SMART VILLAGES
New thinking for off-grid communities worldwide

Smart villages workshop: Business models for off-grid electricity

Workshop Report 15

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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 of the Smart Villages Initiative's workshop on business and financial models held in Cambridge in January 2016. The workshop brought together 36 participants from academia, the private sector, NGOs, and the public sector to share their perspectives and experiences concerning business and financial models for home-based electricity services and decentralised mini-grids. Findings from the workshop will be incorporated into the Smart Villages Initiative's technical reports on business and financial models and recommendations shared with policymakers at national, regional, and international forums.

Participants from the private sector and NGOs discussed the successes of their business models in helping provide access to modern energy to remote, off-grid communities and the consequent socio-economic benefits that materialise. They also addressed the financial, logistical, and political barriers that must be overcome to achieve further scale and growth. Investors noted that there is a view that off-grid technologies represent an energy revolution in developing countries. In order for this to happen, significant debt-financed investment is required for what, despite the success of pioneer firms, are currently often considered unbankable business models. Representatives from the public sector and donor community explained their role in promoting innovation and facilitating market-based approaches, reducing risks and reaching the base of the pyramid, working with intermediaries, engaging with governments, and building the evidence base.

Discussion among participants highlighted three main points: that the entire range of technologies, business models and financing vehicles must be harnessed so that every customer and income bracket can be reached; the need for all stakeholders to work together and for government to play a coordinating role; and the recognition that energy is a means and not an end, and that a holistic vision of success can turn the energy access issue to being seen as an opportunity rather than a challenge.

Introduction

A multi-stakeholder workshop on business and financial models for home-based electricity services and decentralised mini-grids was hosted by the Smart Villages Initiative at Trinity College, Cambridge on 5 January 2016. The workshop involved 36 participants from academia, the private sector, NGOs, and the public sector to better understand the current state of business and financial models as well as what stakeholders must do to help ensure the provision of modern energy access for all. Investors, private and public sector representatives, NGOs, and academics shared their perspectives on business and financial models for home-based electricity services and decentralised mini-grids. This was contextualised both by the Smart Villages Initiative's technical report on business models for home based electricity services as well as presentations on business models in practice, the area of distributed manufacturing, and the situation of off-grid villages in China.

Workshop Proceedings

Smart Villages: setting the scene

Dr John Holmes and Dr Bernie Jones, Smart Villages Initiative

Bernie Jones summarised the rationale for the Smart Villages Initiative (in particular to support the achievement of the Sustainable Development Goals), its aims, and the main activities being undertaken over the three-year duration of the project. The Smart Villages Initiative focuses on sustainable local energy solutions for rural communities and aims to provide an insightful "view from the frontline" of the challenges of village energy provision for development and how they can be overcome.

A core component of the initiative is a series of six regional engagement programmes in Africa, Asia, and Latin America, which brings together the key frontline players in a series of events to consider the barriers to off grid energy and how those barriers can be overcome. The role of the Smart Villages team is then to convey the conclusions and recommendations of those events to policy-makers and development agencies.

Bernie Jones also outlined the concept of smart villages as a rural analogue to smart cities, recognising that nearly half the world's population and 70% of the world's poor live in rural communities. In a smart village, energy access along with modern information and communication technologies (ICT) act as catalysts for improved education and health services, to stimulate the development of new local enterprises, and to enable engagement in democratic processes. Consequently, more resilient communities better able to respond to shocks can be built.

John Holmes then summarised key findings of the initiative to date, in particular in respect of investment in energy infrastructure, research, and technology and supporting Sustainable Development Goal 17 on strengthening the means of implementation. In respect of investment in energy infrastructure, key elements of future strategies for energy access should seek to maximise leverage of public sector funding, establish supportive policy and regulatory frameworks, integrate energy access with other development initiatives, improve access to affordable finance, and create effective public-private-community partnerships.

With regard to research and technology, developments in technology and innovations in business models have expanded the range of accessible services and appliances at the household level and have substantially reduced costs. At this point, it is not clear what will be the relative contributions of electricity generation and provision at the level of the household, clusters of households, or the village: this is a dynamic and fast-changing area. Workshops have pointed to the need for more applied research and improved links between university researchers and local enterprises and have identified key focus areas for future research.

With regard to Sustainable Development Goal 17, there is a need for better collaboration between funders, and workshop participants have pointed to the value of sharing of information and experiences between countries and regions. There should be more focus on capacity building and approaches need to be developed to monitor and evaluate the development outcomes resulting from energy access.

Investment models for off-grid energy in developing countries

Mr Andrew Reicher, Berkeley Energy

Andrew Reicher gave an investor's perspective on business models for solar home systems. He indicated that technical improvements in the various components of solar home systems are leading to rapidly reducing costs, and innovations in business models not least by the use of mobile money, are making fully distributed energy for households and businesses a technically superior and lower-cost choice than the conventional grid model. Consequently, we have entered a revolutionary period and pay-as-you-go (PAYG) solar PV household systems are making rapid progress. The key constraint is building implementation capacity in the sector; access to finance is a secondary constraint, but his view is that as the skills develop, the money will follow.

