SMART VILLAGES
New thinking for off-grid communities worldwide

Off-grid energy for rural development in Latin America and the Caribbean closing workshop

Workshop Report 36

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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

Countries in Latin America and the Caribbean have made significant progress in increasing their rates of electrification in the last decades, and as a result 95% of the population has access to energy. However, 30 million people still live off-grid and lack access to basic energy services, mostly living in remote, dispersed, and isolated communities, with poor access and connectivity and lacking other basic services, such as high quality health, education, and sanitation. As a result, closing the gap in energy access in the American continent requires addressing the most difficult, expensive, and technologically challenging situations.

The Smart Villages Initiative organised a workshop in Panama City on 2-3 May 2017, bringing together significant actors in rural electrification in Latin America to discuss challenges and opportunities in rural electrification, with the aim of jointly developing recommendations to policy makers. Key topics for discussion included the role of the government versus the private sector in rural electrification, innovative options for financing such as smart subsidies, and strategies to increase the impact and sustainability of interventions.

Government-led programmes discussed include the rural electrification programme of Bolivia, where universal energy access is recognised as a basic human right and included in the country's constitution. Electrification efforts in Bolivia include grid-extension and connection, which is promoted by subsidies such as the 'dignity tariff' for families consuming less than 70 kWh. In addition, off-grid projects, especially through the distribution of solar PV systems, have benefitted 64,000 families to date. Increases in the efficiency of solar home systems and reductions in their price and weight have made this technology more accessible and have increased the range of products and services that can be offered.

Government support and backing was also key in achieving rural electrification in Chile: access increased from 53% in 1992 to 98% in 2015, leaving just 12,000 people without electricity compared to 238,000 people in 1992. In Chile, electrification projects could be justified because of their social and economic impact on the rural populations concerned, even if they could not be developed as successful business enterprises. Remaining challenges include a greater consideration of energy for productive uses as opposed to only covering basic needs, and the requirement to develop a suitable regulatory framework for the operation of small, independent systems.

Many countries in Latin America have also made significant progress in the provision of clean and sustainable energy for cooking, with well-established cookstoves projects in eight countries. One million improved cookstoves have been disseminated in the last 10 years, and the continent has an active and fast-growing biomass cookstove sector (with innovation in research, and in marketing and financing strategies). However, more investment in the sector is needed, as are specific interventions aiming to boost the market to promote sustainable access in rural and peri-urban populations. In terms of planning, increased attention is needed to target initiatives to geographical areas with the highest consumption of firewood—which is not sustainably harvested—to maximise the benefits of investment and impact on greenhouse gas reduction. Also important is to select culturally appropriate technologies using locally available biomass sources, bearing in mind that technology stacking is very common when it comes to cooking.

Also discussed were renewable energy technologies for productive uses, such as brick kilns, bio-digesters and solar driers, which can make local businesses more productive. Priorities in

the sector include developing a market-based approach for renewable energy technologies, promoting the participation of financial institutions, stimulating the development of innovative products, and establishing standards.

In terms of the private sector, on the whole, the nature of off-grid populations in Latin America make them less attractive to companies because they present little opportunities to develop viable businesses. Nevertheless, private companies in Latin America have a critical role to play in meeting the needs of underserved populations, and in increasing the impact and sustainability of public sector investments.

Key requirements to enable greater participation of the private sector in rural electrification include the inclusion of off-grid, renewable energy solutions in national electrification plans and in rural electrification programmes; increased transparency in government plans for grid extension; the development of appropriate legislation for off-grid energy solutions; the simplification of administrative and bureaucratic processes for small projects; and the development of novel service provision and financing schemes favourable to off-grid solutions based on renewables, allowing the participation of new actors and recognising the "right to exist" of new enterprises. In addition, a much greater investment in the off-grid sector is needed: for example, currently less than one per cent of the financing made available for electrification by the World Bank is devoted to off-grid solutions.

