SMART VILLAGES
New thinking for off-grid communities worldwide

The Smart Villages Initiative: Interim Review of Findings

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Smart Villages

We aim to provide policymakers, donors, and development agencies concerned with rural energy access with new insights on the real barriers to energy access in villages in developing countries—technological, financial and political—and how they can be overcome. We have chosen to focus on remote off-grid villages, where local solutions (home- or institution-based systems and mini-grids) are both more realistic and cheaper than national grid extension. Our concern is to ensure that energy access results in development and the creation of 'smart villages' in which many of the benefits of life in modern societies are available to rural communities.

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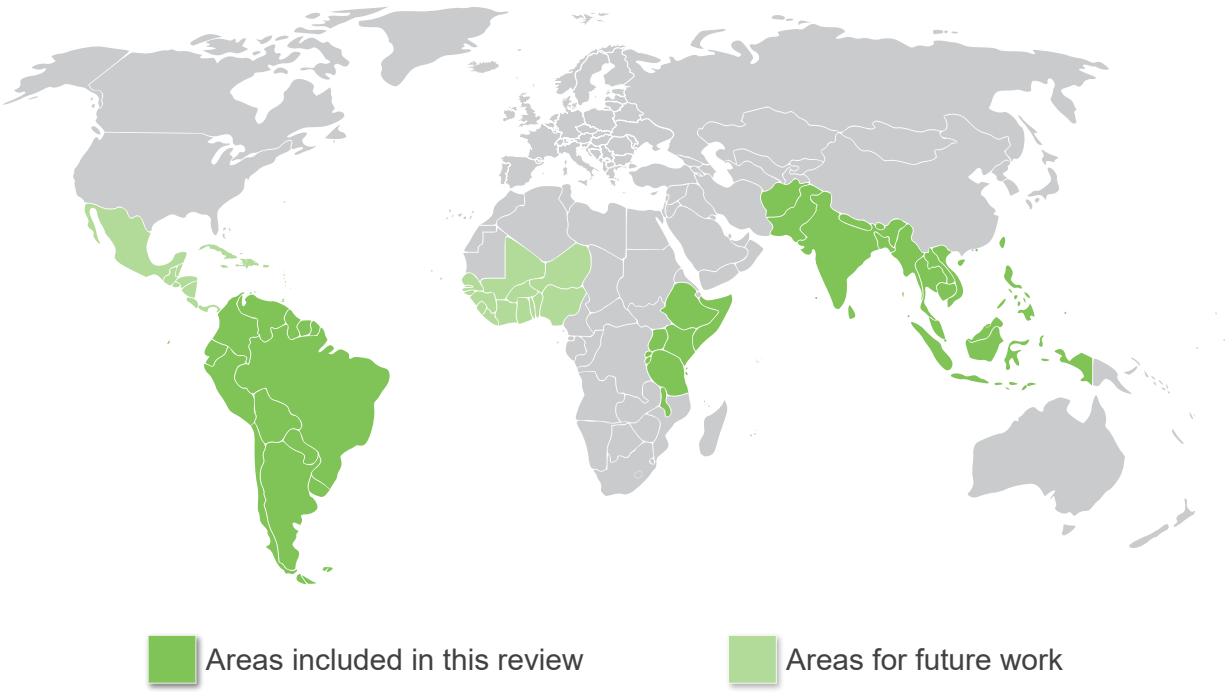
Summary

This report summarises the findings and recommendations arising from the engagement activities of the Smart Villages Initiative in East Africa, South and Southeast Asia, and South America over the first 18-month period of the current phase of the initiative. Over that period, workshops and other engagement activities have involved over 600 frontline workers and researchers in discussions to identify the barriers to the provision of sustainable energy services to rural communities and to assess how those barriers can be overcome.

Some of the arising issues are specific to home-based or village-level approaches to energy services and to cooking: specific sections of the report are dedicated to each of these three areas. Other issues are cross-cutting—in particular, access to affordable finance, support to entrepreneurs, capacity building, creating awareness, gender and age, and giveaways—and are covered in a separate section.

While achieving Sustainable Development Goal 7 on ensuring "access to affordable, reliable, sustainable and modern energy for all" is a central concern of the Smart Villages Initiative, energy access is a necessary precursor to most of the other Sustainable Development Goals. These broader connections are discussed and implications for development support are outlined.



1. Introduction

The Smart Villages Initiative brings together key players—entrepreneurs, scientists and engineers, villagers, NGOs, financiers, civil society and development organisations, policymakers, and regulators—from the frontline of delivering off-grid energy for development to rural communities in order to identify current barriers and how they can be overcome. Findings and recommendations from engagement events in six regions of the developing world (East and West Africa, South and Southeast Asia, South and Central America) will be synthesised and communicated to the policy and development communities to inform the creation of more effective policies and interventions. The ultimate aim is to enable the development of smart villages as a rural analogue to smart cities, providing villagers the opportunity to lead fulfilling and prosperous lives.

Following a three-year scoping phase from 2011 to 2014, the current three-year phase of the Smart Villages Initiative commenced in September 2014. This report provides a mid-phase summary of the findings from the engagement events held during the first 18 months: an up-to-date view from the frontline to inform policymakers, development organisations, and other stakeholders, and to help identify key questions and issues that will be addressed in the second half of the current phase.