The full economic cost of grid connection in the countryside is around US$3000 per customer upfront with continuing costs thereafter, and the service provided can often be poor. In contrast, solar home systems providing up to 100 W can be purchased for US$500, give essentially 100% reliability and incur no further costs. And the costs are coming down all the time.

To be successful in the sector, businesses need to have strong marketing to acquire customers, and this needs to be done face-to-face with each individual buyer at the grassroots. This essential aspect of achieving profitable growth is complex, expensive, and organisationally challenging. Also, companies need access to finance, in particular for working capital and overheads. This funding may most appropriately be considered as infrastructure financing. The amounts required get large very quickly as each installation may cost around US$250-500 and capital investment needs to be covered by the company in a PAYG model. Rather few companies have all the necessary skills and capabilities—technical, marketing, organisational, finance—to achieve scale and major financial success.

Venture equity from friends and family, business angels, and, in due course, institutional venture capital investors is needed, but there is generally plenty of it. Grants continue to be important to enable companies to get started and should be

From left to right: Mr Michael Nique (GSMA), Mr Andrew Reicher (Berkeley Energy), Dr Simon Bransfield-Garth (Azuri), Dr Terry van Gevelt (Smart Villages Initiative)

continued by development agencies, donors, and other actors. An important skill for early-stage companies is to be able to get grants from donor agencies and philanthropic institutions to combine with the equity they raise from their backers.

In order to grow and grow rapidly, PAYG companies need hundreds of millions of dollars of debt financing to cover the upfront costs of the equipment which is then recovered over time from end-users' regular payments. There is a major shortfall currently in this debt financing and a catch-22 that until there is extensive data showing the reliability of PAYG customer payment streams, debt for the upfront cost is not bankable without credit support from large, financially sound entities. To establish payment records you need debt, and no debt is possible without payment records. As things stand, far too much effort is required to put together relatively small amounts of financing, which diverts companies from the customer-facing activities that they need to undertake to drive growth.

Andrew Reicher expressed the opinion that the best way to solve this problem quickly is for the credit risk on the financing to be fully carried by concessional donor funds. Banks and mainstream investors are unlikely to take even partially uncovered risk until the data show that customers are statistically highly likely to pay. If donors do provide PAYG funding in this way, it should be on the basis that the payment records of the customers are collated and placed in the public domain to prove to the private sector that they can afford to lend without support.

Finally, he concluded that African governments should establish benign regulatory frameworks for the sector. Donors have a role in persuading them to do so. Such supportive frameworks are not about providing subsidies. Rather, they should ensure that there are no discriminatory VAT or import duties on the PAYG equipment, that there are no unnecessarily burdensome licensing and approval regimes, and that subsidies on kerosene for household lighting are phased out.

In the ensuing Q&A it was considered that, as yet, there is little venture capital available from African investors. The PAYG sector is now moving so quickly that governmental organisations such as NEPAD are behind the curve: this is a private sector story, under the radar and growing organically (companies such as Offgrid Electric, MKopa and Azuri are each adding around 10,000 new customers per month). Governments often consider that solar home systems provide a second-best approach to energy access: in reality, they provide a better service than is typically available from the grid. There is a danger that governments might seek to regulate the solar home systems market and may, consequently, strangle it.

Azuri's experience

Dr Simon Bransfield-Garth, Azuri

Simon Bransfield-Garth described the Azuri PAYG solar power model and recent developments in their business model and markets. Based around a solar home system product that can provide eight hours of home lighting and home mobile phone charging, and power a limited number of household appliances, the equipment has a low weekly cost (critically a cost that is below the typical weekly household expenditure on kerosene for lighting) that covers the cost of the equipment over an 18-month payback period.

The systems use mobile money to make these payments and also allow a degree of scale-up of equipment, so that while base-level entry systems provide basic lighting, mobile charging, and power for a radio, higher specification systems give additional applications from fans and ultra-bright lights, through entertainment equipment such as TVs, to the 100 W+ range where productive uses are possible. Azuri are

widely active in East Africa, and in South Africa and Zambia in Southern Africa, and Sierra Leone, Ghana and Togo in West Africa.

Statistics from Kenya, for example, show that without solar home systems, the average household expenditure per month on kerosene for lighting is around US$10, and the costs of a mobile phone charge is around US$0.20, resulting in a total monthly outlay of US$13. With an Azuri PAYG system, the one-off installation fee of US$10 and US$1.80 monthly top-up fee translate into a total spend of around US$8 per month for a superior level of light and mobile charging service. Responses to a questionnaire to Azuri customers in East Africa suggested that among the most popular uses of the savings made by using Azuri products were school fees, savings, and investment in entrepreneurial businesses. The research also indicated that the technology enabled the average customer to extend his or her productive day by up to three hours and that children spent an additional two hours per day on homework. In addition, there were health benefits from eliminating kerosene fumes and cutting fire risk.