Participants in the workshop agreed that governments have a critical role to play in rural electrification. This role includes establishing an enabling regulatory framework for rural electrification that creates the environment in which different technologies can be successful, and engaging in public-private partnerships to provide for isolated and remote communities where neither public nor private initiatives alone would succeed. Further roles for the state include developing financing mechanisms that include grants, clever subsidies, and the development of markets; establishing and enforcing minimum quality standards for energy provision; informing rural communities of the technological solutions available; and promoting initiatives to develop skills and capacities. Intelligent subsidies may be required, which should be set at the minimum level needed to achieve the desired outcomes, and also set to decrease and disappear over time, as opposed to increase. Subsidies to capital costs are preferred over subsidies to operating costs, and better targeting mechanisms for the allocation of subsidies are needed.

With regard to the question of how the impact of rural electrification initiatives can be optimised, in particular in view of the limited resources available, participants agreed that priority should be given to meeting the basic energy requirements (including energy for cooking) of everyone with clean and sustainable solutions in the shortest amount of time possible, as the changes to the quality of life of the people concerned are dramatic and potentially life-saving. However, it is critical that efforts do not stop here, but address further energy requirements over time as resources become available. Also important is to increase the sustainability of interventions, which requires attention at several distinct stages of the project, from project design and financing mechanisms, project implementation, and operation and maintenance. The active participation of the target community is essential, as is a clear understanding of its needs and aspirations, not just in terms of energy requirements but of services needed. Education and capacity building are also critical, as they enable the community to understand the potential of the technology installed, derive maximum benefits from it, and contribute to its maintenance. Energy provision needs to be a component of an integrated approach to development, where communities are also provided with other essential social services such as clean water and sanitation, health, and education.

Introduction

The Smart Villages Initiative's engagement programmes in Latin America and the Caribbean commenced with an international workshop in Peru in January 2016 to discuss the challenges and opportunities in rural electrification in South America, and the role that sustainable energy access can play in the development of rural communities. Energy access is not considered as a goal *per se*, but an enabler for improved opportunities for wealth creation; access to safe and nutritious food; clean water; and improved health and education services. The engagement programmes undertaken over the following sixteen months comprised a number of follow-up activities, which included national workshops on energy access (Bolivia, Haiti, and Nicaragua), an international workshop for Central America, Mexico, and the Caribbean held in the Dominican Republic, a workshop in Ecuador with international experts to discuss the role of energy access for risk management and mitigation, and two training events for media professionals.

The engagement programmes in Latin America and the Caribbean were brought to a conclusion by a workshop organised in Panama on 2-3 May 2017 which brought together key experts from the region to discuss and reflect on lessons learned, and to develop policy recommendations to promote energy provision to the 30 million people in the region who lack it.

This report summarises the presentations and discussions at the workshop. Copies of the presentations are available at the Smart Villages Initiative's website: www.e4sv.org.

Tom Purekal from Notre Dame shares his perspective on off-grid energy access in a breakout group.

Session 1

1. Welcome and workshop presentation: Bernie Jones

Bernie Jones welcomed participants to the workshop and outlined the Smart Villages Initiative. A key motivator for the Initiative is the fact that more than one billion people still do not have access to electricity, and three billion people continue to cook on inefficient and dirty cookstoves, resulting in over four million premature deaths each year. The Sustainable Development Goals include Goal 7 on energy access, but it is important to recognise that energy access is a key enabler of most of the other Sustainable Development Goals.

Bernie Jones explained that the underlying concept for smart villages is that energy access acts as a catalyst for improved food security, enhanced health and education, to stimulate productive enterprises, and to increase the possibilities for democratic engagement of villagers. The need for smart villages alongside smart cities arises from the fact that nearly half of the world's population and 70% of the world's poor live in the countryside. Technological innovations are shifting the balance of opportunity between villages and cities.

The Smart Villages Initiative is focusing on local energy solutions rather than national grid extension, as for many villages the latter is too expensive. The aim of the initiative is to provide an insightful view from the front line of the challenges facing village level energy development and how those challenges can be overcome. To develop these insights 38 workshops have been held across Asia, Africa and Latin America, bringing together the diverse range of key frontline players to discuss the barriers, how those barriers can be overcome, and to identify the messages to be taken back to policy makers, development agencies and other stakeholders. The workshop in Panama represents the final event in a series of six engagement programmes held over the previous three years across East and West Africa, South and Southeast Asia, South and Central America, Mexico and the Caribbean.