Fifteen workshops have been held across East Africa, South and Southeast Asia, and South America, and also at the University of Cambridge in the United Kingdom. These workshops have brought together over 600 frontline players and researchers in stimulating and insightful discussions over the 18-month period. As reflected in this report, many of these discussions have focused on the challenges of bringing sustainable energy services to rural communities. Over the next 18 months, the focus of discussions will shift increasingly to how those energy services can be used to enhance the welfare of villagers and to establish smart villages providing key services (education, healthcare, clean water and sanitation, etc.) and increased incomes through productive enterprises, and which are resilient to natural, social, and economic shocks.

The off-grid energy systems evaluated by the Smart Villages Initiative include pico solar, solar home systems, mini-grids, and cookstoves. Several issues have emerged that relate to all technologies, which are summarised in the next section. Sections 3 and 4 then look in turn at issues specific to home-based electricity systems (pico solar and solar home systems) and to mini-grids. Section 5 summarises findings to date on cookstoves.

The Smart Villages Initiative is concerned with facilitating the delivery of the Sustainable Development Goals—not only Goal 7 on energy access, but most of the other goals for which energy access is a critical enabler. Section 6 therefore summarises findings relating to the Sustainable Development Goals that are not covered in the preceding sections. Finally, Section 7 sets out some considerations for national and international programmes that support energy access and the achievement of the Sustainable Development Goals.

2. Cross-cutting issues

Several issues are common to pico solar, solar home systems, cookstoves, and mini-grids:

- Access to affordable finance
- Support to entrepreneurs
- Capacity building
- Creating awareness
- Gender and age
- Giveaways

Findings are summarised in the ensuing paragraphs. Where related issues are relevant more specifically to pico solar, solar home systems, cookstoves, or mini-grids, they are covered in sections 3-5.

Access to affordable finance

The difficulties faced by companies in accessing affordable finance were a consistent message across the countries and regions covered by the workshops so far. Given the need for a major ramp up in finance (by a factor of 10 or more) if 2030 energy access targets are to be met, this is a key concern. For companies developing mini-grids, financing is needed for the initial capital cost of the schemes, whereas companies distributing pico-solar lights and solar home systems need working capital. The latter companies often seek to lower householders' upfront costs through "pay-as-you-go" or "pay-for-service" business models. However, this model transfers the capital cost burden to the companies.

Maasai women inhabitants of Magadi-Kajiado County in Kenya are trained in solar panel installation. They use donkeys to haul their solar wares from home to home in the remote region, giving families their first access to clean and reliable power.

Many companies are unable to demonstrate a successful track record for implementing commercially viable mini-grids or to provide data to show the reliability of pay-as-you-go / pay-for-service customer payment streams for pico solar or solar home systems. This lack of a track record and data results in high perceived risk in the finance community and consequently high interest rates. This problem of perceived risk is exacerbated by the banking sector's lack of familiarity with off-grid energy. Government or donor support may best take the form of some form of credit guarantee making private sector funds more available and enabling interest rates to be reduced. Governments also need to provide stable and supportive policy and regulatory environments to attract private sector capital.

Transaction costs are too high for companies seeking financing to implement projects and to expand, distracting them from their "day jobs" of establishing and meeting the needs of customers and growing their businesses. This applies to access to carbon funds as well as to private sector capital. Mechanisms are needed to reduce these transaction costs, for example, by bundling small projects.

Support to entrepreneurs

Discussions at the workshops and responses to the entrepreneurial competitions run by the Smart Villages Initiative point to the valuable contribution that can be made by bottom-up innovations driven by local people in meeting needs for energy services. Where local entrepreneurs are key players in delivering energy services, as most notably seen in East Africa, it is useful for governments and development agencies to invest in business incubation and advisory support services. For example, in Rwanda, the government has set up a "one-stop shop" to provide advice to entrepreneurs initiating energy projects.

Governments should establish supportive policy and regulatory environments that simplify licensing frameworks, cut red tape, and provide sufficient breathing space in respect of taxation regimes for businesses to get off the ground. Advice may usefully also be given on opportunities for services and products that have been successful elsewhere.

Capacity building

A consistent message in all the workshops has been that a lack of skills (technical and business) and institutional capacity continue to be major impediments to progressing energy access and ensuring the sustainability of energy schemes. Systematic analyses of all the stages in value chains are needed to identify shortfalls in skills and capacity. Training programmes should be put in place to fill the gaps: they may need to be ongoing activities rather than one-off events.

In respect of installation, operation, and maintenance of energy technologies, training is needed at all levels from local technicians, to engineers, product designers, and university researchers. In parallel, training is needed for local entrepreneurs in how to run a successful business, for the financial community to familiarise them with the issues associated with off-grid energy schemes, and for government institutions to build capacity in policymaking and regulation. Government ministries responsible for education and training, business development, and innovation should collaborate with energy ministries.

Creating awareness

In all regions, there is an ongoing need for initiatives to increase villagers' awareness of the available off-grid technologies and of their benefits and how to use them. Also, villagers need to be made aware of the arising opportunities for productive enterprises and increasing the productivity of their existing activities.

It is appropriate to harness the media and marketing techniques and to target keystone actors in communities. "Seeing is believing"—there is a strong demonstration effect—and successful pilots and examples of smart villages should be promoted to snowball success through replication and imitation.

Gender and age

Men and women tend to prioritise energy uses differently, so both need to be involved when communities are approached regarding energy initiatives and in subsequent decisions. The case was made in several workshops that women have a better appreciation of energy needs within the home. Women's groups have also played a critical role in the success of energy projects in regions such as Southeast Asia and Melanesia.

Initiatives like "Barefoot Grannies" and "Wonder Women" in Indonesia demonstrate the potential of women to be local entrepreneurs who promote and sell energy technologies. They are well-connected and trusted in the community and able to develop a good rapport with other women. Such entrepreneurial roles enhance the position of women in rural communities: as individuals increasing their income, providing them with new skills and increasing their self-esteem; in the family, increasing their financial contribution and ownership of assets leading to more say in family decision-making; and in the community, offering higher levels of participation and influence.