The conclusions Azuri draw from their experience are that distributed power systems such as theirs can be more effective, practical, and reliable in rural off-grid areas than other options. They may act as a stepping stone to larger systems and grid-connection in some cases. Since the payback period is so short, the business case is stronger than those models that involve much larger capital costs and longer payback periods. They have also found that they are supplying an end-to-end service, including the necessary devices, as well as the power with which to operate them. Measuring power is also a misleading statistic, since 1 MWh, for example, can provide cooking for one house for a year, or TV for 25 houses, or lighting for 250 houses. The most important metric is the outcomes, not the enabling inputs.

SIM technology as a key enabler of businesses in the rural environment

Mr Michael Nique, GSMA

Mobile telecommunications coverage has become one of the predominant infrastructures in the world, having grown from under 40% of the Earth's population covered in 2000 to over 80% covered in 2015, outstripping the growth rate of electrification, clean water, and sanitation coverage and exceeding the actual number of people with access to clean water and improved sanitation. Several hundred million people in the world do not have access to clean water or sanitation but do have GSM (Global System for Mobile Communications) coverage. The GSM Association's (GSMA) theory of change is therefore to leverage "mobile" for energy, water, and sanitation access, and operate as a market facilitator and innovation laboratory to support development of the strategic and commercially viable products and services in these areas. Its work has been funded predominantly by the UK Government's Department for International Development (DfID) from 2013 to 2017.

There are five principal mobile channels for utilities access: machine to machine connectivity (embedded sensors in equipment and utilities infrastructure such as solar home systems that can send back usage, performance, and environmental data); mobile payment systems (like M-PESA in East Africa); mobile services—bidirectional communications platforms allowing exchange of critical utility systems information like maintenance and repair requests and system upgrade and remote operation; mobile infrastructure, such as using mobile transmission towers as anchor loads in community mini-grid infrastructures; and finally distribution networks, such as using mobile sales and payment collection agents to offer these and additional services. Of these, the two main channels are machine-to-machine connectivity and mobile payments. It is

the combination of these two channels that is responsible for the success of PAYG systems and instalment-payment business models in the off-grid energy sector in those areas where mobile banking is readily available and widely used.

More than 500,000 smart PAYG solar home systems have been installed (predominantly in East Africa) as a result of these technologies and MKOPA has become the second largest utility bill provider in Kenya.

Mobile money systems have become a critical part of mobile for development activities, facilitating the emergence of innovative business models, enabling unbanked customers to access utility services, improving the payment efficiency for traditional utility providers (such as water utilities), enabling payback of commercial or microfinance loan instruments in small instalments, allowing customers to establish a credit history, and enabling service providers to build customer repayment profiles and credit ratings for further product loans.

In turn, the commercial benefit for mobile network operators is the revenue generation from transaction fees on mobile money activities, evidence that access to utilities and regular payment behaviour results in an increase in subscribers' overall usage of their mobile money accounts, increases in airtime purchase and usage (resulting especially from the ability to charge mobiles in an off-grid context), an increase in brand loyalty among consumers, and unanticipated synergies such as mobile operators' agents accessing new underserved markets (such as off-grid) and improving financial literacy in these new consumer populations.

Out of 21 grantees in the second phase of GSMA projects, 16 are using some form of mobile payment model, showing a great deal of appetite in the service provider community for adopting this model. This serves as a positive indicator for those markets that have not yet adopted mobile money and mobile banking, indicating that it is only a matter of (lack of) availability that is responsible, and as soon as the concept is launched in the new markets, there will be considerable uptake and benefit. This will translate into benefit and greater uptake of the rural off-grid technology options that utilise mobile technology to help them succeed in the market.

Business models for home-based electricity services

Dr Terry van Gevelt, Smart Villages Initiative

Terry van Gevelt talked about the various business models that have emerged in recent years for the provision of home based electricity services. The home-based electricity services can be divided into two segments. For small-scale users, pico-solar lighting systems are available in the range of 0.1 W–10 W. The retail price of pico-solar lighting systems is in the range of US$6–100. There are also larger systems available that have been classified as solar home systems. These solar home systems have a capacity of 10 W–1000 W and are available at retail prices in the range of US$75–1000. In 2014, the home-based electricity market was estimated to be worth US$550 million and is dominated by "pioneer firms" like Azuri. Early-entrant multi-national corporations are facing difficulties in making inroads into off-grid rural areas, and they could expand their presence in the market through the acquisition of existing pioneer firms.

Terry van Gevelt also raised some of the issues faced by firms operating in the market segment. One of the most pressing issues is that of ensuring access to working capital. It is important to understand the local context and develop better distribution systems. Most companies working in this segment of the market have developed PAYG models, which help them keep transaction costs low.

Panel discussion

Chair: Mr James Cohen, Green Africa Power

Participants inquired about the challenges of distribution and the cost involved in developing financing intermediaries between manufacturers and consumers . Simon Bransfield-Garth from Azuri Technologies noted that the company is a quasi-leasing enterprise that combines both leasing and services. The PAYG business model highlights the possibilities unlocked due to increasing scale of the business. The off-grid business has a strong multiplier effect, and the demonstration effects across local communities are quite powerful.

