases actually impose additional financial burdens. We argue that principally this is because of the way the energy trilemma, and within it notions of energy poverty, have been politically constructed. Imagined in this way, states and transnational organisations (e.g., international development agencies) have prescribed particular energy futures that comprise “collectively imagined forms of social life and social order reflected in the design and fulfilment of nation-specific scientific and/or technological projects” (Jasanoff and Kim [11], p. 120)). Such ‘sociotechnical imaginaries’ [11,12] become a means by which energy discourses and practices are not merely described, but structured, materialised, naturalised and reified. They thus come to constitute a mechanism through which energy futures are directed (this connects quite closely to the idea of sustainability pathways central to the approach pioneered by the STEPS Research Centre at the University of Sussex: see Leach et al. [13]). But these top-down accounts of potential futures “run into conflict with actors who have different visions and goals” and ignore important visions of the potential of energy technologies to reconfigure and enhance existing social, cultural and technical practices at the household and community levels [114], p. 228).

In the case of RETs, this means that to a substantial degree potential solutions to global energy poverty are being reverse-engineered through the lens of supposedly sustainable technologies, financial models, multilevel policies and scalability in technology rather than attending to the particular (current and future) energy needs and aspirations of the communities in question. This is important to the implementation of projects because the empirical record of their perceived success or failure (both from above and below) supports the assertions made by Eaton et al. [114], p. 228] who, in the specific case of bioenergy, argue that “sociotechnical imaginaries play a crucial role in conflicts over RETs. While the state and interested actors work to convert imagined futures into reality, local actors define and contest the ways bioenergy may or may not contribute to a better future.” At this point it is worth noting that sociotechnical imaginaries are not unreal; on the contrary, where RET projects are concerned, energy and development actors, technology types and scales, government policy and regulation, financial models and resources for implementation, and the agendas and actions of implementers can constitute very real obstacles or opportunities for communities to negotiate on their journeys towards imagined energy futures. Nonetheless, such sociotechnical journeys are as are much shaped by the material realities and lived experiences of individuals and communities subjected to resulting policies and applied technical interventions, as they are by the imagined futures and socially constructed experiences of politicians, practitioners and experts.

This paper examines the often conflicting sociotechnical imaginaries (including the emergence of counter imaginaries) of energy poverty alleviation through the implementation of community solar RETs across the Global South. Given its status as the leading alternative to grid-based rural electrification and the attractor of most World Bank funding for renewable energy, solar is additionally important because of the household/community scale at which it is being deployed. Figures from the REN21 (Renewable Energy Policy Network for the 21st Century) Global Status Report suggest an increasing proliferation of solar home systems (SHS) programmes with an estimated three million systems now installed in the Global South, including particularly substantial uptake in countries such as Kenya and Bangladesh. Bangladesh, for example, has since 2003 installed over 1.3 million systems, totalling 30,000 monthly sales nationwide [16,17]. Sovacool and Drupady [18] suggest that SHS in particular are a ‘vital’ and ‘cost effective’ technology employed by international financial institutions in their efforts to curb global energy poverty. Mala et al. [19, p. 361] characterise the ubiquitous portrayals of solar as reliable, able to satisfy basic needs, being easy to operate and maintain and providing income-generating possibilities, as views that “have become so pervasive that they are hardly questioned.” Building on these success stories, recent years have seen considerable investment in explorations of the potential of small community-scale solar PV (Photo-Voltaic) grids of various dimensions as a next wave of RET development across the South [20–23].

In exploring the burgeoning literature on the deployment of solar technologies at these different scales it is interesting to note the ways in which the purposes, promises and pitfalls of community solar projects are imagined differently by different actors across the whole energy system. Community and household energy projects are a complex amalgamation of science, technology, policy, infrastructure, social and cultural knowledge, practices and norms embedded in and affected by broader national and global political economy processes. Such projects comprise different ways of knowing, performing and imagining (solar) energy in daily life that need to be brought into dialogue with one another to ensure a holistic understanding of how each project can be adapted and implemented to meet each community’s energy needs and aspirations. Consequently, we propose the development of a ‘Social Energy Systems’ (SES) approach to energy projects which we characterise as a framework that establishes connections between different forms of literacy – comprised of an energy systems literacy and project community literacy overlain by a political literacy that is needed to facilitate shared imaginaries across the whole project. This SES approach is indebted to the concepts of sociotechnical transitions [24,25] and approaches that stress the co-production of technology and society [26] in facilitating the process of mutual transformation from one energy system to another [27,28]. It is, moreover, predicated on the premise that learning at multiple levels is important for transitioning to sustainable energy futures [24].

Nowhere is this learning at multiple levels more important than in developing contexts where the sociotechnical transitions approach has in recent years begun to be applied [29–31]. A special edition of Environmental Science & Policy introduced by Berkhout et al. [32] focused on developing Asia to explore the wider impacts of sociotechnical innovations developed via niche experiments. Work on energy transitions in sub-Saharan Africa [33,34] has shown that SHS innovation processes are shaped as much by political, social and environmental forces as by powerful economic and institutional interests and any attempts to replicate the success of initiatives will fail unless sufficient attention is paid to the specificities of the local context. Being literate in the energy system, community and political context in which the energy project is being embedded is critical to the perceived success of the transition.

From this sociotechnical transitions perspective, energy systems can be understood as a patchwork of interdependent regimes whose inter-actions help co-produce and reinforce the conditions necessary to maintain the existing sociotechnical system. Understanding of the different technological, social, cultural, economic, political, regulatory,

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3 In this case, the authors intend reverse-engineer to mean beginning with a particular RE technology (solar, wind) at a particular scale advanced by the state of development of the technology (Solar Home System, large wind-turbine) and then analyzing (the) subject system to create representations of the system at a higher level of abstraction [15].

4 Sociotechnical imaginaries are closely linked to the concept of co-production and help explain why some visions of social and technical orderings are co-produced in preference to others. However, it is important to clarify that Jasanoff’s use of sociotechnical imaginaries is not related to the extensive sociotechnical transitions literature.

5 These are approaches that have frequently been applied to discussions of Northern energy transitions but much more infrequently to energy transitions in other settings.
research and organisational arrangements that combine to lock-in established patterns of energy use and behaviour forms the basis of an energy systems literacy valuable to project implementers if they wish to challenge prior energy commitments of the state and business. Drawing on the sociotechnical transitions concept of the niche, we argue further that this energy systems literacy has to be brought to bear within the context of a relatively protected space at the community level where project and community actors can develop and nurture collectively imagined energy futures on the basis of shared knowledge, experiences, aspirations and visions, and where mutual learning (about new technologies, energy practices, markets and ideas) can encourage deviation from the dominant energy regime [35]. Project and community actors engaging at this level thus require a project community literacy that extends beyond an imagined understanding of the community to encompass a holistic understanding of the community’s energy needs and aspirations and how these are interwoven into the fabric of daily life and imaginings of their future lives. Finally, understanding of the implications of the wider political landscape is crucial for identifying alternative or competing future energy visions and managing any tensions or challenges that threaten to overwhelm local or community imaginaries. Political literacy is thus the final, enveloping constituent of the SES framework within which energy systems and project community literacy must be co-produced (see Fig. 1).