It is important, too, to engage young people in the villages given their distinctive needs and aspirations. An aim of development and energy access initiatives should be to provide sufficient opportunities in rural communities that young people choose to remain there. Both women and younger generations can play transformative roles.

Giveaways

Many examples were given where the free distribution of pico-solar lights and solar home systems had "spoilt the market", undermining the business activities of local entrepreneurs and creating an entitlement mentality that jeopardises the prospects of future commercial initiatives. Also, if villagers are given something for free they tend not to value it, and it usually falls into disuse.

The view was expressed in the Myanmar and Peru workshops that the ability and willingness of households to pay is often underestimated. The focus should be on the long-term sustainability of household energy initiatives—free handouts should be avoided.

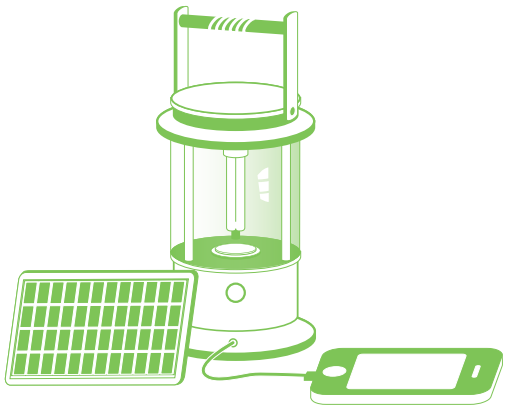
3. Solar home systems and pico-solar lights

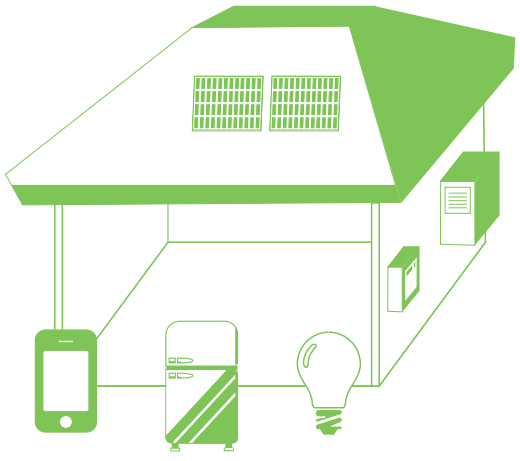
The performance and affordability of solar home systems and pico-solar lights have made major advances over the last five years or so. Consequently, in many countries, they now represent an attractive opportunity to provide a basic level of electricity services to households, generating savings compared to non-electrified technologies such as candles and kerosene lamps. In reality, they offer a better level of supply than an unreliable grid connection. Key factors in this progress have been:

- Substantial reductions in the cost of solar panels
- Major improvements in the efficiency of appliances, for example LEDs for lighting and efficient direct current (DC) fans, radios, televisions, etc.
- Business models that get around the problem of the upfront costs of equipment through pay-as-you-go or pay-for-services approaches, often making use of mobile phone connectivity and/or mobile payment systems

In South America, these developments have resulted in what are termed "third generation" solar home systems that require one-third the amount of power of older systems to provide a given level of electricity services, resulting in cost reductions of 30–50%. Their weight has been reduced from 50 kg to 6 kg, making the devices more portable, and they are much easier to install. Also, particularly in East Africa, commercial companies are offering "energy escalator" approaches in which households can readily move to higher energy systems when they have paid off their current system.

Currently, pico-solar lights and solar home systems mainly provide improved living conditions for households through better quality lighting, improved physical comfort (fans), more convenient and cheaper mobile phone charging, and home entertainment (radios and TVs). Through making light available in the evenings, they provide some limited opportunities to increase the output of domestic enterprises by extending working hours, while higher-end solar home systems





can power electric sewing machines and food-making equipment, opening up new possibilities for domestic enterprises.

Looking ahead, as solar home systems become more powerful and affordable, and with improvements in energy efficiency and availability of DC equipment, a wider range of productive enterprises will come within the ambit of solar home systems. It would be helpful to conduct a 5- to 10-year look ahead to explore the potential for village level enterprises based on domestic solar home systems.

In some countries in **East Africa**, pico-solar lights and solar home systems are making rapid progress driven by commercial companies. Companies such as Offgrid Electric, MKopa and Azuri are each adding around 10,000 new customers per month. But there are a number of constraints to a further acceleration in their rollout of home-based electricity systems:

- The limited availability of affordable working capital discussed above: the companies carry the capital cost of the equipment—typically US$250-500 for a solar home system—which rapidly adds up to substantial amounts when customer volumes increase rapidly
- The time and effort required to build reliable distribution networks for remote communities and to provide effective after sales service in respect of operation and maintenance
- The need to establish the required skill base in respect of both technical and business capacities

However, this success has not yet been replicated across sub-Saharan Africa. For example, in Rwanda, we were informed by the Ministry of Infrastructure that it considered that the market-based approach to disseminating solar home-based systems is not working: less than 1,000 units are sold each month. Further investigation of the differentiating factors across sub-Saharan African countries would help to identify the framework conditions that need to be put in place in those countries that have not yet benefited from the deployment of home-based electricity systems through a market-based approach.

