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EDITORIAL

Energy access for sustainable development

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Abstract

It is abundantly clear that adequate, reliable and clean energy services are vital for the achievement of many of the Sustainable Development Goals (SDGs). In essence, energy access has come to represent one of the intractable challenges in development, and therefore emblematic of the call for poverty eradication, and economic and social transformation. This *focus issue* on 'Energy Access for Sustainable Development' is initiated to draw broadly from the ideas and emerging experiences with energy activities and solutions that sought to enhance sustainable development through expansion of energy access. The focus issue includes several contributions from authors on some of the knowledge gaps this field, including: (i) the role of off-grid and mini-grid energy systems to meet multiple SDGs; (ii) the impacts of the evolving suite of off-grid and distributed energy services on inequalities across gender, and on minority and disadvantaged communities; (iii) the opportunities that the evolving technology base (both of energy services and information systems) plays in expanding the role of off-grid and mini-grid energy systems; (iv) energy options for cooking; (v) new insights into energy planning as well as the political economy, institutional and decision challenges across the energy system. Drawing from papers in this focus issue and other literature, this paper provides a sketch of the key issues in energy access.

Introduction

Energy is a critical enabler of economic transformation and social wellbeing. Heat, light and power are essential inputs to build or run factories and agro-processing plants, irrigate land, and support education and health services. Industrialized economies have universally benefited from secure, reliable and affordable energy services to underpin their development and prosperity (at all levels—definition needed). For developing countries, access to reliable and affordable energy services is increasingly seen as a vital catalyst to efforts in improvements in human development including productivity, health and safety, gender equality and education (Alstone *et al* 2015). Beyond this recognition, there is much to do to turn assessment into action. Current assessments identify over a billion people without access to electricity, and another billion who suffer poor quality service, the majority of whom live in peri-urban or rural areas of sub-Saharan Africa and South Asia. Furthermore, close to 3 billion people lack access to clean forms of cooking energy, having to rely heavily on biomass fuels combusted on inefficient appliances, often in unventilated cooking areas. This means that energy access should be viewed and approached as a cross-cutting development challenge that needs to take a wider view of the complex economic, social, environmental and cultural dimensions in society.

Clearly, meeting the needs of the developing world with modern energy is an important goal. However, the potential to achieve universal access to modern energy is at times in conflict with the need to bring down greenhouse gas (GHG) emissions—a phenomenon largely caused by high consumption lifestyle, propelled by access to cheap fossil fuels, and the technologies to utilise them. Indeed, historically a good deal of the negative impacts associated with high consumption and affluent lifestyles is often felt by upstream communities where the hydrocarbon resources are mined and processed (Mulugetta *et al* 2010). These communities are almost always rural, poor and powerless. One example of this spatial asymmetry in the distribution of benefits and costs is the case of the Niger Delta where oil spills and flares led to extensive local pollution, loss of life and livelihoods, and spiralling poverty and corruption (Ugochukwu and Ertel 2008).

Despite the undisputed value of widening access to electricity, without significant changes to the current thinking around the dominance of centralised and carbon-intensive power systems, a billion people are projected to remain without access in 2030, with the majority in sub-Saharan Africa and significant numbers in developing Asia (World Bank 2013, Alstone *et al* 2015). Some 80% of those projected to be without electricity live in rural areas or in informal urban settlements, where the lack of modern infrastructure and services directly result in low resilience to the potentially catastrophic impacts of climate change, such as drought, losses in agricultural productivity, and extreme events (Ref). Not only is humanity locked in a battle to rapidly change course and explore new models of prosperity that account for social and natural capital, but also facing the challenge of going against established norms and institutions that underpin the present model of development practice.