In conclusion, Bernie Jones explained that a key aim of the Smart Villages Initiative has been to identify the framework conditions to foster entrepreneurial activities in delivering and using energy services, and to maximise leverage of public sector funding. An important working assumption has been that to maximise the social benefit and development impact of energy services it is necessary to integrate energy access with other development initiatives and to take a community-level approach. An important concern is to catalyse rapid progression through the various levels of energy access.

2. The Smart Villages Project and lessons learned

John Holmes, Smart Villages, United Kingdom

Following on from the overview of the Smart Villages Initiative, John Holmes summarised key findings from the work of the Initiative over the previous three years, focusing particularly on the lessons learned in Latin America and the Caribbean.

Starting with a review of crosscutting issues, John Holmes explained that an important need is to improve access to affordable finance both for initiatives to provide energy services and also for the productive use of that energy. Governments and development organisations can play a useful role in supporting risk mitigation; for example, through credit guarantees, which should encourage banks to provide loans at lower interest rates. Transaction costs need to be reduced for entrepreneurs running businesses to supply and

make productive use of energy, for banks making loans to such entrepreneurs, and for development organisations providing financial support.

Supportive policy frameworks need to be established, backed by high-level political commitments and including a national energy access plan identifying the preferred modes of electrification and clean cooking according to location. The policy framework should include renewable energy targets and should reflect an integrated approach to rural development. To the extent that subsidies are used, they need to be intelligent. Entrepreneurs can play an important role in the provision and use of energy services and should be supported through business incubation and advice services, and by cutting red tape.

Governments and development organisations need to invest in building skills and capacities—technical, business, and financial— and to increase the level of awareness in villages of the technological opportunities. A proactive approach should be taken to involving women and youth at every stage. The focus should be on building markets, not giving things away.

Turning to solar home systems, John Holmes reflected on the substantial advances made in recent years through reduction in equipment costs, the availability of efficient appliances, and new business models based on pay-as-you-go approaches (though noting that such approaches were not so evident in Latin America). These advances have resulted in third-generation systems requiring a third of the power to support a given level of service, with equipment weight reduced from 50 kg to six kg, and with costs reduced by 30 to 50%. A question for Latin America is whether, going forward, there should be a shift from government/NGO-led, and typically subsidised, schemes to more commercial pay-as-you-go models.

For solar home systems and solar lights, issues of poor quality and counterfeit products are encountered everywhere: international standards need to be established and effectively policed by national governments. Technical developments continue to be needed to further reduce the costs of solar electricity in households and to make solar home systems easier to install and use.

While there are many successful examples of mini-grids based on micro-hydro and diesel generation, deployment of systems based on solar or wind technologies has struggled to move beyond demonstration plants. For now, costs typically exceed revenues and so subsidies are needed. However, there are several ways in which costs may be reduced over the coming years, including through technical developments, economies of scale, the use of anchor loads to absorb costs, reduction in set-up overheads and lower financing costs. Revenues may be increased by stimulating productive enterprises to increase incomes, by increasing load factors, and through increasing the level of connections. A key issue is to set tariffs appropriately, achieving a balance between affordability and revenue generation.

An important issue for the sustainability of mini-grids is effective community engagement. Villagers should be the main drivers of mini-grid initiatives, which should build on local knowledge and customs. It is appropriate to work with trusted individuals and organisations who can be local champions, and it is important to ensure that the poor people in the village have a voice and stake, not just the powerful. It has often been said that projects are 70% social and 30% technical.

Turning to the productive use of electricity access, a key challenge is to capture more value from the agricultural value chain through agro-processing, reducing post-harvest wastage, and getting better market prices for produce. A more integrated approach is needed with relevant ministries working effectively together, and based on a better understanding of synergies and competing interests. It is necessary to take a participatory and market-based approach, building on existing practices and respecting local cultures, and to

create a conducive environment for the private sector. An important challenge is to build capacity both in the policy community and through providing advice to smallholder farmers, paying particular attention to the needs of smallholder farmers in poor areas.