The ensuing sections of the paper establish the case for a Social Energy Systems Approach in more detail. Drawing on a substantial review of the literature on community energy developments across the Global South, as well as reflections on our own involvement in action-oriented research projects in Kenya and Bangladesh and the wealth of experiences convened in a succession of events we have organised under the auspices of the UK Low Carbon Energy for Development Network over recent years. We set out to challenge the widely held assumption that economic development and livelihood benefits straightforwardly follow on from energy access, especially in Global South settings. Instead, we argue the presumed causal link between the two is problematic for a number of reasons, not least because it assumes a simple techno-fix to complex social problems. To begin, the case of solar community RETs is particularly interesting because it runs the risk of intensifying the dominance of socially-disconnected technocratic approaches and an associated increase in the risk of project failure. We then go on to explore the interactions between the three forms of literacy described above in more detail and consider how they might be operationalized in practice. In the process we reflect on the value of adopting a Social Energy Systems approach towards the burgeoning rural energy development industry and how such an approach might help to strengthen the potential of the significant growth of funding in this arena having clearer positive impacts within the communities where it is brought to bear.

2. Technocracy and an obsession with scale

Despite official claims made over the vital importance of energy and the provision of electricity to economic development and growth [36,37], at least where the countries of the Global South are concerned, evidence for this belief in the developmental benefits of access to modern energy services is ambivalent. In an econometric analysis of 17 African countries, Wolde-Rufael [38], p. 220] suggests that energy is “no more than a contributing factor to output growth and certainly not the most important one” (in Kenya in particular) and that evidence to support the overwhelming official belief that consumption of energy is directly correlated to economic growth was lacking [39]. This position is also supported at a more localised level (in terms of the impacts of electricity access on income levels, economic activity and livelihood creation) by other studies, including one in Namibia where rural households without electricity were shown to have the highest levels of ‘home-based income generating activities’ [40]. Cook [41] provides an interesting review of the literature on this theme and concludes that whilst it does appear that access to electricity does contribute to rural income-generating activities, calculating the beneficial effects of electrification are complicated by the influence of other factors making it impossible to say that access to electricity by itself improves quality of life.

The evidence emerging across Africa is contradictory [42]; there are some studies that do establish a relationship between economic improvement and energy use (143 on South Africa), and others that contradict this finding (44,45 on Nigeria). The consensus of many of these studies is that the energy infrastructure and the levels of economic development in Africa are so weak and fragmented that in most countries the relationship between energy and development is difficult to establish. Thus, how pre-existing socio-cultural patterns of behaviour will shape encounters with new/different energy technologies is in reality “multiply determined by a number of processes and factors that come together to shape the social use possibilities of the technology” [46, p.158]. The importance of this complexity lies in the way that it undermines any linear presupposition that mere access to ‘modern energy services’ of a particular type, delivered in a certain way and using a certain financial model will result in economic growth and development, however that is understood. It may be that at best electricity is an “enabling factor” [42, p.33] interwoven in a skein of sociocultural complexity; if that sociocultural environment is not fully understood and taken into account, at worst electricity could become a ‘disabling factor’ acting to exacerbate poverty and marginalisation. For example, reviews of the ‘developmental impacts’ of grid electricity access caution us about instances where the costs of energy access (connection fees, regular charges and usage costs) have not been offset by any enhancements in livelihood generation, leaving households economically worse off. There are also some interesting discussions of the importance of education and extension services to the take-up of electricity use for productive purposes [47].

Technocratic determinations of the appropriate scale of RET projects, including possibilities for scaling up or down, stem from this purported causal linkage between energy access and economic development and livelihood enhancement. We would, however, argue for caution in relation to the search for ‘delivery models’ and assessments...
of their ‘scalability’ (a term which is used frequently in the literature, yet often without clarity as to its meaning). What type of model is we looking for? Is it a model designed to spread RETs as rapidly as possible or to ensure that they have a particular set of social or economic outcomes? Is it a model designed in conjunction with specific end users or is it of diffuse applicability? In respect of these questions, the idea of scale constantly interposes itself as a conduit for discussing pre-suppositions, agendas and perceptions, as much of vulnerable communities of the Global South as of supra-national donor institutions. As Bridge et al. [[48], p. 338] argue, “the scale at which energy systems are organised and governed is not pre-ordained and arises instead as a product of economic and political decisions.” They maintain this “highlights not only the emergent character of geographical scale in the context of energy systems; it also emphasises the range of choices that exist in how low carbon energy systems might be scaled” and teases out the implications of the patterns of provision that emerge [[48], p. 332].

In RET sociotechnical imaginaries, scaling (and the technologies that determine that scaling) has become an ‘object conflict’, where “design choices between different variations of similar objects become sites for conflict among the range of organisational and individual actors that develop [from social movements] to established industries” [[49], p. 520]. A host of scaling technologies has been devised through a seemingly arbitrary nomenclature to service the RET industry (see Table 1 below). An obsession with promoting the pico-, nano-, micro- or mini-scale of projects as representing the most appropriate scale for off-grid community projects, however, runs the risk of intensifying the dominance of socially-disconnected technocratic approaches determined by outside actors, which already characterise a not insignificant proportion of current RET projects. As Miller et al. [[50], p. 68] argue “(t)he tendency in mid-scale projects is to focus almost exclusively on energy supply, leaving aside questions about the design of socio-technical arrangements that transform energy supplies into energy services that deliver social value.”

The arbitrary nature of this new system of nomenclature becomes more apparent when it is realized that, as the IED (Institute of Economic Development) document produced for DFID from which the above table is taken states, “There are no standard, universal definitions of mini-grid (MG) and green mini-grids” (GMG) [[23], p. 11]. But neither are there definitions for a range of energy systems descriptors, even in the technical literature. For instance, where nano-grids are concerned, Nordman [[51], p. 1] defines them as “a single domain for voltage, reliability, and administration. It must have at least one load (sink of power, which could be storage) and at least one gateway to the outside. Electricity storage may or may not be present.” Bryan et al. [[52] adopt a different size-based definition whereby a nanogrid is defined as a small-scale aggregation of local loads and generators. The loading on these aggregations is generally lower than 20 kW (for example a small industrial zone, a small rural community or similar) and the loads are generally within a few kilometres of the various sources of generation.

