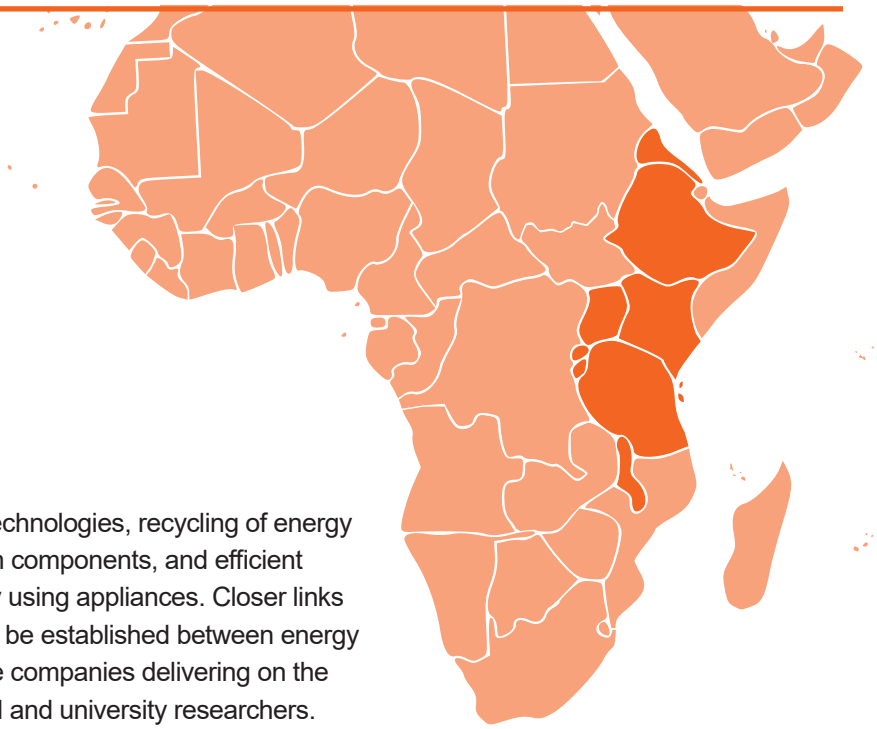
SMART VILLAGES
New thinking for off-grid communities worldwide

BRIEFING
No. 7

September 2015

Lessons Learned from the Smart Villages Engagement Programme in East Africa



Summary

This policy brief summarises the findings and recommendations arising from a 15 month programme of engagement in East Africa, commencing in June 2014, undertaken by the Smart Villages Initiative to identify the barriers to off-grid sustainable energy access for development in rural communities and to gather views on how those barriers can be overcome. It provides an up-to-date view from front-line practitioners and is intended to inform policy makers, development agencies and other stakeholders concerned with upcoming processes to establish and deliver the Sustainable Development Goals.

With regard to **access to appropriate technologies**, a key concern is to continue to reduce costs while improving mechanisms for quality control, essential to eliminate poor quality products from the market. Batteries remain a weak link and should be the focus of international research and development efforts. While affordable and reliable technologies are necessary, the focus of energy access initiatives should be on the services and development benefits enabled by energy access.

Important areas for **research and development** include the development of improved control systems, 'plug and play' technologies, recycling of energy system components, and efficient energy using appliances. Closer links should be established between energy service companies delivering on the ground and university researchers.

In order to achieve the substantially higher rates of **investment in energy infrastructure** needed to meet the Sustainable Development Goals, governments should put in place policy and regulatory frameworks which provide confidence to the private sector to invest. They should also ensure that entrepreneurs can access working capital to expand their businesses and upfront investment capital at affordable rates. Mechanisms need to be put in place to enable village-level energy projects to access international climate funds. Governments should support home-grown businesses by reducing red tape, by creating sufficient breathing space to get businesses off the ground, and by providing business incubation and advisory services.