Responding to questions about the role of the government, Simon Bransfield-Garth noted that the company tends to avoid dealing with the government as the public sector cannot keep up with the pace of innovations in the sector. While governments in some countries have been supportive of deploying off-grid electricity systems, this support has not translated into practical actions. It is important for governments to implement policies which reduce barriers to energy access. A stable regulatory and tariff system is necessary to attract private capital. Terry van Gevelt highlighted the example of Rwanda where changes in government policies have prompted private investors to stop work on a micro-hydro based mini-gird which aimed to supply excess electricity to the national grid.

Howard Alper noted the importance of engaging with the government to ensure success of off-grid energy projects. This engagement could be in the form of lobbying to reduce subsidies on polluting fuels like kerosene. Participants also queried about the problems of accessing long-term financing for off-grid projects. Andrew Reicher responded that for commercial investors it is important to ensure that ventures make commercial sense. Accessing capital is a challenge which is further magnified because of the fragmented aid and financial markets across developing countries.

New business models – EKOCENTERS and EKOCOALITION

Mr Derk Hendriksen, Coca-Cola Company

Derk Hendriksen opened his presentation by observing how the private sector seems to have been missing in the discussions on rural development and energy access and that there is a need for companies like Coca-Cola to be seen as part of the solution. Coca-Cola has been a part of efforts to develop golden triangle partnerships which include stakeholders from the government, private sector and civil society. The company has been keenly interested in ensuring the sustainability of its operations and is expected to be water neutral by 2020. Coca-Cola also aims to ensure the empowerment of five million women across the value chain.

Coca-Cola partnered with Solar Kiosk, a German company, to develop solar powered Ekocenters that serve as outlets providing a wide range of services aimed at improving living conditions and livelihoods in off-grid rural areas, especially of rural women. The Solar Kiosk is envisaged as a social enterprise that is a one-stop shop for high quality products and services including: solar products, fast-moving-consumer-goods, technology products, medicines, and tools. These kiosks provide important services to the local community such as mobile phone charging facilities, internet access, and clean water.

More than 80 Ekocenters have been installed in seven different countries, located primarily in Africa, and they have empowered 450 women who are working in them. The centres have provided 50 million litres of clean drinking water to communities, which have consequently seen a marked reduction in waterborne diseases. They have a combined installed generation capacity of 250 kWh.

Coca-Cola along with other companies like Ericsson and Philips partnered to develop

Mr Derk Hendriksen, Coca-Cola Company

services in Ruhunda, Rwanda, an off-grid area that highlights the development partnerships within the private sector. Coca-Cola aims to develop a coalition of partners for the project and to ensure that it is technology neutral so that the most suitable technology is deployed according to the individual community / country context.

Responding to questions about the impact of government regulations on the implementation of Ekocenters, Derk Hendriksen observed that the project has been quite successful in a number of different countries, including in those countries where there are strict regulations, like Rwanda. The project aims to learn from the different realities in different countries, and these lessons are economic as well as social. The aim is to foster community relationships and develop partnerships. The Ekocenter initiative can be seen as occupying the space between commercial investor and angel investor. When queried about the development of the supply chain for the Solar Kiosk Derk Hendriksen replied that Solar Kiosk has established in-country warehouses to ensure the quality of products is maintained.

Building inclusive businesses; new ideas

Mr Sam Parker, Shell Foundation

Sam Parker introduced the concept behind the Shell Foundation: it is a charity registered in the UK that focuses on mobility, energy, and SME finance. They invest in early-stage startup companies that need support with their business models and capacity building and in ideas that other investors are not ready to fund. They find that there is a dearth of early stage equity with US$5-10 million being necessary to bring early-stage companies to the next stage.

The Shell Foundation operates according to a process model. The first stage consists of identifying a disruptive innovation and a pilot phase. The second stage looks to scale up and demonstrate that operational costs can be covered. Lastly, the focus is on development of the wider industry into maturity through, for example, investment in infrastructure and tackling market barriers.

Sam Parker emphasised that seed-stage companies need impact investors. For this reason, the Shell Foundation decided to develop an incubator, Factor E, based at Colorado State University in

the United States. Factor E has incubated a range of technologies. The estimated success rate is that for every ten incubated early-stage company, one will be highly successful. An example of this is Envirofit, which is now a fully commercial company. Focusing on clean cookstoves, it has 2,500 employees and an expected total production of five million clean cookstoves by 2018. Despite its success, Sam Parker urged the need for further market development through a small number of well-managed companies to bring the cookstove industry into maturity.

Areas of interest to the Shell Foundation include energy efficient appliances, innovations in cold chain storage and sustainable wood production.

Financial models for mini-grids in developing countries

Prof. Subhes Bhattacharyya,
De Montfort University

Subhes Bhattacharyya began his talk by focusing on the financial viability of mini-grids. They must strike a balance between their investment, operating, and fuel costs and the capital and credit available to them through subsidies and grants, tariffs and other charges, and supplier and user credits. Mini-grids are also always constrained by income-side issues, including tariff constraints, differential pricing strategies, and income-side constraints.

In terms of tariff constraints, affordability is a crucial factor. The upper limit is often set by consumers' spending on alternative fuels. Kerosene is often substituted, for example. A differential pricing strategy, on the other hand, is challenging because in most cases, the rates charged for each household remain similar, particularly when it is a lighting-only service. The possibility of subsidising some households by charging some more than others is usually not possible at a political level.