There is no agreed technical definition across a whole range of scalar energy system descriptors – pico-, nano-, mini- and micro – and it is not clear how helpful such symbolic prefixes actually are. This is important with reference to the idea of scaling up or down particularly because the literature on decentralization of energy services demonstrates conclusively that there is no necessary causation between scalability and the provision of better energy services; what does improve the quality of service provision, on the other hand, is the nature and form of decentralization. Across a range of studies from Africa, India and Bangladesh, local participation and the early involvement of local stakeholders [[53], a bottom-up, decentralized approach [[54] and the development of local-based training, education and employment networks [[55] in which to embed the actual energy project are strong supporting mechanisms for successful projects (see [[56] for a discussion of the connections between decentralised energy and political decentralization).

Interpreted another way, in the more successful projects the appropriate scale for implementation is not the size of the generating equipment, the system to which it is linked or the area to be covered, nor is it a financial model deployed in pursuit of these considerations. Rather, it is the social scale by which optimum local participation can be achieved and the scale of a project which can maximize that participation; not just the quantity of participants but who participates and how they participate – reflecting necessarily a conscious decision by the implementers to enable, understand and maximize the effectiveness of that participation. Matters relating to energy systems in transition, where knowledge is contingent, future impacts are uncertain and multiple values and visions are in circulation, require more interactive discussion to explore the range of potential pathways [[57]. Thus it is important that development projects are governed in such a way that they ‘open up’ rather than ‘close down’ the range of possible visions to co-produce future imaginaries with the community in question [[58].

One further component of the dominant RET sociotechnical imaginary is the construct of the ‘financial model’. Again, proposing that the financial model is a political construct is not to suggest that issues of finance, equipment and maintenance costs, cost recovery and financial viability through profitability are not important to the success of a project. Rather we argue that the models proposed for community energy projects are frequently built on perceptual pre-suppositions about the implications of the patterns of provision that emerge [[48], p. 332].

### Table 1

**Definitions of Rural Electrification Systems.** (Adapted from IED, [23][23]:17)

| System Type                          | Description                                                                 |
|--------------------------------------|-----------------------------------------------------------------------------|
| On-grid system (or grid-tied)        | All network or sub-grid or generating systems that are connected to the grid and run by national utility or by IPP. |
| Off-grid system (0–few MW)           | All distribution networks that are isolated from the main grid, supplied by independent source(s) of power, and managed by any kind of operator. |
| Mini-grid system (MG) (10 kW–few MW) | System where all or a portion of the produced electricity (by any source) is fed into a small distribution grid (low & medium voltage (LV/MV); single-/tri-phasé) which provides several end-users with electricity. Note: A mini-grid system can be either isolated or grid-connected. If the mini-grid is connected to the main grid, it should be operated by a third party, separate than the state utility (public or private). The aim of the grid connection is usually to sell extra energy or to compensate the deficit of energy. |
| Green mini-grid (or low carbon) (10 kW–few MW) | Mini-grid system (as defined above) where the energy fed into the grid is produced by renewable energy carriers or hybrid systems (renewables/fossil fuels). Green generators are cleaner and potentially cheaper than conventional generation using fossil fuels. |
| Micro-grid system (mG) (1–10 kW)     | System where the produced electricity (usually below 10 kW) is fed into a very small distribution grid (usually low voltage and single phase) which provides several end-users with electricity. Micro-grids can also operate in both grid-connected or island-mode. |
| Stand-alone system (SA) (0–5 kW)     | Isolated power system that usually supply one rural customer without distribution grid (household, community infrastructure, battery charging station, multifunctional platform, water pumping station). |
| Smart Grids                          | Smart grids are networks that monitor and manage intelligently the transport of electricity from all generation sources to meet the varying electricity demands of end users. |
| Hybrid system                        | System having more than one generating source, either mix of renewable and fossil-fuel sources or mix of renewable sources only. Hybrid generator can supply mini-grids or stand-alone systems. |
regulation, cost, affordability, tariffs, repayment etc. that are developed out of generalised orthodox financial understandings and constructed in ignorance of the lived, local reality of the project community. One example comes from how Pape [59] identifies the major challenge facing the economic potential for green mini-grids in East Africa as the specification of a workable business model. Even before individual communities have been identified, this top-down approach proceeds from the assumption that success depends on having in place a contractual and regulatory framework, financing instruments and investors and operators.

According to this top-down approach, making RET projects affordable to the poor becomes relatively unproblematic [60] and rests on three themes identified by Cook [41]: operators should be obliged to provide access; costs should be reduced through, for example, tariffs or subsidies; and the range of suppliers should be increased to give consumers more choice. This approach has become sufficiently popular and widespread such that “Financial feasibility analysis is performed from the market and entrepreneurial interests to explore the financial incentives, and other subsidies that make the business attractive” [(161, p. 2044)]. It is in this respect and in direct contradiction that the concept of ‘vernacular technology’ – the ‘objective record of the cultural performance that created it’ – becomes useful [162, p. 149] (see Rezende et al. [63] for one treatment of this phrase). Rolffs et al. [164, p. 2625] conclude that “the social practices through which energy is currently obtained and purchased (e.g. kerosene, diesel generators)…… play a significant role throughout on the relative potential of…… new finance approaches.” Thus, they argue, that the more successful RET projects (from a socio-economic perspective) are those able to develop bottom-up financial models evolved from an intimate understanding of the local income streams, earnings possibilities, and debts and commitments of the communities in which they work. Accordingly, such bottom-up financial models can be conceptualised as a form of ‘vernacular financial technology’

This connects to discussions related to the over-riding focus on the private sector and entrepreneurialism as the ‘solution’ to rural energy access across the Global South and the lack of attention being paid to alternative models or to debates over the appropriate roles of public bodies, private companies, NGOs and community organisations within the governance of the energy sector (these discussions are beyond the remit of this paper but are a unifying theme for papers collected in a special edition of Progress in Development Studies [65]).

3. Towards a Social Energy Systems approach to RETs

Calls for improving energy literacy are commonplace in the RET industry, but generally the assumption is that project beneficiaries need to be educated about the kinds of energy sources they are about to receive, rather than the equally important education of energy technology developers and project implementers about the project community’s livelihood needs and aspirations in which energy plays a key enabling role. Such calls also sit uneasily with the fact that users are frequently educated about the benefits of a particular product, rather than about energy and its social, economic and environmental implications more generally. Kanpal and Garg’s [166, p. 393] call for renewable energy education to be provided “to all the people, at all levels, and through all possible modes of education” – remains an ideality even in the richest countries of the Global North.