In other regions, **Bangladesh** stands out, given that 4 million solar home systems have been deployed mainly through a scheme run by the Infrastructure Development Company Ltd. (IDCOL), a government-owned financial institution. Key factors behind the success of this government-led scheme were identified as:

- IDCOL has established a group of stakeholders with a real sense of ownership of the scheme.
- Subsidised finance is provided to the partner organisations that deploy solar home systems to rural communities.
- Households repay system costs in instalments.
- There are effective technical standards and quality assurance: a committee has been established to license products and ensure that only they may be used within the scheme.
- Effective technical support is provided to the operation and maintenance of the systems: all households are given the telephone number of a call centre where they can report problems.

However, problems remain, and there has been a proliferation of systems deployed outside of the scheme that are cheaper (attractive to poor families who cannot afford the IDCOL scheme systems) but have attendant quality problems.

Experience in East Africa and Bangladesh indicates that both top-down, government-led and bottom-up, commercially-driven approaches can work. Looking beyond East Africa and Bangladesh, in **other countries in South and Southeast Asia, and South America** covered by the workshops, so far a more mixed picture emerges. Generally, NGOs and governments play a more active role in the dissemination of pico-solar lights and solar home systems than in East Africa. Initiatives range from free distribution (critiqued above), to subsidies at various levels, to fully commercial. Where subsidies have been provided, a recurrent concern is how to establish an exit strategy. The rate of progress is less than in the East African countries discussed above and in Bangladesh.

Several other problems are evident in relation to access to affordable working capital, establishing distribution chains and supporting operation and maintenance, and building the necessary skill base, as identified above for East Africa. Access to affordable financing is needed at all stages of the value chain. Effective distribution chains require the building of confidence and trust through face-to-face interaction and establishing ecosystems of suppliers, spare parts, etc. And establishing an effective and financially viable system to support the ongoing operation and maintenance of systems is crucial to their long-term sustainability. It is remarkable how many initiatives have failed on this point.

The technical training of local people in the maintenance of systems is essential, and householders need to be educated in how to operate the system to avoid recurrent problems of overloading, battery misuse, etc. Availability of spare parts is often a problem, and there were calls for more standardisation of components to facilitate procurement and stocking.

In all countries, there is a major problem with **poor quality and counterfeit products**. This undermines customer confidence and can spoil the market for home-based systems. National governments need to set and vigorously enforce quality standards, establishing the required institutional infrastructure and testing facilities. And there were calls for international action to stem the flow of counterfeit and poor-quality goods. Reliable hallmarking is needed at the customer level, and there is ongoing value in initiatives to educate householders in the issues around cost and quality. Governments may exert influence through taxation regimes as, for example, in Pakistan where import duties are only exempted on equipment that meets quality standards.

Where dissemination schemes are government-led, governments have more scope to control the quality of systems. For example, in Bangladesh, the IDCOL scheme only distributes solar home systems that have been certified by its quality control committee. However, governments may lack the institutional capacity to police and enforce standards.

Additional uncertainties faced by organisations deploying pico-solar lights and solar home systems are the lack of clear plans for the extension of electricity grids and the difficulties in discerning householders' willingness or ability to pay. Governments and electricity companies need to provide clear forward planning of grid extensions. Surveys and market testing can provide a better fix on the prices that can be charged for home-based systems: schemes need to be established to enable the effective sharing of such information by the private sector, governments, and NGOs.

Looking ahead, new business models were mooted, for example, where the marketing focus shifts to the services provided by domestic appliances (lighting, cooling, TV, and radio, etc.) and the emphasis shifts to sales of

domestic appliances. The solar home system, as the enabling technology, becomes part of a broader package. In this scenario, white goods manufacturers may be drawn into the market. Also, making use of the established distribution networks of domestic products and services companies is potentially attractive but may not be straightforward, and, consequently, some innovative thinking is needed.

Necessary technical developments, requiring research and development and effective interaction between the research community and enterprises disseminating home-based solar systems include the following:

- Batteries were consistently identified as the weak link in solar home systems and can account for half their cost. They have made rather limited progress in recent years in comparison to solar panels. Some significant potential advances are in train that need to be actively pursued and brought to market as soon as possible.

- The environmental impacts of redundant equipment from pico-solar lights and solar home systems is of increasing concern, particularly in respect of batteries, which may need to be replaced after just two or three years. Systems and system components need to be designed to be recyclable or reusable.

- "Plug and play" technologies provide for easier and more reliable installations. But while some progress has been made, further developments are required.

- Balancing supply and demand through the day, and avoiding overloading of circuits and components, requires improved control systems.

- To further reduce system costs, R&D on new solar PV technologies such as printable organic solar cells holds the prospect of significant further improvements and should be actively pursued.

- Just as important are further developments in appliances to increase their efficiency, reduce their costs, and improve their capability to operate with intermittent electricity supplies. Forward look workshops have identified the significant headroom that exists for further improvements, for example, in refrigeration, water pumping, and electric motors to drive mechanical applications such as grinding and milling.

Technology development and manufacturing within developing countries brings added value and should be supported.

Linking together clusters of houses (typically 10 to 30) with DC connections ("DC nano-grids"), either with a central solar panel or with solar panels on each house, can provide opportunities for load sharing and can be more cost-effective for villages of an appropriate size. Advanced control systems are needed with intelligent metering to support variable charging through the day: to the extent that battery storage can be avoided, electricity services can be provided significantly more cheaply.

Such DC-based routes to electrification may become affordable more quickly than AC mini-grids and may progressively be able to support a wider range of applications. While concerns were expressed about "AC lockout" (i.e., not being able to use AC appliances), the relative future roles of AC mini-grids and DC solar home systems/nano-grids are not yet clear. Further research is needed to help elucidate the issues.