In September 2015, world leaders adopted 17 Sustainable Development Goals (SDGs) at the UN that constitute goals and targets that integrate economic, social and environmental aspects and recognize their interlinkages in achieving sustainable development. In addition to adopting a specific SDG on energy that ensures 'access to affordable, reliable, sustainable and modern energy for all', there was a widespread recognition that none of the other SDGs can be achieved without adequate access to energy services. In essence, the key mission behind the SDGs is to think in terms of systems where the provision of and access to modern energy cannot be divorced from the wider social goals, economic possibilities and ecological constraints. The fact that access to modern energy services has gained ever greater attention globally in recent years partly reflects its critical importance to all three pillars of sustainable development.

Understandings of access and links to SDGs

A core concern within the energy-development work relates to the quality and quantity of modern energy, and how that informs the different framings of energy access. In aligning the thinking around energy access with the SDGs, there is a consensus that the concept should embrace multiple sustainability objectives. Fuso Nerini *et al* (2018) analysed synergies and trade-offs between efforts to achieve SDG7 and delivery of the 2030 Agenda as a whole. Their analysis found evidence that about 85% of 2030 Agenda targets are mutually reinforcing with SDG7, and also found evidence of trade-offs between SDG7 and about 35% of the 2030 Agenda targets. Interestingly, many of these trade-offs relate to tensions between the need to rapidly expand access to basic services, and the need for efficient energy systems underpinned by renewable resources. In line with this, one of the papers in this focus issue (Rao and Pacahuri 2017) give importance to the provision of access to electricity, clean cooking energy and improved water and sanitation as being critical in improving people's living standards in the home, and contributing to the SDGs. Their assessment of regional patterns in the pace of progress and relative priority accorded to the different services revealed that countries in sub-Saharan Africa would have to 'undergo unprecedented rates of improvement in energy access in order to achieve the goal of universal access by 2030' (p 4). Furthermore, given the centrality of energy to the achievement of several other goals such as those related to health, education and productive sectors, the quality and quantity of energy services would need to be significantly higher than what is presently available in many parts of sub-Saharan Africa and South Asian rural areas. Hence, this goes to the heart of what constitutes 'energy access'.

Since the emergence of SDGs, the issue of what 'access' means has been debated and investigated beyond the domain of the research community where it had remained in the past. Indeed, this discussion has been discussed at length in an influential paper by Bazilian and Pielke (2013). They questioned the concept of 'energy access,' which is unfortunately often defined in terms that are too modest and lacking proactive ambition where discussions about energy and poverty assume those who lack modern energy services will only require modest amounts over the coming decades. This assumption gives rise to projections of future energy consumption that not only underestimates the energy aspirations of communities but limits the policy options and could leave large numbers of people, albeit unintentionally, in poverty. Bazilian and Pielke (2013, p 7) go on to argue that 'now more than ever the world needs to ensure that the benefits of modern energy are available to all and that energy is provided as cleanly and efficiently as possible. This is a matter of equity, first and foremost, but it is also an issue of urgent practical importance.'

In a recent initiative, the World Bank's ESMAP, under the SE4ALL initiative, in consultation with multiple development partners has developed the Multi-tier Framework to monitor and evaluate energy access by following a multidimensional approach (World Bank 2013). This approach uses a multi-dimensional definition of access as 'the ability to avail energy that is adequate, available when needed, reliable, of good quality, convenient, affordable, legal, healthy and safe for all required energy services'. In effect, energy access is measured in the tiered-spectrum, ranging from Tier 0 (no access), Tier 1 (basic electricity service) to Tier 5 (2000 watts over 22 h d^{-1}). These tier levels are intended to serve as descriptive tools and not prescriptive, leaving it for planners to explore the appropriate electricity systems for their context. Other energy access models also exist such as the International Energy Agency which defines initial electricity access as 250 kWh per year for rural households and 500 kWh for urban households, projecting that this base level increases to 750 kWh per person by 2030 (IEA 2017).