Carbon credits are limited by transaction costs, which make them mainly appropriate for large or aggregated projects. Some companies generate by-products, like biomass, which can generate some income, but most do not have this advantage.

The expense-side drivers include the aforementioned costs, such as the cost of the investment, operations, and fuel, as well as other factors, including geographical remoteness and upkeep costs (e.g. equipment, components and batteries). The cost of capital is a fundamental factor in any mini-grid's success.

To give examples of the different approaches to financing mini-grids, Subhes Bhattacharyya offered five different scenarios: mini-grids that were state funded, donor funded, privately funded, owned by joint liability groups, and owned by cooperatives. Each of these options varies in terms of several factors, including the motivation of the investment and whether a financial return would be anticipated and, relatedly, whether the tariff would cover the costs or not. Additionally, the five scenarios vary in terms of the level of operational support or subsidies, reliance on equity contributions of developers or community members, and whether debt from financial institutions would be necessary. More often than not, a combination of approaches must be used as each has strengths and weaknesses.

Additional options for funding mini-grids include project finance and crowdfunding. In the case of project finance, the mini-grid would be treated as a special purpose vehicle (SPV) and include bankable contracts with major consumers and financing on the basis of cash flows. This is only possible for large-scale projects, however. In the case of crowdfunding, the funding comes from small contributions from the public through online platforms or other means.

Prof. Subhes Bhattacharyya, De Montfort University

Regarding the way forward for mini-grids, no single option fits all cases and any and all possible combinations must be used. Flexible financing arrangements remain one of the most necessary elements, including support for mitigating risk, replacing components, and other ways of reducing costs. Innovative fund designs also need to be explored: flexible viability gap funding and funding for an entire project cycle. Lastly, he called for mini-grids to be better joined up with rural development as a whole, especially the energy-agriculture-water-health nexus.

Business models in practice: off-grid RE success stories in developing countries

David Lecoque, Alliance for Rural Electrification

David Lecoque began his presentation with an overview of the Alliance for Rural Electrification (ARE). ARE is an international business association representing the decentralised energy sector working towards the integration of renewables into rural electrification markets in developing and emerging countries. It was created in 2006 by companies and pioneers with decades-long experience. It promotes improved energy access through business development support for more than 90 members along the whole value chain for off-grid technologies by targeted advocacy and facilitating access to international and regional funding. It provides a global platform for knowledge sharing and works on a wide variety of topics.

David Lecoque then provided six case studies of off-grid renewable energy successes with a variety of business models in the developing world and shared some lessoned learned from the examples.

The first case study was on Access Energy in Bancoumana, Mali. Access Energy used an initial investment of €400,000 in a mini-grid (20% from Access Renewable Energy Ltd., and 80% from the Malian Renewable Energy Agency) to provide electricity for 393 households, small business, schools, health centre and street lights, and has created new jobs and activities in the village. Operational expenditures are covered by a tariff of €0.28 per kilowatt hour. The next steps involve densification of the mini-grid, and the Malian government replicating the project in another 50 villages.

The second case study looked at E.ON off-grid solutions, which has developed a containerised 7.5 kW-peak solar-PV/battery hybrid mini-grid in the Manyara region of Tanzania. The container is divided into two parts: the back houses all electrical equipment and in the front there is a kiosk (with a refrigerator, battery charging station, and other items). A mini-grid has been built up to connect individual customers and a pre-paid metering solution based on mobile money is used for electricity sales. The pilot project does not intend to fully recuperate costs but future projects expect payback in seven to eight years.

The third case study was on the Foundation for Rural Energy Services (FRES). FRES advances rural electrification in developing countries. It is active in South Africa, Uganda, Mali, Burkina Faso and Guinea-Bissau. Eight installed PV mini-grids—mainly PV-diesel hybrids—have a combined total installed capacity of 550 kWp. The actual production level is 1200 MWh/year, and the PV contribution to power output ranges from 50–100% across the 8 mini-grids. System configurations are largely PV/battery storage/diesel genset. The initial capital expenditure was financed by FRES, Nuon, and AMADER (Malian Rural Electrification Agency) and the World Bank through grant financing. Invoicing is consumption based (€0.38/kWh) and revenue finances ongoing operations and replacements. Ongoing technical assistance and training for local technical staff is provided from a grid network operator in the Netherlands.

The fourth case study was on Photalia, who implement infrastructure for solar electric production for isolated localities in Mauritania. Photalia belongs to the Vergnet Group, an internationally recognised energy and water supply specialist for remote or complex locations, providing customised solar energy systems adapted to all the specific constraints of isolated sites. Hybrid diesel solar energy, with storage batteries prioritising the solar energy portion, were installed—three mini-hybrid power plants for three towns, including the distribution network. Photalia designed the system based on Innotec Studer technology. The total project investment amounted to approximately €1.28 million for Photalia, in a joint-venture with a local partner, COGER. This project was financed by the European Union. The power plants are managed by the ADER. About 8000 inhabitants (through 555 individual connections and 25 industrial connections) will benefit from the project. The project is a large investment but affects a lot of people and so is an efficient use of funds.