There is some evidence emerging, however, of a wider sense of RET literacy development, or at least recognition of its value to all RET stakeholders, amongst project developers. Part of the success of the take-up of Solar Home Systems in Bangladesh [67], for example, reflects the ways in which the Infrastructure Development Company Limited (IDCOL), the Rural Electrification Board (REB), Grameen Shakti (GS) and the Local Government Engineering Department (LGED) have all interacted deeply with a range of local actors as they have implemented, albeit still top-down, awareness programmes to develop public literacy around RETs. GS in particular has used a range of literacy development tools including “village fairs, exhibitions, RET posters, and distribution of calendars” and has developed its business approach through detailed knowledge of local communities [(53, p. 4630) (see also Murphy and Sharma [68] for connected discussions over the role of awareness raising and engagement with locally specific circumstances within the successful promotion of solar lanterns across Sub-Saharan Africa via the World Bank’s Lighting Africa programme).

This fits well with Hirsch’s [69] suggestion that literacy should be seen as a shared body of knowledge enabling people to communicate with each other and make sense of a mutual world. This implies a universal, two-way learning process. The most successful community-focused energy programmes are likely to be those that make strong efforts educationally, particularly on the part of project teams, in educating themselves about the communities they work in, as well as providing relevant information to those communities.

In speaking to the idea of education as a shared, universal process, GS (established by the Grameen Bank in 1996) is instructive. The Grameen methodology has effectively been a labour-intensive form of institutional self-education whereby Grameen, working over decades, has established extensive networks anchored to local communities through which to educate the bank itself about the circumstances of the poor in Bangladesh. Building on those decades of work, GS has been ideally placed to nurture deep networks of local participation in RETs, using grassroots promotions, demonstrations and different forms of training programmes designed to understand and address local demand, ranging from entrepreneurship to engineering [54,70]. Nevertheless, as the size of the GS SHS programme has grown so it has proven extremely challenging for even GS to maintain and develop this kind of two-way approach to their relationships with the communities where they work and how to respond to changing community needs and aspirations which perhaps deviate from their established delivery models (drawn from conversations with GS staff during recent visits to Bangladesh; see also [18,71]).

Literacy therefore is not a neutral, objective process absent of context or environment and energy systems literacy for RET projects is comprised of different forms of knowing, performing and imagining energy in daily life constituting a literacy triumvirate with project community literacy (a full and comprehensive understanding of the community in which the project is located and, as a consequence, how best a particular project can be adapted and implemented to suit) and, as detailed below, an overarching political literacy (understanding of the implications of the politics of energy transitions is crucial for identifying competing future energy visions and managing any tensions or challenges that threaten to overwhelm community imaginaries).

There is extensive evidence in the literature of the need for a fuller understanding of the project community and of the consequences of inadequate pre-understanding and preparation of what is referred to by Siyambalapitiya et al. [72] as the techno-economic-social parameters of a project. Some authors [73] have tried to identify what they see as the critical factors for the dissemination of decentralized energy systems in rural areas, including “institutional support, local ownership and local participation, market aspects and other energy management issues based on case studies learning” [(161, p. 2045). Compiling individual lists of factors leading to success or failure (see Sovacool [74] for a good example) is in essence also identifying some of the symptoms of inadequate energy systems and project community literacy specific to given sociocultural settings. Rather than attending to the symptoms of inadequate literacy once implementation has begun, best-practice would dictate that the mutual literacy of stakeholders is developed as much as possible before technological and scalar commitments become locked in.

In support of this contention, there are a wide range of examples in the literature of projects that have succeeded by engaging with local specificities in different ways, but always within the context of coming to understand local socio-economic conditions. Yadav and Crucshank
[75] analyse the setting-up of rural power co-operatives in Nepal and Bangladesh, where success has been achieved through a social orientation that has helped them to improve local quality of life even though profit margins are slight. More specifically, other examples demonstrate that social orientation should revolve around not just the provision of energy but of what Cook [41], p. 309] terms “complementary services” derived from that energy product – these can include various kinds of business training and development, a range of different financial products based on micro-finance models and other kinds of infrastructure including ICT and transport [76–78]. These are plainly variations on a theme piloted more intensively by organisations such as GS and BRAC (a development organisation dedicated to alleviate poverty by empowering the poor) in Bangladesh. Each example underlines the importance of understanding energy not as an individual service focused on income and employment but as one thread in a social fabric of community service provision and infrastructure.

By way of contrast, organisations and institutions that envisage RET projects from a narrow technical or financial viewpoint are the most problematic, including those whose central focus is on cost-recovery (recently even the World Bank has moved away from this towards a more pro-poor approach [41]). Sovacool [74], citing the examples of Indonesia, Malaysia and Papua New Guinea, highlights the record of problems in renewable energy projects in developing contexts that stem from a tendency to narrowly focus on one technology or one scale. Smits and Bush [79] describe the situation in the Lao PDR where the local popularity of pico-hydro power units and a thriving local market in parts and units risks being swept away by government/elite preference for large hydro projects and World Bank insistence on the superiority of SHS. Speaking directly to the sociotechnical imaginary described above, Smits and Bush ([79], p. 124) assert:

“The policy actors involved in rural electrification in Laos appear to underestimate the existing use of pico-hydro power. The lack of information available to them means they make simplified and sometimes unsubstantiated policy claims based on broad ‘problem narratives’ that are not supported by our empirical observations.”

It is important to point out, however, that even those organisations that conform most closely to an energy systems-project community awareness ideal do not perform perfectly. Studies by Palit [55] and Sovacool and Drupady [18], for instance, point out that in the case of GS there is evidence to suggest that the financial model, particularly the requirement of a down-payment for an SHS, is still excluding the poorest strata of Bangladesh. In other countries where RET projects have shown themselves to be feasible rural electrification alternatives – Fiji, Nepal, Brazil and India – there are still substantial problems impeding performance in terms of financial, technical and non-technical barriers such as poor engagement with local communities and a lack of awareness of users’ needs and aspirations [80]. There is however an increasing awareness that there is no one-size-fits-all approach to stand-alone RET projects and that everything hinges on specific local socio-cultural awareness; as an example of this, elements of the check-list provided by the IED for the UK DFID in respect of green mini-grids are instructive [23]:

- There are many different possible schemes for MG and GMG implementation but there is no reference implementation or business model that can be easily/prompty replicated for scaling-up GMG programmes; there are no best practices as such for GMG implementation.
- Implementation of MG in rural areas can face many different barriers that are project, site and country-specific: national policy and regulatory environment, financing models, technology choice and management organisation.
- Success and sustainability of a GMG electrification project is intimately linked to key issues and specific barriers. The experiences show that long term sustainability of MG and GMG can strongly be improved with proper appreciation of grid extension, choice of high quality components (standards), adequate local O & M skills (trainings), end-users commitment (awareness) and associated productive uses/IGA activities (incentives).