Building resilience is an important issue for rural communities as rural development gains are hard won but easily lost. The enhanced prosperity inherent in smart villages helps to build assets and savings which can provide an important buffer in the event of natural disasters. Similarly, energy access and connectivity means that villages can build greater skills and knowledge on resilience and establishing resilient infrastructure. Connectivity brings advance warnings and better disaster response, and health centres in villages can play a central role in supporting the welfare of villagers in the recovery period after a natural disaster.

Building social capital is as important as the physical infrastructure. In the smart village concept, villages undertake an environmental stewardship role; for example, preserving forests and water catchments in a way that reduces vulnerabilities. Access to modern financial systems enabled by energy access and ICT can support the implementation of mitigation measures and the accumulation of appropriate buffer stocks, and rebuilding in the post-disaster phase. Care needs to be taken in the design of energy facilities to minimise their vulnerabilities to anticipated risks.

John Holmes concluded his presentation with some reflections on the Sustainable Development Goals more generally. For Goal 7 on energy access, the level of ambition needs to be set higher than is typically the case if energy access is to support the achievement of other Sustainable Development Goals. An integrated approach is necessary to realise the development benefits from energy access. For Goal 17 on strengthening the means of implementation, better coordination is needed between development agencies and more needs to be done to share information on successes and failures in village-level energy access for development. More should be done to encourage effective collaborations between universities and frontline implementers, and more attention should be given to the evaluation of development outcomes from energy access.

Responding to questions, John Holmes stressed that measures need to be taken to address quality issues for solar home systems: international standards are needed which are policed by national governments. Generally, mini-grids currently require some level of subsidy in order to be economically viable, but developments and scale-up should enable subsidies to be reduced or eliminated over time. The Smart Villages Initiative accepts that mini-grids powered by fossil fuels may be appropriate in certain circumstances: for example, hybrid systems incorporating solar panels and a diesel generator are increasingly being deployed.

3. Challenges in scaling-up rural electrification initiatives and considerations on sustainability

Lucia Spinelli, Senior Energy Specialist, World Bank Group, Argentina

Lucia Spinelli opened her presentation by explaining that initiatives on rural electrification need first to understand the issues in the villages then to find the most sustainable technical solution to meet the needs. The usual questions that are asked include: Where is the population not covered? Which is the most appropriate technical and durable solution? How many resources are required and where should they come from? Which actors should be involved and what role does each one play? What are we replacing? Is the solution culturally appropriate and accepted? How should the area be accessed? While the individual questions are not sophisticated, the overall challenge is complex.

The context for rural electrification is changing. Solar-based technologies have lower costs and greater efficiency. A solar lamp and LED light bulb can now be bought for $10, whereas a solar lamp cost $40-$45 in 2009. Around 15% of this price reduction is due to lower solar prices and 85% is due to the higher efficiency and reducing price of LED bulbs. Similarly, a solar home system capable of supporting four lights, a 19-inch colour TV, a radio and mobile phone charging now costs under $300, whereas it cost around $1000 in 2009. A wider range of products and services is now available for solar home systems.

The energy escalator concept provides for progressively increasing the power and quality of the electricity supply in rural communities: households may progress from a pico-solar light to a solar home system, and the village may benefit in due course from a mini-grid and eventually connection to the national grid. It is important to identify the best technology according to the circumstances. The story is not just about falling costs and efficiency improvements: pay-as-you-go, mobile phone payments, and smart micro-networks are transforming business models. There is a gradual change from sales models to service delivery models. The services approach improves costs (eliminating high initial payments) and helps people reach higher levels of energy access.

Historically, a binary metric of access to electricity was used: 'to have or not to have'. Energy access is now understood as a continuum of improvement, based on the results of the provision of energy services and evaluated according to the multi-tier concept. Taking the example of Nigeria, Lucia Spinelli explained that geospatial planning can provide the basis for energy access strategies. Such geospatial planning can identify where people are located, whether they have mobile phone coverage, whether the solar resource is sufficient, and whether they are served by the national grid and have access to an existing road.