The fifth case study concerned RVE. SOL, a social entrepreneurship organisation using renewable technology to eradicate poverty, create jobs and empower businesses in rural Africa. In Sidonge Village, Busia Region, Western Kenya, they have installed KUDURA technology, which is a sustainable integrated solution encompassing potable water production and renewable energy generation, distribution, monitoring, mobile prepayment and smart metering, and safe biogas and organic fertiliser production (from cassava residues). The total installed capacity is 2.5 kWp. RVE.SOL invested US$87,000 in this pilot project, with a break-even point expected after 10-12 years. A local community-based organisation provided the on-the-ground know-how and community management. The end-user pays a €4 per month flat rate for 250 Wh of daily allowance. The fees for provision of water, biogas, and electricity services fund the day-to-day operation. The micro-grid provides energy and potable water to 12 families in Sidonge, and an independent assessment confirmed the positive social and environmental impact

The final case study was on the Neu-Ulm University of Applied Sciences (HNU), which has an applied entrepreneurship education programme, in Arba Minch, Ethiopia. In collaboration with Arba Minch University industry partners such as Phaesun, micro-entrepreneurs were trained to build and maintain prototypes for diverse businesses giving a productive use of energy. Business

Opportunities with Solar Systems (BOSS) models were developed and constructed in Arba Minch, e.g., a solar-powered barber shop, cafeteria, charging station, ice cream shop, mobile city photography shop, and ICT training centre for rural areas. Project funding came from the German Federal Ministry of Cooperation and Development and was received under the umbrella programme "Industry Partnerships 2013". The programme has a financial revolving mechanism. Micro-entrepreneurs get materials for building the prototypes and are obligated to pay back all costs including a small extra fee within two years to the Arba Minch University, so the university can refinance the programme with the repayments. Potentially, single micro-businesses will be scaled up in the form of a production facility and a similar or adapted project version will be implemented in a further University in Ethiopia and in South Africa.

In his closing remarks, David Lecoque summarised some lessons learned by ARE. Specifically, business models must: be commercial, scalable and replicable; address the ability-to-pay of end-users; integrate capacity building; manage risks; be financially sustainable in the mid-to-long term; have local management and maintenance; and ensure high socio-economic impact at the local level. To facilitate this, he called on the development community to:

- engage with national governments and provide technical assistance, increase the availability of public-sector financing, and leverage private capital to facilitate small-and medium-sized projects
- engage in capacity building, the sharing of experience and best practices
- engage with stakeholders from the private sector and civil society who in the end will implement the projects.

At the same time, national policymakers should create favourable market conditions by having a high-level political commitment for renewable energy-based rural electrification; clear and stable regulatory frameworks for the energy sector; provide incentives for project developers; invest in projects; provide market information; and determine which areas will not be covered by grid extension over short, medium, and long timeframes.

Investment models for distributed manufacturing in developing countries

Professor Sir Mike Gregory, University of Cambridge

Mike Gregory provided an overview of the concept of distributed manufacturing, the business models associated with it, and what its implications might be for off-grid communities He also outlined a potential UK-India collaboration on distributed manufacturing. Distributed manufacturing can be described by the following aspects: digitalisation, localisation, personalisation, new production technologies, and enhanced designer/producer/user participation. The benefits of distributed manufacturing include economic growth, job creation, direct engagement of people in remote and less developed areas, and development of broad capabilities to leverage across many sectors. Distributed manufacturing can act as a vehicle to enable micro-, small- and medium-sized enterprises' participation in global value chains, and enable "leapfrogging" to the next level of sustainable manufacturing.

Mike Gregory noted that distributed manufacturing may be significant for developing countries, provided that the approach is tailored to different contexts and the availability of local resources. It can be used for enabling local production that can capture value locally and provide tradeable goods. For example, distributed manufacturing has emerged as a strong theme during key engagements between India

and UK, with the objectives to enhance growth and productivity of Indian and UK manufacturing SMEs, develop emerging distributed manufacturing concepts as a basis for collaboration and knowledge transfer, and to explore frameworks for long-term collaboration and partnership in distributed manufacturing. During the question and answer section, it was pointed out that in an African context, distributed manufacturing is ideally suited to the first stages of adding value to agricultural products (e.g., cold storage or canning).

A sustainable hybrid energy system: the financial case

Mr Thomas Grant and Mr Tom Mille, Cambridge Energy Partners

Thomas Grant and Tom Miller explained that the aims of Cambridge Energy Partners (CEP) are to: reduce the environmental impact of off-grid industries (primarily the mining industry) through providing low cost renewable energy to industry and rural electrification solutions to satellite communities in these off-grid areas, and by building on its commercial relationships to develop "economic hubs" in these areas – what CEP terms its "Anchor Tenant Model".

To make their business model sustainable, CEP provides solar energy as a service. Solar energy (captured by a technology pending patenting) is sold to the mine. Energy is also provided to surrounding commercial enterprises, social services (schools and health centres) and private units, with a PAYG payment model underwritten by the mine. Mines are targeted mostly due to the cost competitiveness of solar versus traditional generation technologies, such as diesel generators, which are expensive to operate due to high transportation costs. For a given location, CEP sees the mine as the key initial customer to ensure economic viability but envisages the diversification of businesses and customers in its "economic hubs" will gradually eliminate the financial dependence on the mine.