Completing the triumvirate with energy systems literacy and project community literacy is an overarching political literacy. This article critiques the causal connection between sustainable energy access and socio-economic development. It questions the widely held assumption (and indeed practice) that energy and financial technologies as well as technocratic determinations of the appropriate scale are sufficient to address the complex and contextual issues of socio-economic development in poor regions when in fact the problems, and the solutions required to fix them, are political as much as they are technical, financial or social in nature. The process of transitioning from no/low to sustainable energy access is inherently political in nature. Yet the transitions literature has been criticised for its lack of attention to politics and for failing to ask reflexive questions such as ‘how is the transition framed, by whom, and to whose benefit?’ to reveal the politics of whose priorities should be steering the transitions agenda [35,81,82].

These questions take on an even more critical edge in Southern contexts where power and knowledge disparities between RET project implementers and beneficiaries are stark, and where energy transitions have the heightened potential to lessen or exacerbate socio-economic and environmental inequalities. Baker et al’s [83] analysis of the political economy of South African energy transitions is a rare example in the transitions field that focuses on the politics of transitional change. Exploring the nexus between the direction and form of an energy transition and the political economy within which it is embedded, Newell and Phillips’s [84] study of neoliberal energy transitions in Kenya also presents a nuanced analysis to show how issues of power and political economy can play a key role in determining the winners and losers of different energy pathways, and on whose terms the trade-offs between competing policy objectives are resolved in the distributional politics of transitions.

Further afield, the literature examining the political economy of renewable energy in developing contexts is more extensive; although we would argue in most instances politics are narrowly framed in terms of spatially-limited techno-economic concerns and fixes. In ‘The Political Economy of Renewable Energy’, Burke ([85], p. 3) observes that “in reality, apparent technical blockages in the RE sector are often highly politicized” before going on to identify a number of political factors requiring attention at the national level: the relative cheapness and flexibility of fossil fuels if carbon emissions are left out of the equation, the lack of public interest in climate change mitigation, a strong political desire for economic growth and energy security, contradictory government laws and regulation and transparency and good governance. The document thereafter stresses the need for all RET project staff to be literate in the political economy.

Kaundinya et al. [61], p. 2046] also emphasise the need for political literacy within RET project development based on the fact that evaluations of the outcomes of projects in the literature have increasingly focused on policy because without policy support at local, institutional and national-levels, RET projects cannot expect to succeed. The temptation to envisage projects purely in technical and financial terms and to leave aside the ‘messy’ business of political economy, wider geopolitics and socio-cultural realities may initially make things easier for project funders and implementers but almost certainly means the project will not succeed in the long run. In Bangladesh, the SHS programme begun by IDCOL in 2002 could not have been undertaken without government support, and across the range of Bangladeshi solar initiatives political support has been vital in a spectrum of systemic components, from setting national quality standards for PV panels, batteries and other components to providing the necessary institutional support to expand existing programmes further into rural Bangladesh. The significant expansion of SHS in Bangladesh from 1998 to 2002 took
place because of substantial government support, as well as substantial international assistance and finance and the community-oriented focus of key players such as Grameen Shakti. Nonetheless, Ockwell and Byrne [31] urge us to treat policy regime interactions such as PV standards setting processes with caution as such processes are inherently political. They suggest that "(w)e can interpret standards as socio-technical visions: they are highly detailed prescriptions for certain aspects of action and so intended to formally institutionalise particular behaviour" (Ockwell and Byrne, [[31], p.123]). Consequently, who gets a seat at the negotiating table is important in that the vision or imaginary that prevails could affect system actors in different ways such that some will be winners and others losers.

Moreover, the political economy literature suggests that government-supported programmes ranging from IDCOL in Bangladesh to mini-grids in Sunderban and Chattisgarh in India have been more successful than other programmes because of strong institutional arrangements and guidelines set within appropriate policies [55,86,87]. In these cases, complementarity between internal institutional structures and processes and the development of government and political structures has greatly supported the RET sector. Knowledge of how to achieve such cross-sectoral institutional alignments in a given socio-cultural setting is plainly as important as systemic, technical and financial knowledge. Burke [85] also advises developing a comprehensive background knowledge of how policy is devised and implemented at every level from the local to the national and securing the backing of community, local and national ‘champions’ (see also Sovacool [74] on this) and well-known political figures who can act to promote RETs, concluding:

"Evaluations of RE projects tend to stress the achievements of technically-defined outputs like training, pilot sites and policy development. These factors are important but ensuring that such outputs achieve concerted change depends on understanding the interests of different stakeholders and bringing them on board"

Our use of the term ‘political’ rather than ‘political economy’ as utilised by many of the authors that we have engaged with above reflects a desire to incorporate a somewhat broader set of issues under the banner of political literacy to highlight asymmetries in power, knowledge and impacts. Ockwell and Byrne [31] focus a spotlight on the neglected issue of intervening actors (whether individuals or organisations) in energy transition projects as the role of all actors and the nature of their actions (and interactions) are inherently political. They argue that opening up the politics of energy transitions has important implications for both the analysis and governance of (inter)actions to achieve transformations in sustainable energy access. From a Social Energy Systems perspective, this requires attending to the different imaginaries of key actors seeking to realise their vision for a sustainable energy future. Consequently, imaginaries are political in nature. The question of how the problem of sustainable energy access is imagined and by who gives priority to certain solutions over others (such as technology development over attending to socio-economic and political factors that fundamentally affect energy access), thus benefiting certain social groups over others.

We also contend that spatially-limited transitions, such as ‘national’ or ‘community’ transitions, which figure prominently in political economy treatments of energy transitions, are problematic since such transitions draw on resources from and engage with a wide variety of different actors and institutions that operate at very different geographical scales [88,89]. During nearly three years of research into community energy programmes in Kenya under the SONG project, we have been struck by the complex and highly networked political geographies within which such programmes are situated and the need to broadly align the solar imaginaries held by this complex network of individual actors, communities and organisations/institutions towards a common future vision. Individual projects with which we have been heavily involved have co-evolved through the complex interactions of the contrasting solar imaginaries of local community members themselves, their local political representatives, local NGOs and small
businesses, larger international NGOs, national electrification agencies, county-level authorities, international academics, energy sector financiers and international donors and international financial institutions (see Fig. 2 for an illustration of this).