Improved collaboration is needed between funders, and there is much benefit from sharing of information and experiences between countries. More attention is needed to capacity building based on systematic analysis of the knowledge and skills required to implement and maintain energy services. There should be an emphasis on vocational training for local technicians.

There is widespread support for the concept of smart villages and a view that national champions could usefully be established to promote them. The Smart Villages Initiative should do more to develop and publicise case studies of smart villages as inspiration to other rural communities.

Introduction

This policy brief summarises the findings of a 15 month programme of engagement activities in East Africa undertaken by the Smart Villages Initiative to identify remaining barriers to off-grid electricity provision for development and how those barriers can be overcome[1]. It has been prepared by the Smart Villages project team to inform the positions of East African governments and other stakeholders in the UN Summit on the Sustainable Development Goals to be held in New York in September 2015, and to support the major national and international efforts that will be required to achieve the goals once they have been adopted.

In order to maximise the development benefits of energy access, actions to establish electricity services in rural communities need to be integrated with other development initiatives. The Smart Villages concept provides that integrating mechanism: in smart villages access to sustainable energy services acts as a catalyst for development, enabling the provision of good education and healthcare, access to clean water, sanitation and nutrition, the growth of productive enterprises to boost incomes, and enhanced resilience, gender equality and democratic engagement[2].

The Smart Villages Initiative began its engagement in East Africa with a major international workshop in Arusha, Tanzania[3] in June 2014 which brought together a diverse cross-section of 'front-line' players from across the region to share their experiences of challenges and solutions for off-grid rural electricity.

Subsequently (August 2015), a group of community leaders and local champions from villages and initiatives in Ethiopia, Kenya, Malawi, Rwanda, Tanzania and Uganda met in Terrat in the Maasai region of Tanzania to discuss their development pathways towards becoming smart villages and to identify key enabling factors and required interventions.

A competition has been run for young East African entrepreneurs (current and recent university students) which attracted proposals for novel approaches to off-grid energy from nearly 100 teams. And further workshops have been run in Uganda in collaboration with the African network of national science academies (NASAC), and for science journalists in Kigali, Rwanda. Also in Rwanda, a research programme has been initiated to monitor and evaluate the development benefits anticipated to flow from a mini-grid currently being installed in the village of Rubagabaga in Western Province.

Inputs have been made to conferences on recycling and on mini-grids in Kenya, on information and communication technologies in Rwanda, and on rural electrification in Malawi: all of which have provided useful learning points reflected in this brief. The brief also draws on reviews of other studies and reports on electricity provision in Sub-Saharan Africa, and where appropriate, on information derived from the engagement activities of the Smart Villages Initiative in Southeast and South Asia.

A synthesis workshop was held in Kigali, Rwanda on 8th September 2015 in collaboration with MININFRA, the Rwandan Government Ministry of Infrastructure. The workshop brought together over 40 government representatives and other key stakeholders from across the region to share information on progress and remaining challenges, and to reflect on lessons learned.

This brief summarises the views of the broad range of people and organisations that have been involved in the Smart Villages Initiative's engagement programme in East Africa over the last 15 months. It synthesises their experiences on the 'front line' in East Africa of delivering sustainable energy services to catalyse development in rural communities and their considerations on how to enable further progress in coming years.

The policy context

The Sustainable Development Goals expand on the Millennium Development Goals which they will replace from January 2016. 17 goals and 169 associated targets have been established[4] and it is anticipated that they will be adopted, substantially in their present form, at the UN summit in New York, on 25-27 September 2015. They are intended to frame sustainable development agendas and political policies of all UN member states for the next 15 years to 2030. Indicators are being developed to measure progress towards achievement of the goals and targets, and are expected to be agreed by Spring 2016.

> *"In smart villages access to sustainable energy services acts as a catalyst for development*

Unlike the Millennium Development Goals, the Sustainable Development Goals include a goal (7), with three associated targets, focusing specifically on ensuring 'access to affordable, reliable, sustainable and modern energy for all'. But equally important is a recognition that sustainable energy access and use is linked to all the other goals, and is a necessary precursor to achieving many of them, for example in respect of poverty, food security, improved health and education, clean water and sanitation, economic growth etc.