4. Mini-grids

In contrast to pico-solar lights and solar home systems, mini-grids comprising a central power source and a distribution network providing electricity to a village or cluster of villages have made rather limited progress. Exceptions identified in the workshops include the micro-hydro mini-grids installed in mountainous regions in Nepal and Pakistan and the jungle interior of Malaysian Borneo and the diesel-based mini-grids found in many islands in Southeast Asia and the Pacific. In most cases, these systems have been made possible through subsidies of one form or another.

In general, mini-grids cost more than the revenues that they can generate through electricity sales. While there have been many pilots, there is as yet little evidence of significant scale up through commercial or semi-commercial schemes. To "balance the books" in future schemes, costs need to be reduced and/or revenues increased.

On the cost side, we may expect that future scientific and technical developments (particularly for solar panels and batteries) together with economies of scale should continue to reduce the cost of mini-grids. Improved control systems and intelligent metering should also contribute to reducing costs through enabling more kilowatt hours to be extracted from a given capital investment: load factors are important. Reducing the cost of capital will be just as important (as discussed under cross-cutting issues above).

Costs to households may also be reduced if anchor loads can be established that can absorb a significant part of the capital and operating cost of the system. Schools and health centres may constitute such anchor loads, and several governments have established initiatives to achieve 100% electricity coverage for such institutions. Alternatively, commercial and industrial facilities such as mobile phone

masts, mines, and biomass processing facilities (for example, palm oil plants) may provide the anchor. In all cases, careful consideration needs to be given to who is responsible for the operation and maintenance of the system: it may not be appropriate to distract headmasters and doctors from their main tasks, and operators of commercial and industrial facilities may well have other priorities.

On the revenue side, limits may be set on what can be charged, either by a government requirement to match grid-connected rates in urban areas or by the ability or willingness of villagers in poor rural communities to pay. With regard to matching grid-connected rates, electricity provision to remote rural communities typically costs more than grid-connected electricity for urban areas. Governments may effectively lock out mini-grid development by private companies, unless they are prepared to provide subsidies. Such subsidies may well prove to be prohibitive, particularly if they relate to the operation and maintenance costs of the mini-grid rather than just to the upfront capital cost. A lower limit on affordability may be set by avoided costs for kerosene and candles.

In order for villagers to pay more, new money must be brought into the village. Stimulating new productive enterprises and increases in the productivity of existing enterprises was identified in many workshops as a key to the long-term financial sustainability of mini-grids. The stimulation of such enterprises requires an integrated approach in which market barriers are identified and requisite investments in infrastructure such as information and communication technology, roads, etc. are made.

Often, the viability of mini-grids is challenged because only a relatively small proportion of households connect. If connection charges are the barrier to greater penetration, then governments may appropriately consider well-targeted subsidies to meet connection costs. Also, charging schemes need to be enforced and a strong line taken on disconnection if households do not pay: for example, in Tonga, electricity connections and metering are located outside the house so that disconnections can readily be made if necessary.

Other key factors in enabling progress on mini-grids include policy and regulation, national grid extension planning, and community engagement. To attract private sector involvement, governments need to put in place a stable and supportive policy and regulatory environment. Mini-grids should be put on a par with grid extension, and there should be clarity on the framework conditions in which they will operate. Sufficient safeguards need to be in place to provide the private sector with the confidence to invest, not least covering the arrangements that will apply if and when the national grid arrives. Licensing frameworks should be simplified.

National grid connections to villages can become very political: politicians make vote-winning promises, which may or may not be delivered after an election. A consistent message was that there needs to be a national grid extension master plan based on sound analysis of which rural communities can most appropriately be served by national grid extension and which by off-grid solutions. National grid and off-grid planning should be better integrated.

Perhaps one of the strongest and most consistent messages from the workshops was the need for off-grid energy initiatives to be founded on close and extensive community engagement to ensure the support of villagers and so that the development path and energy schemes can benefit from, and build on, local knowledge, cultures, and customs. Villagers should retain control of their development path and should be the main drivers of energy initiatives. In the absence of such engagement and buy in, energy initiatives are likely to fail.

Such engagement takes time—typically at least 18 months—and needs to build trusting relationships, potentially by working through individuals and organisations that are already trusted by the community. The effort required should not be underestimated: we heard various formulations along the lines of projects being "70% social/30% technical". While village chiefs and elders will play an important role, and it is appropriate to identify and nurture champions within the village, care should be taken that there is a voice for the poorest and marginalised within the village, not just the powerful.

Communities should have a stake in energy initiatives, possibly through "sweat equity", for example, by providing labour for the construction of a micro-hydro scheme, or by providing some part of the initial capital investment. While there are some examples of mini-grids being run effectively by village committees, for example, micro-hydro schemes in Pakistan, on balance, the view was that villagers tend to lack the necessary business skills and discipline. Hybrid models were proposed involving community ownership and private sector management.

With regard to technologies for mini-grids, micro-hydro schemes often provide the most cost-effective approach if there is sufficient hydrostatic potential and a reliable source of flowing water (but seasonality of rainfall exacerbated by climate change can be problematic). However, there is a premium on flexibility to respond to future electricity demands, which can be difficult to predict and for which modular systems such as solar PV generation are better suited. Hybridisation of existing diesel-based mini-grids, often by adding solar PV generation, is an increasingly popular route, particularly on remote islands.

Reflecting on the relative contributions of home-based and village-based systems, workshop participants promoted the idea of a "hub and spoke" model in which mini-grids would power larger villages where productive enterprises and institutions such as schools and health centres would be based, and solar home systems would be used for more dispersed communities in surrounding areas. Over time, we may expect a dynamic interaction between the evolution of the distribution of settlement and the characteristics of technologies supplying energy services.