Off-grid villages in China

Dr Eden Yin, University of Cambridge

Eden Yin stated that rural electrification in China is considered a success with the electrification rate being close to 90% in rural areas. This is mostly attributed to a number of large-scale government programmes primarily based on fossil fuels. Despite this success, Eden Yin highlighted that 10% of the rural population does not have access to electricity. Reasons for this include the deterioration of infrastructure and a lack of funds for necessary maintenance and upgrades.

Rural areas in China are also experiencing social and economic problems related to the loss of human capital to urban areas, due to the country's very large migrant workforce. For this reason, villages are rapidly disappearing (at the rate of 20,000 villages a year) and many rural centres are inhabited only by grandparents and children. There are an estimated six million children left behind in rural areas. Farming land is also being abandoned which may negatively impact the country's food security.

Eden Yin concluded with his belief that the concept of Smart Villages, if implemented in China, could revitalise the rural economy and society.

The public sector's role in the supply side

Mr Alistair Wray, DfID

Alistair Wray began by setting out the current context in which businesses focusing on off-grid clean energy solutions operate. Focusing specifically on home-based electricity services, Alistair Wray highlighted how, although there are increasing opportunities for scaling-up, the market has been limited to a handful of countries offering a supportive environment and even in these countries a number of barriers face pioneer firms.

Mr Alistair Wray, DfID

By deconstructing the development timeline of decentralised energy businesses into four stages, he was able to highlight the various barriers that face pioneer firms, as well as the form in which support should be administered. In the first stage, which consists of prototyping and early testing, firms are limited by a lack of resources and skills to develop new technologies and business models. In this stage, the most appropriate form of support is grants and contingent grants for research, development and incubation of new technology and business models.

The second stage—early commercialisation of ideas—is characterised by the following barriers: implementing business propositions, building markets, and low investor confidence due to a lack of information on potential returns. Similarly, in this stage, support should come in the form of grants and contingent grants for early-stage proof of concept and business development.

Barriers facing firms in the third and fourth stages, validation of the business and building the customer base and taking the business to scale, take the form of a difficulty in understanding where and how to access equity and debt financing. This requires support in the form of equity, working capital, and debt financing over longer-term time frames.

In addition to barriers at each of the four stages of the development timeline, Alistair Wray highlighted a number of cross-cutting barriers. These included: the low purchasing power of customers; the risk of customer non-payment; low consumer awareness and low demand for off-grid renewable energy; regulatory barriers (particularly import barriers); market spoilage due to sub-standard products; government bias towards grid connection; and market distorting policies failing to provide a level playing field for off-grid renewables.

Alistair Wray proceeded to explain the five pillars of an effective public sector. The first pillar concerned promoting innovation and facilitating market-based approaches to access to off-grid modern energy services. Tools in the public sector toolkit include: innovation prizes and competitions, business development, working with proven enterprises, and building the customer base. The second pillar is reducing risks and reaching the base of the pyramid. To

do this, the public sector can harness a range of innovative financing vehicles and results-based payment schemes, such as results-based financing, results-based aid, and development impact bonds. The third pillar is to work with intermediaries. This is particularly important for the public sector given how quickly the sector develops and moves forwards.

The fourth pillar—engaging with governments—was illustrated through an overview of the Energy Africa Access Campaign Policy Compact. This policy compact brings together the key policy measures needed that, when adapted to country contexts, can unlock the household solar market. Specifically, the key policy measures are: remove policy uncertainty; help mobilise access to finance across the value chain; facilitate the import of household solar related equipment; provide a level playing field; protect consumers and hold solar system providers accountable; keep sub-standard products out and prevent market spoilage; promote consumer awareness; ease access to end-user and consumer finance; build a qualified workforce for the sector; and increase in-country value creation.

The fifth and final pillar is building the evidence base through impact evaluation assessments. Alistair Wray reiterated how despite the many benefits of improved household and community access that are widely acknowledged to result in terms of health, education, gender empowerment, income and well-being, the evidence base of impacts remains weak. The lack of a robust evidence base makes it difficult to justify investment from governments and private sector investors. Furthermore, there is a lack of understanding of the effectiveness of different innovation and financing instruments.

Discussion session

Chair: Professor Sir Brian Heap, University of Cambridge and Smart Villages Initiative

The workshop concluded with a discussion session chaired by Sir Brian Heap, which centred around three main points. The first point was the recognition that the entire range of technology, business models and financing vehicles must be harnessed so that every customer and income bracket can be reached. This point stemmed from the need to address the artificial antagonism between home-based electricity services and decentralised

Professor Sir Brian Heap, University of Cambridge and Smart Villages Initiative

mini-grids. Furthermore, a point was made that, although innovations such as PAYG have made substantial impact, the sector moves fast and other promising innovations should also be nurtured. The benefits of harnessing domestic finance through, for example, development banks or incorporating consumers as shareholders were discussed. A key potential benefit here was that domestic financing would mitigate the risk of exchange rate volatility.