While the Sustainable Development Goals have been generally welcomed, some concerns have been expressed that they may be prone to a 'silo-approach' which fails to recognise potential interactions between activities to achieve individual targets and which misses synergistic opportunities that could be identified through taking an integrated approach informed by a more holistic systems perspective. This is particularly important in respect of energy access and use given the close integration with other goals and targets. Similarly, critiques have pointed to the absence of an overall narrative which explains how the goals will lead to broad outcomes for people and the planet[5].

The Smart Villages concept provides such an overall narrative for rural communities, and the proposed approach, integrating energy access with other development initiatives, will help address concerns about needing to avoid fragmentation of efforts into silos.

The three targets for goal 7 on energy appropriately reflect those driving the Sustainable Energy for All Initiative[6], though the dilution of target 7.2 from a doubling of the share of renewable energy to 'increase substantially' is potentially something of a retrograde step. For target 7.1, on ensuring universal energy access, care needs to be taken to **ensure that an appropriate level of ambition is set which goes beyond minimal levels of energy access in order to enable communities to benefit from the full range of energy services**. The global tracking framework established by the Sustainable Energy for All initiative provides an appropriate multi-tiered framework in this respect[7].

Going forward, care also has to be taken to **ensure that all dimensions of energy access and use are addressed**. For example, over 4 million people die each year due to inhalation of smoke and fumes from kerosene lamps and dirty cookstoves: addressing this major killer (which accounts for more deaths than from malaria, aids and tuberculosis combined) must be an important component of the global endeavour to deliver the Sustainable Development Goals. And **taking the Sustainable Development Goals as a whole, more emphasis should be placed on tackling rural poverty and development**: just under half of the world's population and 70% of the world's poor live in the countryside.

The energy context

In Sub-Saharan Africa over half the population - some 600 million people - lack access to modern energy. It is estimated that power shortages diminish the region's growth by 2–4% a year[8]. Total electricity generating capacity in Sub-Saharan Africa, excluding South Africa, is just 45GW, corresponding to an average annual per capita electricity consumption of 162 kWh, i.e. just 2% of the world average of 7000 kWh. The 138 million households living on less than US$ 2.5 per person per day pay the equivalent of US$ 10/kWh on lighting, nearly 100 times the price paid by a typical resident of the United States and Europe. The annual shortfall in financing to meet demand and to achieve universal access to electricity in Sub-Saharan Africa is around US$ 55 billion over the period to 2030 (3.4% of Africa's GDP in 2013).

As illustrated in Table 1 below, despite migration to cities the majority of people in East African countries continue to live in the countryside. Rates of access to electricity for rural populations remain very low, and are lower than for Sub-Saharan Africa as a whole. Despite robust economic growth in recent years (6% in 2014[9]), East African countries remain classified as Least Developed Countries. As such, they should benefit from the 'special attention' and 'focussed and scaled-up assistance' identified in the SDGs[10]

Country/ Region	Rural Population (% of total)	Access to Electricity (% of population)	Access to Electricity (% rural population)	Access to Electricity (% urban population)
Burundi	88	6.5	1.2	58.5
Eritrea	78	36	12	100
Ethiopia	81	27	7.6	100
Kenya	75	23	6.7	58.2
Rwanda	72	18	7.7	61.5
Malawi	84	9.8	2	37
Tanzania	69	15.3	3.6	46.4
Uganda	84	18.2	8.1	71.2
Sub-Saharan Africa (except South Africa)	61	37	18	66

Table 1: Access to electricity in East African countries[11]

Delivering the Sustainable Development Goals

The Smart Villages Initiative is focusing on actions necessary to achieve sustainable energy access in rural communities and consequently to catalyse development. Delivery of the Sustainable Development Goals (SDGs), in particular Goal 7 but also other goals and targets for which energy access is a necessary enabler, is therefore the Initiative's prime concern. The SDG text for adoption identifies two 'means of implementation targets' which focus primarily on **access to technologies, research and development, and investment in energy infrastructure:**

7.a
By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.