5. Cooking

So far, just one workshop has focused exclusively on cooking and improved cookstoves—in Myanmar looking at cookstove dissemination issues in Southeast Asia—though the issue has been considered at each of the workshops. Key drivers for the adoption of improved cookstoves include reduction in environmental impacts (deforestation and climate change), social benefits (less time needed to collect biomass and women's lower exposure to dangers while doing so), and reduced health risks due to exposure to smoke and fumes (but noting that many improved cookstoves do not provide substantial advantages on this dimension).

Findings from the Myanmar workshop may be summarised as follows:

1. **Addressing user needs and cultures:** The use of cookstoves is driven by socio-cultural factors: the adoption of improved cookstoves at the household level is not purely a technical issue. The designs of improved cookstoves and programmes to disseminate them should be tailored to local cooking habits and be cognisant of other functions such as providing light and repelling insects, otherwise their adoption and sustained use will be limited.

2. **Pricing and financing:** Across Southeast Asia, most rural consumers are very cost-conscious; therefore, improved cookstoves need to be priced so that they are affordable. Furthermore, stakeholders involved in cookstove dissemination programmes should develop financing mechanisms to support the uptake of improved cookstoves. Such financing mechanisms should be available throughout the value chain: actors at each stage need to be able to establish viable business models.

3. **Subsidies:** If cookstoves are given for free to households, there may be a lack of ownership and, consequently, sustained use, so well-targeted partial subsidies or financing schemes to overcome the up-front cost hurdle are preferred. Government support could also be in the form of reduced duties on the import of manufacturing machinery and materials that are not available locally.

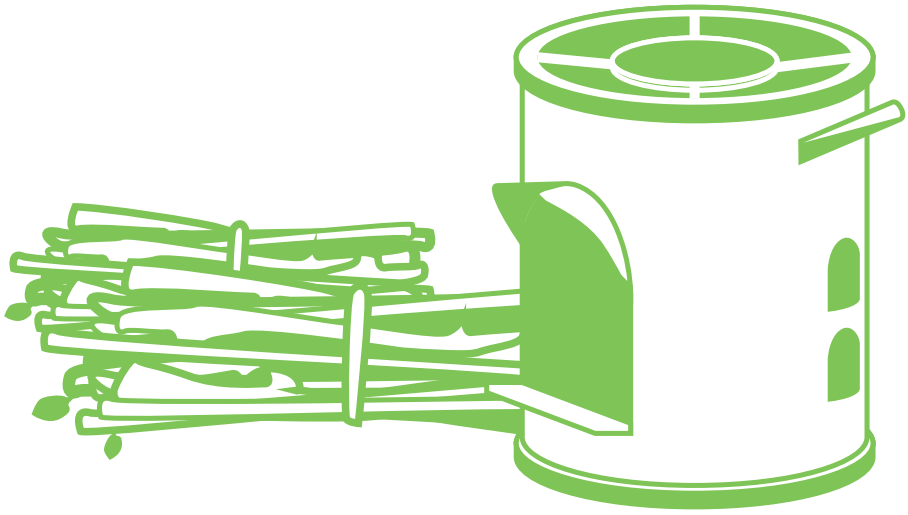
4. **Increasing awareness:** Householders lack awareness of the benefits of adopting improved cookstoves, so governments and donors should continue to invest in public awareness projects for householders to understand the health, environmental, and social benefits of using them. More research is needed in order to build a body of evidence about the positive effects of improved cookstove adoption, requiring collaborative projects between academia and other stakeholders.

5. **Gender issues:** In many cases, improved cookstove dissemination programmes are not targeted primarily at women, who have the main responsibility for cooking within the household and are most at risk from indoor air pollution. While this is changing, more needs to be done to engage women in order to ensure sustained adoption of improved cookstoves. Women's voices should be brought to the fore, and women's groups and unions can play a key role.

6 **Product quality:** Most traditional cookstoves, especially in rural areas, are produced either by households themselves or by artisanal producers. There are concerns about the quality of these cookstoves and their efficiency. Programmes aimed at developing the improved cookstoves value chain should provide technical support and training to producers to help improve product quality. Ensuring uniform quality of the product is likely to have a positive impact on the uptake of improved cookstoves.

7 **Support to businesses:** Local cookstove manufacturers should be provided with managerial support in order to develop their business expertise as many of them do not have the managerial capability to develop systems that can support the growth of successful enterprises. Sustained and long-term support is also required to develop local stove-building expertise. Support needs to be provided to actors across the value chain, like wholesalers and retailers, to incentivise them to stock improved cookstoves and promote their use by consumers. Informal social networks can play an important role in such promotion.

8 **Standards:** While there has been progress in developing standards and testing facilities for cookstoves, more needs to be done. Such standards are necessary to ensure the quality of products so that consumers have an idea of the performance of the products that they buy. These standards would also help to ensure that there is evidence of their benefits to present to local and international stakeholders, not least to support access to carbon credits and results-based financing. Testing methodologies need to recognise potential differences between performance in the laboratory and the home and that the quality of manufactured products may deteriorate over time, requiring repeat testing and accreditation.



6. The Sustainable Development Goals

The preceding text has focused particularly on how to achieve Sustainable Development Goal 7: "Ensure access to affordable, reliable, sustainable and modern energy for all". A key point made, though, is that the long-term viability of energy services for rural communities depends on catalysing new productive enterprises and income-generating opportunities in villages, providing a direct link to other Sustainable Development Goals such as Goal 1 on ending poverty and Goal 8 on inclusive economic growth and productive employment. Similarly, ensuring the active participation of women in the provision and use of energy services has been identified as a key enabler of energy schemes linking directly to Goal 5 on gender equality and empowerment. Linkages can similarly be found to most of the other Sustainable Development Goals.