Building on the first point, participants unanimously recognised that the sector is changing quickly and that there is the need for all stakeholders to work together to achieve the goal of universal access to modern energy services. In order for this to happen, it is important to recognise the different incentives and objectives facing stakeholders. For example, many entrepreneurs care primarily for their business and this requires a distinction from stakeholders concerned with achieving universal access. Therefore, the appropriate level for coordination was considered to be at the country-level and the government was judged to have to play a key role. The metaphor of an orchestra was used to describe this with the government being the conductor and other stakeholders being members of the orchestra. Participants noted that members of the orchestra must be provided with a score.

The third and final point discussed has its roots in the recognition that energy is a means and not an end. Therefore, the point was made that a holistic vision of success is needed in order to ensure that end-users are able to benefit fully from energy services. This could be achieved by first focusing on human well-being and setting aspirational targets high. This would then provide a framework in which various energy generation and distribution strategies could be assessed. By viewing the energy access issue in this holistic way, participants suggested that what is often viewed as a challenge could be seen more as an opportunity.

Conclusion

The multi-stakeholder workshop on business and financial models for home-based electricity services and decentralised mini-grids brought together 36 participants from academia, the private sector, NGOs, and the public sector. Together, participants exchanged learnings to better understand the current state of business and financial models, as well as what stakeholders must do to help ensure the provision of modern energy access for all. The workshop also served as a key input into the Smart Villages Initiative's series of technical reports on business and financial models for home-based electricity services and decentralised mini-grids. These technical reports will in turn form the basis of recommendations that will be made to policy makers at the national, regional, and international level.

Annex 1: Workshop Programme

Monday, 25 January 2016

1030 **Registration**

1100 **Smart Villages: setting the scene**

Dr John Holmes and Dr Bernie Jones, Smart Villages Initiative

1120 **Investment models for off-grid energy in developing countries**

Mr Andrew Reicher, Berkeley Energy

1130 **Azuri's experience**

Dr Simon Bransfield-Garth, Azuri

1140 **SIM technology as a key enabler of businesses in the rural environment**

Mr Michael Nique, GSMA

1150 **Business models for home-based electricity services**

Dr Terry van Gevelt, University of Cambridge and Smart Villages Initiative

1200 **Panel discussion**

Chair: Mr James Cohen, Green Africa Power

1230 **New business models – EKOCENTERS and EKOCOALITION**

Mr Derk Hendriksen, Coca-Cola Company

1300 **Lunch**

1400 **Building inclusive businesses; new ideas**

Mr Sam Parker, Shell Foundation

1430 **Financial models for minigrids in developing countries**

Prof. Subhes Bhattacharyya, De Montfort University

1500 **Business models in practice: off-grid RE success stories in developing countries**

David Lecoque, Alliance for Rural Electrification

1530 **Investment models for distributed manufacturing in developing countries**

Professor Sir Mike Gregory, University of Cambridge

1550 **Break**

1610 **A sustainable hybrid energy system: the financial case**

Mr Thomas Grant and Mr Tom Miller, Cambridge Energy Partners

1620 **Off-grid villages in China**

Dr Eden Yin, University of Cambridge

1630 **The public sector's role on the supply side**

Mr Alistair Wray, Department of International Development

1640 **Discussion session**

Chair: Professor Sir Brian Heap, University of Cambridge and Smart Villages Initiative

1700 **Summary of key points**

Dr John Holmes, Smart Villages Initiative

Annex 2: Workshop Participants

Name	Organisation
Lara Allen	Centre for Global Equality
Howard Alper	Advisory Board Member
Subhes Bhattacharyya	De Montfort University
Simon Bransfield-Garth	Azuri Technologies
Claudia Canales	Smart Villages Initiative
Jim Cohen	Advisory Board Member
Heather Cruickshank	Smart Villages Initiative
Sandy Evans	Smart Villages Initiative
Thomas Grant	Cambridge Energy Partners
Mike Gregory	University of Cambridge
Richard Hayhurst	Smart Villages Initiative
Brian Heap	Smart Villages Initiative
Derk Hendriksen	Coca-Cola
John Holmes	University of Oxford
Daniel Hulls	AgDevCo
Molly Hurley-Dépret	Smart Villages Initiative
Bernie Jones	Smart Villages Initiative
David Lecoque	Alliance for Rural Electrification
Diran Makinde	Advisory Board Member
Tom Miller	Cambridge Energy Partners
Deepak Nayyar	Advisory Board Member
Michael Nique	GSMA
Peter Nolan	Advisory Board Member
Sam Parker	Shell Foundation
Nalin Patel	University of Cambridge
Ed Phillips	Practical Action
Mike Price	University of Cambridge
Andrew Reicher	Berkeley Energy
Tayyab Safdar	University of Cambridge
Richard Sidebottom	University of Cambridge
Ravi Solanki	Cambridge Development Initiative
Meredith Thomas	Smart Villages Initiative
Terry van Gevelt	University of Cambridge
Alistair Wray	Department of International Development
Jane Wright	PA-to-go
Eden Yin	University of Cambridge

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SMART VILLAGES

New thinking for off-grid communities worldwide

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