7.b
By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, land locked developing countries and small island developing States in accordance with their respective programmes of action.

In addition, Goal 17 sets out a cross-cutting agenda to strengthen the means of implementation of the SDGs. The following paragraphs summarise key findings under these four headings: technology, research and development, investment in energy infrastructure, and Goal 17.

Access to Technologies

With regard to technologies, the Smart Villages Initiative's engagement in East Africa has pointed to the ongoing **need for reductions in the costs of energy technologies for deployment in rural communities**. All renewable energy sources are anticipated to play a useful role (the choice – see Table 2 - depending on local circumstances), potentially in hybrid systems in combination with a diesel engine as one option to tackle the issue of intermittency of supply.

Pico-solar lighting solutions and solar home systems provide enhanced amenity and cost savings[12], and have reached a 'tipping point' in which sales are rapidly increasing on a commercial basis. For solar powered systems the cost of solar panels has reduced substantially in recent years, but similar progress has not been made for batteries which are a key component of both solar home systems and solar powered mini-grids: **improvements to batteries in respect of both cost and durability should be a key focus** going forward.

The durability of solar home systems and solar lights is an area of concern: poor quality and counterfeit appliances too often spoiling the market. **Enhanced mechanisms for quality control and systems for ratification of quality are needed** at national and international levels. Enforceable warranties and effective maintenance plans can also play a useful role in ensuring the reliable operation of appliances.

'Lighting Global' – a World Bank Group initiative – has established standards and certification systems for pico-solar technology, and is developing similar measures for solar home systems[13]. These are welcome developments but must be backed by adequately resourced enforcement mechanisms.

An 'energy escalator' approach to upgrading pico-solar lighting solutions and solar home systems, combined with breakthrough developments in low energy direct current (DC) domestic appliances, is bringing additional applications such as TVs, refrigerators and sewing machines into the reach of householders. Recently, DC nano-grids have emerged as a promising technology to bridge between home-based systems and village-level mini-grids. This is a fast-moving area and establishing the potential complementary roles of alternating and direct current systems/appliances and the various candidate scales for local electricity generation and distribution will benefit from international cooperation.

The economics of mini-grids are determined by a range of factors but generally some form of government or donor support continues to be required to achieve returns which are acceptable to potential investors[14]. Attention is needed to reducing the cost of mini-grids and to establishing effective business models to help bring them to a point where they can achieve commercial viability. Financial viability may be facilitated by engaging with, and the promotion of, local anchor customers such as agricultural processing units and mobile phone towers.

Procurement of mini-grids should have regard to life-cycle costs, not just up-front costs, and **pilot schemes should address the migration path to commercial applications**: hence private sector developers need to be actively engaged from the start. While mini-grids should be designed to meet the distinctive needs and circumstances of the communities they serve, an appropriate level of standardisation and modularisation can enable scale-up.

More generally, **the focus needs to be on the services and development benefits provided by energy access rather than the energy per se**. And while the Smart Villages Initiative's engagement in East Africa has concentrated primarily on electricity, improving technologies used for cooking remains a key issue, particularly for women and children. This is a concern of young people as reflected in the many entries to the Smart Villages Innovation Challenge which addressed cleaner cooking technologies, often proposing to use waste to generate biogas.