Furthermore, the political component of an SES approach is important not just because the elision of differences between the institutions and processes of RET stakeholders and policy-makers will make RET projects more functional, but because the entraining of an escalating network of relationships between political elites and poor communities outside formal political arrangements through RET projects can impact positively on all aspects of citizenship. In this sense, energy itself becomes a conduit for promoting the creation of more participatory forms of citizenship for elite and project subjects alike. Smaller-scale energy generation and the political changes necessary to empower and sustain it can potentially enhance community cohesion and foster greater political participation organised around the often-substantial techno-social change needed to bring about socio-economic change (see Brown et al. [56] for further discussions around the relationship between decentralised energy and political participation). Here we reiterate our earlier point that the most appropriate scale for project implementation should not be based on technocratic or financial considerations – rather it is the social scale by which the optimum breadth and depth of local participation can be achieved. In this sense, procedural justice is an important precursor to sustainable energy access for all.

Finally, we should be wary of assuming that intervening actors will always act in the interests of the energy poor and marginalised. Ockwell and Byrne [31] contend that such an assumption masks important political questions about who these actors are or should be, how they can understand the needs and aspirations of the energy poor and how intervening projects can be governed in ways that lessen rather than exacerbate power inequalities. Our contention is that the political literacy of project actors (including energy researchers such as ourselves) can help catalyse energy transitions that are truly transformational.

4. Conclusion

“Sociotechnical imaginaries draw attention to the way national actors legitimize science and technology investment, design, and deployment through mingling policy action with collective visions of a better future made possible through techno-science’

An important part of the sociotechnical imaginary is the kind of positive, imagined future envisioned by Eaton et al., however, we would argue, drawing on the discussion over the preceding pages, that we need to open up these sociotechnical imaginaries and the relations of power which sustain them to alternative visions and understandings of the role of RETs in transforming rural communities. This kind of approach has rarely been applied to the burgeoning community energy phenomena accelerating across the Global South. We recognise of course that all we have been able to do here is provide a generalised overview of what our Social Energy Systems approach offers and we are currently developing more detailed explorations of how the approach is being operationalised within the context of specific energy initiatives. It is important to underline here, however, that the critique of the dominant techno-economic RET imaginary and the portrayal of an alternative vision presented by the Social Energy Systems approach depicted above does not challenge that positive view of the role of community energy projects and their crucial role in addressing key dimensions of the complexities of the global energy trilemma, but seeks to make the case for their development fuller, more holistic. Whether community access to energy services improves the lives of the poor or not depends on how those heterogeneous lives are understood and by whom, which includes understanding that all forms of poverty are snapshots of complex processes which flow through dynamic multi-scaled systems. Indeed, the focus on concretising how terms like ‘energy poverty’ are themselves to be defined universally suggests over-simplistic economic or technological ‘fixes’ [90].

The literature on community energy projects is full of good practices and processes that have contributed to project success; inclusion of multiple stakeholders, capacity-building, affordability, maintenance, demonstrations, thorough dissemination and education practices, local manufacturing and training centres, simultaneous implementation with employment-generating practices, the development of symbiotic services (irrigation, etc.). But not all of these will work in all contexts and what is vital to understanding which will work where and what other innovations might be needed cannot be achieved through top-down perceptual models based on finance and technology: “In the end, economic and technical metrics should leave room for a more complex analytical process (Alfaro and Mille [91], p. 910).”

Overall, there remains a debilitating lack of research into the social complexities of the evolution of community energy systems across the Global South or the positionalities of that research. Schäfer et al. [92], however, suggest that the current push for Sustainable Energy For All (SE4ALL) by the UN provides the ideal window of opportunity to discuss adequate methods and instruments for integrating different types of knowledge into the debate on sustainability and renewable energy systems in the Global South. They argue that, “research on decentralized energy supply has so far mostly taken place in a ‘niche’ – as are the technical systems it is investigating – it has mostly been carried out with few resources and little (wo)manpower. Additionally, it has been difficult to define a ‘research community,’ because research in this field is being done by very different disciplines, deals with a variety of technologies and has been carried out in very different geographic and cultural contexts.”

Ultimately, the key to understanding and mapping Social Energy Systems lies in the analysis of the self-replicating dynamics of deprivation in complex and multi-scaled systems. Within these complex systems the processes of exclusion relating to culture, socio-economic environment and the politics of energy generation, distribution and use form an underlying pattern of energy marginality. The dynamics of deprivation and those of energy marginality are interconnected in a complex fashion and a Social Energy Systems approaches to energy access/RET projects need to be designed to analyse these two sets of factors as a pre-condition for project involvement. Sovacool [74], p. 9161] concludes, as do we, that “(effective programmes ….. contemplate political, institutional, social, and cultural needs alongside economic and financial ones.”

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References

[1] A. Goldthau, From the state to the market and back: policy implications of changing energy paradigms, Glob. Policy 3 (2) (2012) 198–209.

[2] A. Scott, The Energy Trilemma for Developing Countries, ODI development progress blog, 2012, www.developmentprogress.org/blog/2012/08/03/energy-trilemma-for-developing-countries-

[3] N. Gunningham, Managing the energy trilemma: the case of Indonesia, Energy Policy 54 (2013) 184–194.

[4] O. Wyman, World Energy Trilemma, (2014) Available at: https://www.worldenergy.org/wp-content/uploads/strategic-insight/assessment-of-energy-climate-change-policy/. (Accessed 30 May 2017).

[5] J. Watson, R. Byrne, M. Morgan Jones, F. Tjang, J. Opazo, C. Fry, What Are The Major Barriers To Technology Use Of Modern World’s Poorest People And Are Interventions To Overcome These Effective, (2012) Systematic Review, Collaboration for Environmental Evidence, CEE Review No. 11–04.

[6] S. Bhattacharrya, D. Palit, Enabling policies for enhancing sustainability of electricity access programmes, in: A. Goswamy, A. Mishra (Eds.), Economic Modeling, Analysis and Policy for Sustainability, IGI Global, USA, 2016Chapter 9.

[7] P. Diaz, R. Peña, J. Muñoz, C. Arias, D. Sandoval, Field analysis of solar PV-based collective systems for rural electrification, Energy 36 (5) (2011) 2509–2516.

[8] D. Lauffer, M. Schafer, The implementation of Solar Home Systems as a poverty reduction strategy – a case study of Sri Lanka, Energy Sustain. Dev. 15 (2011) 330–336.

[9] P. Nusbaumer, M. Bazilian, V. Modi, K. Kumella, Measuring energy poverty: focusing on what matters, Oxford Poverty & Human Development Initiative (OPHI) Working Paper 42, (2011) Available at: www.ophi.org.uk/wp-content/uploads/OPHI_WP_42_Measuring_Energy_Poverty.pdf?1f8b0a . (Accessed 30 May 2017).

[10] R. Sasoan, The poverty of energy poverty: a review of key challenges, Energy Sustain. Dev. 16 (3) (2012) 272–282.

[11] S. Jasanoff, S.H. Kim, Containing the atom: sociotechnical imaginaries and nuclear power in the United States and South Korea, Minerva 47 (2009) 119–146.