Cooking: it is not all about electricity

The challenge with cooking has been around for several decades. A large proportion of the world's population of around 3 billion people uses polluting and inefficient systems that are linked to health hazards, gender inequality and impacts on local environments and the climate system, mainly from deforestation and black carbon emissions (Alstone *et al* 2015). Inefficient combustion of cooking fuels is a major health challenge in low income countries, contributing to the suffering and premature death of people due to illnesses attributable to indoor air pollution (World Health Organization 2016). The health effects of cooking are not limited to indoor air pollution. The physical burden of lengthy and arduous fuel collection, often by women and children, means increased risk for injury and personal security—not to mention the loss of potential income and leisure. The consequences of unsustainable biomass harvesting for direct combustion and charcoal production contribute to deforestation and land use problems, as well as significant net GHG emissions (Bruckner *et al* 2014).

Recent data indicates that there has been some movement in the transition from solid fuels for cooking to non-solid fuels, even though the use of non-solid fuels has increased almost in line with population growth (World Bank 2013). Taking a deeper look into this picture lends itself to some interesting observations in terms of regional trends. Firstly, the actual number of people who still use solid fuels has remained nearly constant, mostly concentrated in sub-Saharan Africa and South Asia, to a lesser extent. And secondly, the greatest growth in the number of people who transitioned to using non-solid fuels is largely concentrated in the leading emerging economies, namely China, Brazil and India; even though the increase is 200 million less than their overall increase in population (Banerjee *et al* 2014). Hence, whilst there is a clear indication of some movement towards non-solid fuels, the sheer weight of population increase will retard the transition and increased urbanization is likely to have the opposite effect.

The health effects of moving from one category of cooking fuels to another is well studied. However, there remain uncertainties about the direction of the transitions: whether towards improved firewood and charcoal cookstoves or LPG and electricity. Each of these pathways will mean different things in terms of GHG emissions, local environmental impacts and deforestation levels. For example, one of the papers in this *focus issue* provides evidence on the cost of cooking a meal in a Nyeri County, Kenya using several cooking solutions (Fuso Nerini *et al* 2017). The paper found that improved firewood and charcoal cookstoves come with a significant cost improvement while the LPG and electricity options are still relatively costly. Of course, the result is a reflection of context specific costs and so the outcome of such studies depend on local costs for material, labour and fuels (including electricity). Such analysis can be very useful to help develop local strategies, and develop bottom-up planning tools that are robust and built on real data, information and experience. Some of this will be discussed in the later section on energy planning.

Cooking is a complex energy end-use, often displaying the use of multiple fuels and appliances—a phenomenon known as fuel stacking. The practice of fuel (and stove) stacking has been attributed to a combination of factors that include household income, multiple end-uses, seasonality, fuel availability and price fluctuations, cooking practices, taste preferences and access to infrastructure (Kowsari and Zerriffi 2011). The widespread practice of fuel and stove stacking with biomass stoves, even when clean technologies are available, is an issue that requires careful localized understanding to plan interventions that would allow communities meet their cooking energy needs from progressively clean sources (Ruiz-Mercado and Masera 2015).

Electrification and its multiple benefits

Education

SDG4 of the 2030 Agenda is about ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all' and has seven targets and three means of implementation. Electricity provision plays a major role in the delivery of these services. Education may be enhanced by increased access to information (through radio and ICT), and more hours with lighting for children to study. These benefits may be reflected in a positive correlation between electricity access and higher levels of Human Development Index (HDI). A paper by Borges *et al* (2017), featured in this *focus issue*, presents the case of Brazil's Luz para Todos (Light for All) programme, a rural electrification policy launched in 2003 to electrify 10 million households within a 5 year period. The paper aimed to show the correlation between electrification and three dimensions of Municipal HDI, consisting of income, education and health. The result showed that the presence of electricity is positively correlated to MHDI, with the caveat that these benefits can only be achieved if other complementary actions are executed alongside the electrification process. Further empirical results revealed that the education component of HDI was the one most influenced by electrification, hence demonstrating that electrification has a strong effect on educational outcomes. Another challenge identified by the paper is what would happen to the programme once it comes to an end in 2018, given that it was heavily subsidized by the government as part of its staunch social development agenda.