Reflecting on how to build the sustainability of the solution, Lucia Spinelli concluded that we have cost reduction, increased portability, geospatial planning and communication technologies, and that we need to continue to take a multidimensional approach.

Responding to questions, Lucia Spinelli indicated that a national grid connection is not necessarily the most desirable solution for all cases: it is important to understand the demand and the financial conditions. It is accepted that the political context can be influential: it is necessary to understand this context and to select the energy access approach accordingly. The World Bank is supporting energy access through the development of geospatial tools and through its access to third-party funds.

4. Rural electrification initiatives in Bolivia

Joaquín Rodríguez, Vice-minister for Electricity and Alternative Energy, Bolivia

Joaquin Rodriguez explained that Bolivia is divided into nine departments which are each responsible for the development of rural electrification plans in their area. Access to a basic electricity service is a fundamental right in the Bolivian constitution which requires that access is universal and equitable.

The state proposes policies and strategies for energy supply to small populations and the rural areas, with the aim being to achieve electricity access for all by 2025. A four-stage plan has been established. Electricity access in Bolivia increased from 65% in 2005 to 90% currently, but this still leaves one million people without electricity. Guidelines have been established for the development of the electrical infrastructure to meet domestic demand and to boost productive activities.

Joaquin Rodriguez summarised the current geographical coverage of electricity services in Bolivia both through national grid connection (totalling

1855 MW of capacity) and local supplies (152 MW of capacity). He outlined the projects based on solar PV which have benefitted 64,000 families.

In some rural areas, the distribution network is being extended in order to provide electricity access. Efforts are being made to reduce the cost of such access and subsidies are provided for families with low consumption (a 'dignity tariff' for families consuming less than 70 kWh). The disadvantages of this approach are that costs are high for dispersed populations (around $5000 per family), the quality of service is degraded when network connections are long, and progress in extending the range of distribution networks is slow.

Solar home systems represent an alternative approach for more isolated households. They are now lightweight, portable, low-maintenance and high-efficiency systems, and are easy to install. Their disadvantages are that battery replacement is costly, it is difficult to ensure their sustainability, and their ability to support productive activities is limited.

Hybrid mini-grids are being installed comprising solar PV and a diesel generator. They can provide improvements in the quality and availability of the service (24 hours), reduce the consumption of subsidised diesel, and can in due course be integrated with the national grid. Their disadvantages are high costs of implementation and operation, dependence on suppliers for operation and maintenance, and difficulties in the transport logistics of diesel.

Photovoltaic systems have been installed in 21 health posts in the Department of Pando in order to improve the quality of care. Another initiative using photovoltaic systems for electricity generation and rainwater harvesting for clean water supply is planned to benefit 45,000 households nationwide in 650 communities by 2020.

Responding to questions, Joaquin Rodriguez explained that a 20 W solar home system supplying three LEDs costs $500. The response of rural communities to electrification initiatives varies according to location. Communities in the high plains area want electricity but have concerns that local solutions are expensive compared to national grid electricity, and they want three-phase electricity so that they can undertake productive activities such as sawing wood. Isolated communities in the Amazon basin are very receptive to solar lights and solar home systems. Different approaches are therefore required in each area.

5. Energy for cooking

Ana Isabel Moreno, Director, Energising Development – EnDev Peru

Ana Isabel Moreno's presentation outlined the current situation in respect of access to clean cooking in Latin America and summarised considerations to be taken into account in designing clean stoves. She explained that there is a wide diversity in the social, cultural, and environmental contexts for cooking across Latin America.

There is widespread use of firewood in rural areas (typically accounting for 80-100% of cooking needs). The non-renewable use of firewood is located in specific regions: it is important to identify those regions in order to maximise the benefits of projects to reduce greenhouse gas emissions. Access to modern fuels such as LPG, particularly in cities, is greater than in other regions such as Africa and Asia. Policies on subsidies to LPG have been established for some time but with mixed results.