Technology	Generation capacity (kW)	Energy sources	Services available
Pico-solar lighting solution	0.001–0.01	Solar PV	Lighting, radio communication reception, two-way mobile communication
Stand-alone home systems	0.01–1	Hydro, wind, solar PV	Same as above plus additional lighting and communication, television, fans, limited motive and heat power
Mini-grids	1–1,000	Hydro, wind, solar PV, biomass; diesel; hybrid combinations	Same as above plus enhanced motive and heat power, and ability to power community-based services
Regional/National grid connection	1,000–1,000,000	Gas, hydro, wind, solar PV, biomass	Assuming high quality of connection, same as above up to a full range of electric power appliances, commercial and industrial applications

Table 2: Electrification technology options for smart villages[15]

Research and Development

In order to maximise the practical benefits derived from research and development, **closer links should be developed between university researchers and the SMEs implementing energy access on the ground.** Entrepreneurs at the Arusha workshop indicated that university research often does not address the practical technical issues they face, and innovations arising in universities need to be road-tested in rural communities. There should be more emphasis on applied research and getting researchers out into the field. International research collaborations can help the capacities of research teams in developing countries, and ensure that research focuses on practicable developments[16].

R&D on more efficient appliances for both domestic and business use, for example refrigerators, televisions, computers and sewing machines, is of equal importance to research on energy supply technologies: reducing the power demands of appliances provides more amenity for a given level of electricity supply. Recent experience indicates that the headroom for improvements in efficiencies is high: for example, replacing incandescent light bulbs with LEDs reduces power requirements from 40–100 W to 1–2 W, and standard televisions use 80–400 W whereas at least one television is now on the market requiring just 5 W.

Information and communication technologies, in particular the use of mobile telephones for pay-as-you-go access to home-based electricity systems and to monitor system performance, have played a key role in enabling breakthroughs in sales of home-based systems. Further developments are needed to reduce transaction costs and to enable an appropriate level of standardisation across systems.

Other areas in which further technology developments are needed **include improved control systems** enabling better matching of supply and demand for home- and village-based systems supplied by renewable energy, more easily used '**plug and play' technologies,** and upfront **consideration of environmental impacts** and design for recycling of energy system components.

Investment in Infrastructure

Mobilising the required levels of investment in energy infrastructure will be a major challenge (as indicated above, in Sub-Saharan Africa an additional US$ 55 billion is needed each year until 2030), and frameworks should be put in place to maximise the leverage from the private sector of financing from governments, international development funds, and donor communities. **Electrification strategies should make clear the complementary roles of grid-based and off-grid systems.**

Supportive and coherent policy and regulatory frameworks need to be established which set clear targets, establish systems to measure progress, and support the creation of local businesses. Representatives of such businesses made a plea for **less red tape** and some **breathing space** in relation to taxation regimes in order to get their businesses off the ground.

A particular concern is that **governments should establish well-founded long-term plans for national grid extension**, identifying which rural communities will gain grid access and on what timescales. Also, the commercial arrangements that will apply to mini-grids if and when the national grid arrives should be made available to developers when schemes are being formulated. Without this clarity private developers may be reluctant to invest.

In developing policies, regulatory frameworks and support schemes, governments and funders should consider how to support emerging enterprises which are well rooted in the communities in which they operate. Bottom-up innovations in rural communities need nurturing in order to reach maturity: **governments and donors should support business incubation and development, and advisory support services**[17].

A consistent message from organisations and individuals endeavouring to deliver rural energy services is that insufficient capital is available at affordable rates: interest rates for debt capital can range from 16–24 %, and are typically 20 %+ for equity capital[18]. Financing costs for

mini-grids can be punitive as lenders often perceive risks to be high (Table 3 identifies risks, stakeholders driving them and governance levels in electrification projects). **Support from funding bodies and governments is needed to de-risk investments sufficiently to bring interest rates down**. And while good progress is being made in rolling out pico-solar lighting systems and solar home systems, further acceleration of the rates of deployment (necessary to achieve energy access targets) is hindered by the lack of access to working capital for the SMEs spearheading progress so far.

Given the scale of the investment challenge, funding will be required from the full range of potential sources including the private sector, national governments, international development finance institutions, regional development banks, donors and civil society organisations. **More effective mechanisms need to be established to provide access to international climate funds for the development of off-grid village level energy services**. Socially oriented 'impact investors', which aim to solve social or environmental challenges by investing on sub-commercial terms while generating sufficient financial returns, and are therefore able to offer lower than commercial rates, may also play an important role[19]. Such impact investors may appropriately build a relationship with entrepreneurs similar to venture capital funders, in which they continue to support the entrepreneur as his or her business grows.