Health

Other studies on other parts of the world also support that improved electricity access can deliver improved HDI and wellbeing. The co-benefits associated with extending electrification can be wide-ranging depending on the goal projects set out to achieve. For example, there is ample evidence showing that for those living in poverty, lack of access to services from electrification undermines health outcomes. Lam *et al* (2012) and Borah *et al* (2014) provide research results on the health effects of using kerosene for lighting, especially for people sitting in the vicinity of the wick lamp while engaged in specific tasks such as reading. Supporting this claim, Barron and Torero (2014) argue that electrification can yield significant health benefits at the household, but just as importantly, the benefits also extend to the public services such as health facilities.

Health facilities are community institutions where access to adequate and reliable energy is seen as an important determinant of effective delivery of essential health services. Some of the impacts of electricity access on health indicators include prolonging night-time services, attracting and retaining skilled workers, immunization services, and the provision of emergency response (Millinger *et al* 2012). Other services such as water pumping and thermal energy needs for cooking and water heating and sterilization contribute to overall improvements. Meeting high health outcomes therefore require a systematic energy plan to enhancing the quality of the health system.

Gender

The impact of energy on gender (in)equality has gained significant momentum in recent years in public and private spheres. Part of the emphasis on gender-energy nexus is the fact that women are disproportionately affected by energy poverty and inequality (Oparaocha and Dutta 2011; Skutch and Clancy 2006). However, much of the policy and research focus is on the household energy challenge, and less so on gender in relation to the productive uses of energy. De Groot *et al* (2017) argue further that there is overwhelming evidence that access to energy for productive uses increases productivity and enables business development. They go on to state that 'access to a range of energy services suitable to their enterprise would provide women with building blocks to operate their enterprise and provide them with increased control over enterprise operation' (De Groot *et al* 2017).

As part of the collection of papers in this *focus issue*, Burney *et al* (2017) presents an evaluation of the impacts of the Solar Market Garden—a distributed PV irrigation project. This is expected to have an effect on the structure of women's empowerment in Benin, West Africa for which they have been able to develop a 'methodology and set of practices that could be used to document women's empowerment more broadly, and to benchmark the empowerment impacts of different kinds of development projects, including those focused on energy and environment pathways (p 10).

Jobs

One of the important factors in any development intervention is whether more and better jobs are created, owing to the action taken. The same logic about job creation resulting from a given action also applies to the choice of competing energy systems. The past few years have seen the expansion of the renewable energy (RE) and energy efficiency (EE) market, largely driven by a combination of technological innovations and supportive policies for low carbon transition (van Vliet *et al* 2012, Kammen 2015, Chaturvedi 2016). Indeed, experience has revealed that for many developing countries addressing climate change independent of development co-benefits might not lead to policy interventions due to other competing domestic priorities. Featuring in this *focus issue*, Cantore *et al* (2017) argue that RE + EE programmes could help countries in decarbonizing their economies, but the higher upfront costs of the technologies created obstacles to short-term GDP growth. Their methodology confirms this tension, but reveals evidence about the positive impact of RE + EE in terms of creating employment opportunities. Taking the case of Africa, the analysis by Cantore *et al* shows that a low carbon power generation would lead to additional jobs, but with the potential trade-off in regards to the cost of electricity generation. One way to look at their analysis is the 'social dividend' of additional employment means 'lower costs of generation per additional employee'. The longer term trajectory of lower costs of renewables means that there is a potential that the 'greening' of the economy could favourably impact on all three pillars of sustainable development.

Energy planning for sustainable development

The energy system in developing countries is inherently complex. It comprises of demand-side issues ranging from heat for household cooking to heavy industrial heat and electricity; supply side issues from RE resources to liquid oil and gas resources; and distribution systems deployed to meet demand at different scales, involving centralized and decentralized systems. Hence, questions of energy access and energy security are ever present given the dual nature of the energy system in developing countries where the traditional and modern energy systems and practices co-exist (Sokona *et al* 2012). This duality is often dynamic with significant levels of inter-fuel substitution and fuel stacking to meet particular energy services.