Goal 7 is silent on the level of energy services that would constitute achievement of the energy access goal. A consistent concern in the workshops has been that energy access initiatives often take a minimalist approach, providing only for basic domestic services and doing little to support productive enterprises (for example, in Pakistan, the point was made that making light available only extends women's working hours). In the workshop in Nepal, participants called for a paradigm shift, moving from off-grid energy for lighting to energy schemes that support key services and new income generating opportunities. A higher level of ambition in the provision of energy services is needed (as reflected also in the contribution of Bazilian and Pielke[1]) if smart villages are to be achieved and provide a genuine opportunity for rural communities to have a 2030 quality of life consistent with the Sustainable Development Goals.

A point made repeatedly across all countries and regions was the **need for integration** between energy access initiatives and initiatives on, and investment in, productive enterprises if development goals are to be achieved. Energy access does not automatically lead to development and to the creation of productive enterprises. Such integration still tends to exist more in theory than in practice, though there are some notable exceptions. In Nepal, the Government's Alternative Energy Promotion Centre supports the establishment of productive enterprises in rural communities alongside supporting energy access schemes, and in Chile, the government and NGOs support community productivity for poverty alleviation through providing energy and water pumping facilities to increase agricultural productivity.

Associated investments are needed to connect to markets (in particular, information and communication technologies and transport), and affordable finance needs to be available to support the means of production (for example, at the domestic level, sewing machines, food mixers, and bread bakers, and at that the SME/village cooperative level, grinding equipment, welding tools, refrigerators, water pumps, etc.). Villagers should be made aware of successful income-generating enterprises that have resulted from energy access in similar contexts and be trained in how to set up and run the businesses (for example, in Bolivia, training on running homestays for tourists in the mountains). Otherwise, energy access may enhance living conditions and support a wider range of leisure activities but not lead to new or more effective productive enterprises.

Energy should be provided in sufficient quantity and quality to support the desired set of income generation activities. A point

1 Bazilian, M. and Pielke, R., 2013, 'Making energy access meaningful', Issues in Science and Technology, Summer 2013. bit.ly/1IUCJVM

made in the regional workshop held in Peru was that energy services and productive enterprises in villages constitute a complex system, and that it is not a straight road from energy access to productive enterprises, increased incomes, and poverty alleviation.

Goal 17 to "Strengthen the means of implementation and revitalise the global partnership for sustainable development", includes a target (17.16) to enhance global and multi-stakeholder partnerships to support the achievement of the Sustainable Development Goals. In this context, an important point made in countries where several donor organisations and development agencies are active (for example, in East Africa and in Pakistan) was that there is little coordination, indeed in some cases there is apparent competition, between those organisations. Also, collaboration with the national government may be limited. This leads to duplication, gaps, and missed opportunities for synergies. It is unhelpful to the intended beneficiaries on the frontline who are distracted from their core activities to deliver energy for development by endless and time-consuming rounds of grant calls and application processes, often providing relatively small sums of money for a lot of effort. Mechanisms need to be put in place to enable better collaboration between donor organisations and development agencies.

The value of sharing information between different stakeholder communities and between countries and regions was repeatedly stressed. This information needs to cover failures (and the reasons why) as well as successes and good practices. Otherwise, governments, development organisations, and NGOs are prone to cover up failures and repeat mistakes. It should include the experiences of developed as well as developing countries. There is much value in the kinds of engagement events run by the Smart Villages Initiative, and there were calls for information portals to encourage collaborative learning between communities. Academia can undertake a useful independent review function.

Workshops in East Africa, Southeast Asia, and Latin America all pointed to the value of collaboration between university researchers and frontline organisations delivering energy access on the ground. With regard to the capacity building element of Goal 17 (17.9), more could usefully be done to build the capacity of universities in developing countries to work effectively with entrepreneurs on real-life technical challenges. Also, international research programmes and research networks that bring together developed and developing world researchers are valuable—for example, the African Network for Solar Energy (www.ansole.org), a collaboration of researchers from African and non-African countries.

Goal 17's concerns with data, monitoring, accountability, and development of measures of progress of sustainable development (17.19) were echoed in workshops, which pointed to the need for methodologies and measures to evaluate the development outcomes resulting from energy access. Organisations delivering energy access initiatives are increasingly being asked by donors for evidence of development impacts from proposed projects which they have difficulty in providing. All energy access projects should have built-in measures and evaluation schemes of their impacts.

7. Considerations for development support

Following the ratification of the Sustainable Development Goals (SDGs) in September 2015, governments and development organisations are reviewing their development policies and initiatives with a view to delivering the SDGs. Such reviews are being undertaken by the European Union and its member states.

The SDGs are to be achieved by 2030—just 14 years away. Rates of delivery of energy access will need to be substantially increased compared to those achieved over the last 14 years. For Goal 7 on energy access, this will be a major challenge given the tenfold ramp up needed in investment, the moving target presented by population increases in developing countries, and the time and effort required at the village level for essential engagement activities necessary to pave the way for sustainable energy interventions. Recognising that energy access is a necessary precursor for achieving many other SDGs, time pressures are further exacerbated by the time lags inherent in achieving social benefits and increased incomes as a result of energy access.