[12] S. Jasanoff, S.H. Kim, Sociotechnical imaginaries and national energy policies, Sci. Cult. 22 (2) (2013) 189–196.

[13] M. Leach, I. Scoones, A. Stirling, Pathways to Sustainability: an overview of the STEPS Centre approach, STEPS Approach Paper, STEPS Centre, Brighton, 2007 Available at: steptoolbox.org/steptoolbox/wp-content/uploads/final_steps_overview.pdf. (Accessed 30 May 2017).

[14] W. Eaton, S. Gasterly, B. Burch, Bioenergy futures: framing sociotechnical imaginaries in local places, Rural Sociol. 79 (2) (2014) 227–256.

[15] E.J. Chikofskey, J.H. Cross, Reverse engineering and design recovery: a taxonomy (1998) 537–561.

[16] O. Wyman, World Energy Trilemma, (2014) Available at: https://www.worldenergy.org/wp-content/uploads/strategic-insight/assessment-of-energy-climate-change-policy/. (Accessed 30 May 2017).

[17] J. Ommar, O. Gomaa, S. Mohamed, A. Aboelkassem, L. Elauzy, N. Elwahabi, Sustainable energy for whom? Governing pro-poor, low carbon pathways to development: lessons from solar PV in Kenya, STEPS Working Paper 61, STEPS Centre, Brighton, 2014.

[18] M. Lehtonen, F. Klem, Deliberative socio-technical transitions, in: I. Sraeva, G. Mackerron (Eds.), Energy for the Future: A New Agenda, Palgrave Macmillan, Basingstoke, 2009, pp. 103–122.

[19] OECD-IEA, OECD Green Growth Studies: Energy, Preliminary Version, (2011) Available at: www.oecd-ilibrary.org/energypolicy/growth-energy/49157219.pdf. (Accessed 12 December 2015).

[20] USAID, Energy, (2014) Available at www.usaid.gov/what-we-do/economic-growth-and-trade/infrastructure-energy. (Accessed 30 May 2017).

[21] Y. Wolde-Rufael, Energy consumption and economic growth: the experience of African countries revisited, Energy Econ. 31 (2009) 217–224.

[22] Y. Wolde-Rufael, Energy demand and economic growth: the African experience, J. Policy Model. 27 (2005) 891–903.

[23] N. Wamukonya, M. Davis, Socio-economic impacts of rural electrification in Namibia: comparisons between grid, solar and un-electrified households, Energy Sustain. Dev. 5 (3) (2001) 5–13.

[24] P. Cook, Infrastructure, rural electrification and development, Energy Sustain. Dev. 15 (2011) 304–313.

[25] A. Welle-Strand, G. Ball, M. Hval, M. Vlaicu, Energizing solutions: can power sector aid boost economic growth and development, Energy Sustain. Dev. 16 (2012) 287–299.

[26] O. Ndiagbo, Electricity consumption and economic growth in South Africa: a trivariate causality test, Energy Econ. 31 (5) (2009) 635–640.

[27] A. Akialo, Electricity consumption and economic growth in Nigeria: evidence from co-integration and co-variance analysis, J. Policy Model. 31 (2009) 681–693.

[28] Y. Wolde-Rufael, Electricity consumption and economic growth: a time series experience for 17 African countries, Energy Policy 34 (10) (2006) 1106–1114.

[29] A. Jacobson, Connective power: solar electrification and social change in Kenya, World Dev. 35 (1) (2007) 144–152.

[30] M. Blunck, Electricity and Sustainable Development: Impacts of Solar Home Systems in Rural Bangladesh, Department of Geography, Johannes Gutenberg University Mainz, 2007 Diploma thesis, Available at http://energygeography.info/images/2/5/Impact_of_Solar_Home_System_in_Rural_Bangladesh.pdf. (Accessed 17 December 2016).

[31] G. Bridge, S. Bouzarovski, M. Bradshaw, Eyre, Geographies of energy transition: space, place and the low-carbon economy, Energy Policy 53 (2013) 331–340.

[32] D. Hess, Technology and product-oriented movements: approximating social movement studies and science and technology studies, Sci. Technol. Hum. Values 30 (4) (2005) 515–535.

[33] C. Miller, C. Altamirano-Allende, N. Johnson, M. Ayegamye, The social value of mid-scale energy in Africa: redefining value and redesigning energy to reduce poverty, Energy Res. Soc. Sci. 5 (2015) 67–69.

[34] B. Nordman, Nanogrids: Evolving Our Electricity Systems from the Bottom up, Building Technology and Urban Systems Department (BTUS), Report, Berkeley Laboratory, 2013 Available at nordman.lbl.gov/docs/tnano.pdf. (Accessed 30 May 2017).

[35] J. Bryan, R. Duke, S. Round, Decentralised Control of A Nanogrid, Report, Department of Electrical and Computer Engineering, University of Canterbury, 2002.

[36] M. Mondal, L. Kamp, N. Pachova, Drivers, barriers, and strategies for implementation of renewable energy technologies in rural Bangladesh—an innovation system analysis, Energy Policy 38 (2010) 4626–4639.

[37] M.S. Islam, A. Khan, S. Naureen, F. Rabbi, M.R. Islam, Renewable energy: the key to achieving sustainable development of rural Bangladesh, J. Chem. Eng. 26 (1) (2011) 9–15.

[38] D. Palit, Solar energy programs for rural electrification: experiences and lessons from South Asia, Energy Sustain. Dev. 17 (2013) 270–279.

[39] E. Brown, J. Cloke, J. Harrison, Governance, decentralization and energy: a critical review of the key issues, Renewable Energy and Decentralization Working Paper 1, (2015) Available at: thereadproject.co.uk/wp-content/uploads/2014/04/READ-WP1-FINAL.pdf. (Accessed 30 May 2017).

[40] A. Mohr, S. Raman, G. Gibbs, Which publics? When?: Exploring the policy potential of involving different publics in dialogue around science and technology, Policy Thematics Leadership Programme commissioned by Sciencewise-ERC, (2011) Available at: www.sciencewise-erc.org.uk/cms/assets/Uploads/Which-publics-FINAL-VERSION.pdf. (Accessed 12 December 2015).

[41] A. Siring, Opening up and closing down power participation, and pluralism in the exploration of technology, Sci. Technol. Hum. Values 31 (2006) 282–294.

[42] H. Pape, Identifying the Gaps and Building the Evidence Base on Low Carbon Mini-grids, IED Report Presentation, London, 2013 November 2013. Available at: www.worldenergy.org/~/media/documents/publications/finals3/publications/ied/2d-il-fd-presentation-du-rapport-ied-le-08-novembre-2011.pdf. (Accessed 12 December 2015).