Whilst energy system of course vary from one place to another, the globalized nature of markets for fuels and technologies, as well as how consumption patterns are distributed across space, creates major impacts and uncertainties on the energy security of the poor, oil-importing countries. It implies that today's energy planners in poor countries must strive to balance and manage several conflicting factors, including the impact of a changing climate on the energy system itself. At the most fundamental level, energy planners would need to balance energy needs and energy supply within the confines of country visions, political space and any possible changes in the external environment.

Increasingly, the importance and inter-connectedness of an equitable and just energy access, energy security and climate change are becoming mainstream agendas that need to feature in national energy planning. Additional criteria and issues may also exist that speak to particular country contexts. For example, despite its large and growing population (over a billion), human settlements in parts of Africa are sparse, with about 60% still living in non-urban areas (UNAGECC 2010). This social and economic reality, along with the rapid reduction of the cost of RE technologies and low per-capita energy consumption, many parts of rural Africa have the ideal setting for energy development based on distributed generation such as stand-alone systems and mini-grids (Szabó *et al* 2013). To date, the integration of rural energy needs and their development agendas into energy planning has been limited, in part, by a lack of planning tools with the capability to accommodate the issues and energy options of rural communities. However, there is a recognition among policy makers that 'failing to plan is planning to fail', and so planning the future direction of the energy system needs to embrace all options and scales. There is also a growing community of planners and modellers, supported by new breakthroughs in IT technology and planning tools, who are developing decision support tools to help decision and policy makers to plan for sustainable rural electrification options while reducing energy poverty.

Two interesting and complementary papers are featured in this *focus issue*. The first by Mentis *et al* (2017) presents results of a geographical information system (OnSSET) approach, coupled with open access data on sub-Saharan Africa. The paper presents least-cost electrification strategies on a country-by-country basis, taking into account an array of options: grid extension, mini-grid and stand-alone systems for various settlement types and loads. The second paper by Moksnes *et al* (2017) takes Kenya as an example to develop two electricity demand scenarios, using two modelling tools, OnSSET and OSeMOSYS. The two scenarios represent high and low end-user consumption goals. In these two papers, similar conclusions are reached in that low demand scenario can be associated with high penetration of stand-alone systems, whereas increasing end-user consumption leads to a higher level of penetration of mini-grid and grid extension technologies.

On the whole, the premise of an effective planning process is recognizing that the energy sector does not operate in isolation. Infrastructure for meeting water, energy and transport are interdependent and thus policy makers would need to embrace a systems thinking in delivering services. Hence, the future of the energy system needs to be developed with the range of investment shaping risks and uncertainties in mind. Traditional energy planning however has focused on finding only the least-cost generating alternative. But with the diverse range of resource options and a dynamic, complex and uncertain future facing the network infrastructures such as the electricity industry, reliance on least-cost planning methods alone may not be sufficient, and the use of additional criteria dimensions may be necessary (Awerbuch 2006, Vithayasricharoen 2012). More than ever, planners in developing countries need to embrace and embed uncertainty and complexity in order to add robustness into their models. This will also require them to build their capability and the capacity of their institutions so they have some degree of control and ownership of the knowledge systems and the tools and models that are developed for the country or region.

Conclusion

To a large extent, the contributions to the *focus issue* on 'Energy Access for Sustainable Development' have addressed some of the knowledge gaps in the field, notably deepening the understanding of access and links to SDGs; challenges related to cooking; multiple benefits of electrification; and energy planning for sustainable development. The set of articles that constitute the Special Issue will remain a valuable store of knowledge and reference material to support the attainment of the SDGs by many countries, with the expansion of energy access playing a major role.

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