Public-private partnerships will play a key role in bringing together the necessary skills and resources, and partnerships should be extended to include the communities in which energy schemes are developed as community involvement and ownership are key to the success of energy access initiatives. Rural energy agencies have an important role to play in facilitating connections between key players. Also, more initiatives are needed (particularly from governments) to inform villagers of the costs and benefits of, and options for, modern energy access as reflected in the attention paid to these issues in the competition entries. A marketing orientation is appropriate, making use of modern communication channels including social media.

Looking more broadly to the catalytic role of energy access in enabling achievement of other Sustainable Development Goals, the Smart Villages Initiative's engagement in East Africa has confirmed that programmes for energy access should be integrated with other development initiatives, for example on healthcare, education and clean water/sanitation. Associated investments in productive enterprises – in the home (for example, sewing machines and food mixers) as well as in the community (for example, agricultural processing, carpentry and welding) – are essential for development and progression through levels of energy access. As well as enabling the creation of new local enterprises, there must be a focus on increasing the productivity of existing income generating activities, including agriculture. Financing schemes should be tuned to the seasonality of incomes through credit limits/overdraft allowances being made according to an agreed cash flow projection across the year.

Risk	Stakeholder	Governance level
Regulatory risk (permits, market access, power market regulation)	Public sector	National/(local)
Grid extension risk (arrival of main grid)	Electricity utility/grid operator/grid regulator	National/sub-national
Technology risk (quality of equipment and project planning)	Technology supplier/engineering contractor	International/national/(local)
Operations risk (operating and maintaining equipment)	Project developer	Local
Financing risk	Financial sector	National/International
Customer payment risk	Villagers	Local
Public acceptance risk	General Public	National/local

Table 3: Common risks in electrification projects, stakeholders driving these risks and their governance level[20]

"National champions for smart villages should be appointed in governments

Goal 17

Turning to Goal 17, the enabling framework for implementation, there are concerns over the confusing array of funding schemes and a feeling that funders sometimes seem to compete rather than to cooperate. **Frameworks to enable better cooperation between funders should be put in place in East African countries and for the region as a whole.**

The value of sharing of information and experiences is consistently stressed. Governments of East African countries could usefully do more to systematically discuss their approaches and share good practices, for example, the supportive policy and regulatory frameworks recently put in place by the Tanzanian Government, and the Rwanda Development Board set up by the Rwandan Government as a 'one-stop shop' which provides advice and support to entrepreneurs initiating energy projects. Similarly, there is value in sharing information and experiences across and between regions, as is being facilitated by the Smart Villages Initiative. **An information platform could usefully be created to support sharing of experience and information between all stakeholders**. Information-sharing is equally important on failed initiatives and successes, and needs to include analysis of why schemes have succeeded or failed.

Government and donor funding may appropriately support the creation of national datasets, for example maps of wind, solar and hydro potential, that are pre-requisites for entrepreneurs, but which they could not fund themselves.

Government and donor funding should focus on capacity building for all key actors, and enabling local people to do it for themselves rather than being continuing recipients of aid. More vocational training is needed in order to create the large cadre of artisans required to install and maintain off-grid energy systems as they scale-up in coming years. For all energy projects and initiatives there should be systematic analysis across all stages and actors to ensure that the necessary capacities, knowledge and skills are in place: training schemes should be established where there are gaps. There are too many failed projects and wasted resources: a manual should be prepared which focuses on the process of how to design projects to suit local circumstances.