Going forward, time will therefore be of the essence, and a central consideration of development interventions will need to be their capability to make things happen quickly, including the scale up of successful pilots and business models. Herein lies a dilemma, as this might otherwise point to a top-down, "one size fits all" approach in the interests of efficiency and replication. However, past experience tells us that this does not work. Rather, bottom-up approaches need to be cultivated that are capable of responding to the differentiated needs of village communities. The ability to act local will be key, building successful energy interventions and consequent development benefits through face-to-face interactions, community ownership, and the development of trusting relationships.

Local entrepreneurs, and the private sector more generally, will need to play a leading role. To date, many governments have been slow to establish an environment that enables the private sector to contribute effectively to energy access. A key concern for governments and development organisations will be to provide entrepreneurs with the framework conditions and support that will enable them to grow their businesses fast and that protect against ill-judged development interventions that undermine business viability.

Minimising transaction costs, while providing sufficient protection against the misuse of development funds, must be a central concern. For governmental and intergovernmental development organisations, this means finding an efficient and effective way of supporting tens of thousands of village-level projects rather than a few large centrally-planned electricity supply projects, perhaps through establishing appropriate intermediary organisations.

More importantly, transaction costs should be viewed through the eyes of a local entrepreneur in a developing country. She will need streamlined procedures for licensing, etc. and mechanisms to access funds that do not divert undue attention from her "day job" of growing her business. A particular concern is the need for better collaboration between governmental development organisations, a long-standing aim, for example, of the European Union's development policies, but which has not yet been achieved in terms of the experience of local organisations seeking development support. More generally, establishing conducive framework conditions needs take the transaction costs of other key players in value chains into account, not least the banking sector that might otherwise baulk at financing a plethora of small-scale projects in remote locations in a sector with which they are not familiar.

Development initiatives can also play an important role in establishing other necessary framework conditions that will provide for the rapid expansion of off-grid energy. These include facilitating access to affordable capital (potentially through risk mitigation measures), building skills and capacity, providing business incubation and advisory services, raising awareness, creating public goods such as maps of the availability of renewable energy resources, and supporting research and development. Particular priorities for technical developments have been identified in the preceding sections. More research is needed on the social issues associated with the effective provision and use of energy services at the village level. A general need is to build capacity for effective collaboration between organisations providing frontline energy services and university researchers.

Mechanisms should be put in place to enable fast learning, enabling rapid communication of what works, what does not, and why. This information should be shared between actors in a particular market, between countries, between the frontline and development organisations, etc.

Policy coherence at the country level is essential but often lacking. Energy access initiatives need to be integrated with other development initiatives if benefits are to be maximised, requiring governmental ministries in countries receiving aid to work closely together, and development organisations to avoid silos within their operating structures. Hard choices may need to be made between competing policies and principles. For example, a choice may need to be made between equality of opportunity and therefore electricity tariffs between urban and rural areas versus the commercial viability of off-grid projects. Similarly, schemes that provide for a limited dissemination of free or heavily subsidised energy technologies may cut across attempts to facilitate the development of a private sector which provides energy services on commercial terms that are more sustainable in the long term. Development organisations may usefully work with national governments with a view to overcoming such difficulties and establishing coherent, supportive policy frameworks.

8. Conclusions

The workshops and engagement events held by the Smart Villages Initiative to date have provided useful insights on the barriers to sustainable provision of energy services to rural communities and how those barriers may be overcome. Discussions within the workshops have begun to explore how energy access can act as a catalyst for development, supporting the provision of essential social services and the establishment of productive enterprises. These issues will be a particular focus for workshops and engagement events in the second half of the current phase of the Smart Villages Initiative.

The concept of "smart villages" has been enthusiastically supported by the frontline players with whom we have interacted. It provides an appropriately ambitious and integrating vision, helping to bring together the various development strands which otherwise may not be sufficiently joined up.

Annex 1: Smart Villages workshops reviewed in this report

Please follow the links below for further information about each workshop reviewed and to download relevant workshop reports and policy briefs.

East Africa

First East Africa regional workshop
Arusha, Tanzania, June 2014
bit.ly/1VS68t9

East Africa media dialogue workshop
Kigali, Rwanda, November 2014
bit.ly/1TweYZy

East Africa community leaders' dialogue workshop
Terrat, Tanzania, August 2015
bit.ly/1YTqOhX

Concluding high-level workshop for East Africa engagement
Kigali, Rwanda, September 2015
bit.ly/1QA688B

Southeast Asia

First Southeast Asia regional workshop
Kuching, Malaysia, January 2015
bit.ly/1VS664C

Southeast Asia media dialogue workshop
Seoul, South Korea, September 2015
bit.ly/242AAoN

Energy for off-grid islands
Bunaken island, Indonesia, November 2015
bit.ly/235VhKM

Sustainable dissemination of improved cookstoves: lessons from Southeast Asia
Yangon, Myanmar, December 2015
bit.ly/235Vei9

South Asia

Smart Villages in Nepal
Kathmandu, Nepal, April 2015
bit.ly/1VS5ZpE

Smart Villages in Bangladesh
Dhaka, Bangladesh, August 2015
bit.ly/1XW2kV8

Smart Villages in Pakistan
Islamabad, October 2015
bit.ly/1SrPOML

South America

First South America regional workshop
Lima, Peru, January 2016
bit.ly/1WSxZbz

University of Cambridge

First Forward Look workshop: New technologies for off-grid villages – a look ahead
January 2014
bit.ly/26tECFJ

Second Forward Look workshop: Potential breakthroughs in the use of energy in off-grid villages
December 2015
bit.ly/1T4jYle

Business and financial models
January 2016
bit.ly/1NSOYDB

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SMART VILLAGES

New thinking for off-grid communities worldwide

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