[43] A. Estache, M. Fay, Current debates on infrastructure policy, Policy Research Working Paper 4410, World Bank, Washington, 2009.

[44] D. Kauya, P. Bitao, N. Niyonkuru, Net-neutrality, Grid-connected versus stand-alone
energy systems for decentralized power—a review of literature, Renew. Sustain. Energy Rev. 13 (2009) 2041–2050.

[62] A. Galley, The nature of tradition, Folklore 100 (2) (1989) 143–161.

[63] M. Rezende, J. Leite, F. Cardoso, Vernacular technology in Brazil, in: M. Correia, G. Carlos, S. Rocha (Eds.), Vernacular Heritage and Earthen Architecture: Contributions for Sustainable Development, CRC Press, Leiden, 2013, pp. 147–152.

[64] P. Rolf, D.G. Ockwell, R. Byrne, Beyond technology and finance: pay-as-you-go sustainable energy access and theories of social change, Environ. Plan. A 47 (2015) 2609–2627.

[65] E. Brown, J. Cloke, Energy and development: the political economy of energy choices, Prog. Dev. Stud. 17 (2) (2017) vii–xiv.

[66] T. Kandpal, H. Garg, Renewable energy education for technicians/mechanics, Renew. Energy 14 (1–4) (1998) 393–400.

[67] M. Najmul Hogue S, M. Kumar Das, Present status of solar home and photovoltaic micro utility systems in Bangladesh and recommendation for further expansion and upgrading for rural electrification, J. Renew. Sustain. Energy 5 (2013) 042201, http://dx.doi.org/10.1063/1.4812993 (Accessed 30 May 2017).

[68] D. Murphy, A. Sharma, Scaling Up Access to Electricity: The Case of Lighting Africa. Livewire: A Knowledge Note Series for the Energy Practice, World Bank, Washington, 2014 Available at openknowledge.worldbank.org/handle/10986/18681 . (Accessed 17 December 2015).

[69] E. Hirsch, Cultural Literacy: What Every American Needs to Know, Vintage Books, New York, NY, 1988.

[70] D. Barua, Grameen Shakti: An Integrated and Sustainable Model for Bringing Light, Income, Health and Affordable Climate Friendly Energy to the Rural People, Grameen Shakti, Dhaka, 2008.

[71] M. Hackett, Can social enterprise deliver gender ‘appropriate technology’ in rural Bangladesh? Outskirts Online J. 25 (2011) Available at www.outskirts.arts.uwa.edu.au/volumes/volume-25/michelle-t-hackett . (Accessed 17 December 2015).

[72] D. Siyambalapitiya, S. Rajapakse, S. de Mel, S. Fernando, B. Perera, Evaluation of grid connected rural electrification projects in developing countries, IEEE Trans. Power Syst. 6 (1) (1991) 332–338.

[73] R. Holland, L. Perera, T. Sanchez, R. Wilkinson, Decentralised Rural Electrification: The Critical Success Factors, Experience of ITDG (Intermediate Technology Development Group), 2002 Available at www.itdg.gov.uk/PDF/Outputs/Energy/R8148-ITDC.pdf . (Accessed 12 December 2015).

[74] B. Sovacool, Design principles for renewable energy programs in developing countries, Energy Environ. Sci. 5 (2012) 9157–9162.

[75] A. Yadav, H. Cruickshank, The value of cooperatives in rural electrification, Energy Policy 38 (2010) 2941–2947.

[76] C. Kirubi, A. Jacobson, D. Kammen, A. Mills, Community-based electric micro-grids can contribute to rural development: evidence from Kenya, World Dev. 37 (7) (2008) 1208–1221.

[77] A. Brew-Hammond, Energy access in Africa: challenges ahead, Energy Policy 38 (2009) 2291–2301.

[78] S. Mustonen, Rural energy survey and scenario analysis of village energy consumption: a case study of Lao People’s Democratic Republic, Energy Policy 38 (2) (2010) 1040–1048.

[79] M. Smits, S. Bush, A light left in the dark: the practice and politics of pico-hydro power in the Lao PDR, Energy Policy 38 (2010) 116–127.

[80] J. Alfaro, S. Miller, Satisfying the rural residential demand in Liberia with decentralized renewable energy schemes, Renew. Sustain. Energy Rev. 30 (2014) 903–911.

[81] J. Meadowcroft, What about the politics? Sustainable development, transition management, and long term energy transitions, Policy Sci. 42 (4) (2009) 323–340.

[82] A. Smith, A. Stirling, Moving outside or inside? Objectification and reflexivity in the governance of socio-technical systems, J. Environ. Policy Plan. 9 (3–4) (2007) 351–373.

[83] L. Baker, P. Newell, J. Phillips, The political economy of energy transitions: the case of South Africa, New Polit. Econ. 19 (6) (2014) 791–818.

[84] P. Newell, J. Phillips, Neoliberal energy transitions in the South: Kenyan experiences, Geoforum 74 (2016) 39–48. August 2016.

[85] A. Burke, The political economy of renewable energy; Why a political economy approach is essential in promoting market entry for renewables, UNDP Discussion Paper, UNDP, New York, 2011 Available at www.thepolicypractice.com/papers/PoliticalEconomyRenewableEnergyFeb2012.pdf . (Accessed 14 March 2014).

[86] D. Palit, A. Chaurey, Off-grid rural electrification experiences from South Asia: status and best practices, Energy Sustain. Dev. 15 (2011) 266–276.

[87] K. Ulrea, T.D. Winther Palit, H. Rohracher, J. Sandgren, The solar transitions research on solar mini-grids in India: learning from local cases of innovative socio-technical systems, Energy Sustain. Dev. 15 (2011) 293–303 (Accessed 13 March 2014).

[88] L. Coenen, P. Bennesworth, B. Truffer, Toward a spatial perspective on sustainability transitions, Res. Policy 41 (2012) 968–979.

[89] H. Bulkeley, Reconfiguring environmental governance: towards a politics of scales and networks, Polit. Geogr. 24 (8) (2005) 875–902.

[90] T. Makhabane, Promoting the role of women in sustainable energy development in Africa: networking and capacity-building, Gend. Dev. 10 (2) (2002) 84–91.

[91] J. Alfaro, S. Miller, Satisfying the rural residential demand in Liberia with decentralized renewable energy schemes, Renew. Sustain. Energy Rev. 30 (2014) 903–911, http://dx.doi.org/10.1016/j.rser.2013.11.017 ISSN 1364-0321.

[92] M. Schäfer, N. Kehir, K. Neumann, Research needs for meeting the challenge of decentralized energy supply in developing countries, Energy Sustain. Dev. 15 (3) (2011) 324–329 Special issue on off-grid electrification in developing countries.