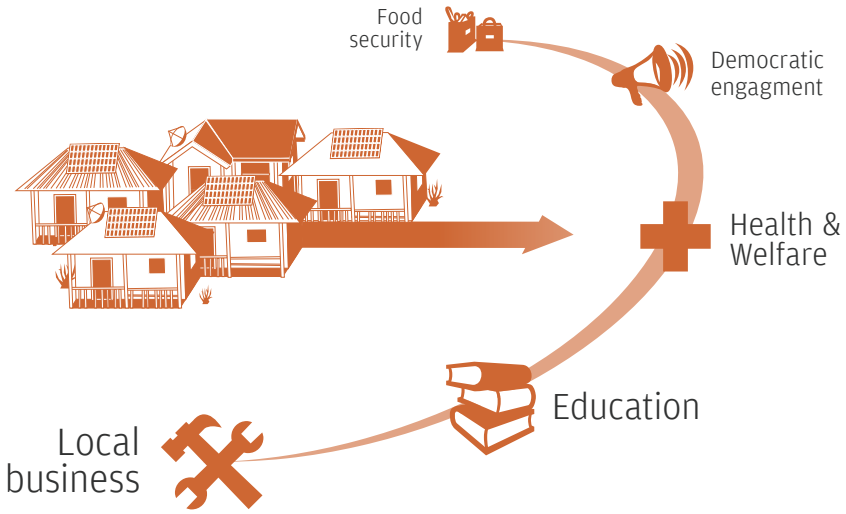
This policy brief has already reflected on the need to take a holistic approach to delivering the Sustainable Development Goals and has pointed to the value of the Smart Villages concept as an integrating mechanism. This value of the concept was supported by the people with whom the Smart Villages Initiative has engaged over the last 15 months who recommended that **case studies of smart villages should be publicised**: they will help to promote the concept and inspire communities to pursue this route. **And national champions for smart villages should be appointed in governments** to stimulate appropriate initiatives and ensure integration across government departments and agencies.

Community leaders and champions emphasised that the specific features of a smart village will depend strongly on context and should be driven from the bottom-up to reflect local needs and priorities. Those priorities for the development benefits intended to be catalysed by energy access include improved female and child health, employment and opportunity generation especially for young people and women through skill development and training, improving educational outcomes and standards, access to water resources, and increasing participation in agricultural value chains. Community engagement activities to guide energy access, and development initiatives more generally, should **ensure that the voices of women and youth are heard.** Their experiences and perspectives are valuable, and their empowerment should be an important outcome of development initiatives.

Monitoring Progress

Work continues to identify the **indicators** which will be used to monitor progress towards the targets and goals. The global indicator framework, to be developed by the Inter Agency and Expert Group on SDG Indicators, is planned to be agreed by the UN Statistical Commission by March 2016 and adopted thereafter by the Economic and Social Council and the General Assembly. The choice of indicators will have a strong influence on where the activities of states and resources are directed. They therefore need to be chosen carefully and to reflect the integrated nature of sustainable development, focusing attention on key outcomes. Therefore indicators relating to energy should monitor the intended development outcomes of energy access, such as improved education and healthcare, new opportunities for productive enterprises etc., as well as progress on energy per se.

More research is needed in order to develop and apply approaches to evaluate the outcomes of energy schemes in respect of development benefits, and to identify what works and why. The absence of evaluation systems is acting as a barrier to financiers supporting schemes.



Conclusions

The Smart Village Initiative's engagement programme in East Africa has been met with an enthusiastic response and has generated valuable and up-to-date insights from the frontline of delivering energy services to catalyse the development of rural communities. This brief for policy makers, development agencies and other stakeholders has endeavoured to summarise practical experiences of the barriers to providing village level energy services and how those barriers can be overcome.

Much has already been achieved in East Africa in respect of rural energy access, but progress needs to be accelerated if the Sustainable Development Goals are to be achieved by 2030. It is hoped that this policy brief, and the much larger body of evidence that underpins it (which has been made available on the Smart Villages website - www.e4sv.org), will inform future initiatives on rural energy access for development and consequently help to achieve the Sustainable Development Goals in East African countries.

Notes

1 The Smart Villages Initiative is focusing on rural communities that are sufficiently remote from the national electricity grid that local solutions – village-level mini-grids and individual systems for homes and establishments – are preferred over grid extension, Globally, the International Energy Agency has estimated that 70% of the new rural connections required to achieve universal energy access are best made in this way.

2 The 'vision paper' for smart villages is available at: www.e4sv.org/publication/a-vision-for-smart-villages/. A book of essays by leading experts has been published to elaborate on the various dimensions of smart villages: 'Smart Villages: new thinking for off-grid communities worldwide': www.e4sv.org/new-thinking

3 The presentations, workshop report and policy brief for the Arusha workshop are available at: www.e4sv.org/events/arusha-workshop/

4 'Transforming Our World: the 2030 Agenda for Sustainable Development'. Finalised text for adoption, 31 July 2015. https://sustainabledevelopment.un.org/post2015/transformingourworld

5 For example, ICSU and ISSC, 2015,'Review of targets for the Sustainable Development Goals: the science perspective': http://bit.ly/1MgpiEt

6 See: http://www.se4all.org/

7 SE4ALL Global Tracking Framework: http://www.worldbank.org/en/topic/energy/publication/Global-Tracking-Framework-Report

8 Figures in this paragraph taken from 'Power People Planet' by the Africa Progress Panel 2015: www.africaprogresspanel.org/Report-2015

9 Source: World Bank, 2015. 'World Development Indicators': http://databank.worldbank.org/data/

10 Paragraphs 16 and 22 of 'Transforming Our World: the 2030 Agenda for Sustainable Development'. Finalised text for adoption, 31 July 2015.

11 Source: World Bank, 2015. 'World Development Indicators': http://databank.worldbank.org/data/

12 For example, a study conducted in Kenya, Malawi and Tanzania by the charity SolarAid found that the purchase and use of a pico-solar lighting system led to an average saving of US$70 per year, averaged over three years. This equates to approximately 10% of the total income of a household living on US$2 per day. In Keane, J., 2014. 'Pico-solar electric systems: the Earthscan expert guide to the technology and emerging market'. London: Routledge.

13 Lighting Global, 2015. 'Lighting Global Quality Standards'. Version 5, March 2015. Washington D.C.: World Bank Group. http://bit.ly/1Q6nATN

14 Chapter 4 of RECP, 2014 ' Mini-grid policy toolkit' provides a good overview: http://euei-pdf.org/thematic-studies/mini-grid-policy-toolkit

15 Holmes and van Gevelt, 2015. 'Energy for development – the concept'. In 'Smart Villages: new thinking for off-grid communities worldwide': www.e4sv.org/new-thinking

16 For example the ANSOLE collaboration between researchers in Africa and the rest of the world on the development of solar technologies (www.ansole.org).

17 For example, supported by development programmes, GVEP International works with micro-enterprises to build their capacity and as a result strengthen the 'last mile' delivery chain for energy access: http://www.gvepinternational.org/en/business/micro-enterprise-support

18 RECP, 2014 ' Mini-grid policy toolkit' pages 54/55 (http://euei-pdf.org/thematic-studies/mini-grid-policy-toolkit)

19 For example the ERM Foundation Low Carbon Enterprise Fund which provides finance, technical and management support for small low carbon social enterprises in the developing world: http://www.ermfoundation-lcef.com/

20 Schmidt, T., 2015. 'Will private sector finance support off-grid energy?' In 'Smart Villages: new thinking for off-grid communities worldwide'. www.e4sv.org/new-thinking

Notes

The Smart Villages Initiative aims to provide policy makers, 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.

www.e4sv.org | info@e4sv.org | @e4SmartVillages

CMEDT – Smart Villages Initiative, c/o Trinity College, Cambridge, CB2 1TQ

The Smart Villages initiative is being funded by the Cambridge Malaysian Education and Development Trust (CMEDT) and through a grant from the Templeton World Charity Foundation (TWCF). The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the Cambridge Malaysian Education and Development Trust or the Templeton World Charity Foundation.