The preferred technology depends on the local cooking tradition and the availability of biomass. Technology stacking is commonplace. For example, in Mexico the preparation of tortillas requires the corn to first be softened and hence cooking is undertaken over open fires whereas the preparation of coffee is often undertaken on an LPG

stove. A combination of technologies is therefore needed at the household level.

Latin America was the region where the movement for clean cookstoves began with the Lorena stove in the early 1970s. Currently, there is an active and fast-growing biomass cookstove sector. One million improved cookstoves have been disseminated in the last 10 years, and there are mature cookstove projects in eight countries. There are two large-scale national cookstove programmes in Mexico and Peru.

Impact studies have been undertaken including: the first and largest epidemiological studies on health impacts related to cookstoves (RESPIRE); pioneering work on environmental impacts of woodfuels harvesting (WISDOM Model); in-field GHG emission measurements; stove adoption and usage (SUMS); field-based performance of stoves; and carbon offset methodologies and projects. There is also an active group of leading regional research institutions, many robust stove models and a regional cookstove think-tank where many state-of-the-art innovations have been developed. Latin America is also the location for many creative marketing strategies that have increased adoption rates as well as pioneering micro-credit strategies.

Ana Isabel Moreno summarised the considerations to be taken into account in the design of clean cookstove interventions:

- It is a priority to foster initiatives that include the creation of global and regional institutions and networks.
- An enabling political environment is necessary which establishes measures to support the deployment of clean cooking technologies.
- Grants should be complemented by an approach based on the development of the market.
- Joint actions should be undertaken to increase consumer awareness.
- Energy access interventions for clean cooking should promote the development and articulation of the value chain.
- Mechanisms should be put in place for access to financing, including micro-finance.
- Initiatives are needed to develop skills and capabilities.
- Complementary actions should be undertaken to ensure sustainability.

Responding to questions, Ana Isabel Moreno indicated that several initiatives have been undertaken in Haiti where the efficiency of biomass use is typically very low. Quality assurance is a big issue and protocols have been established in some Latin American countries. Educating children in the issues around clean cooking is important.

6. Dynamisation of the market for thermal renewable energy technologies for productive use; FASERT's experience in Peru

Angélica Fort Meyer, National Technical Coordinator FASET, InterAmerican Institute for Cooperation in Agriculture (IICA), Peru

Angelica Fort Meyer introduced FASERT—the Sustainable Access to Thermal Renewable Energy Fund—which began in 2014 as an initiative funded by the Energizing Development EnDev programme and implemented by the InterAmerican Institute for Cooperation on Agriculture (IICA) in Peru. The IICA is the specialised agency for agriculture of the Inter-American System (IAS), which supports the efforts of member states to achieve agricultural development and rural wellbeing. The fund seeks to boost the market for thermal renewable energy technologies to promote sus-

tainable access to clean and efficient energy in rural and peri-urban populations, promoting an improvement in their quality of life.

Thermal renewable energy technologies include solar technologies for water heating and drying, and technologies for more efficient use of biomass such as clean cooking and bio-digesters. The strategy is to streamline the market for thermal renewable energy technologies, including by developing markets, promoting the participation of financial institutions, stimulating the development of innovative products, and establishing standards.

Important outcomes of phase 1, which ran until 2016, included the deployment of 10,443 improved cookstoves, 66 brick kilns and nine bio-digesters. The brick kilns improve energy efficiency by 30%, making the businesses more profitable. The bio-digesters require five to six cows or 80 guinea pigs to provide enough gas for a household's cooking.

In phase 2, $180,000 has been allocated in credit funds for six producer organisations that have contributed matching funds, and $90,000 for productive uses, in particular solar dryers. There is a strong demand for solar dryers which are more efficient than traditional open-air drying approaches and give a better quality product.

Angelica Fort Meyer concluded her presentation by indicating that IICA is committed to continue the intervention in renewable energy technologies with a market-based approach. The emphasis is on productive technologies and those related to agriculture and the rural sector.

Responding to questions, Angelica Fort Meyer indicated that for bio-digesters the gas is used by the family itself. There is interest in developing a bio-digester for a cheese plant. Solar dryers are particularly useful for drying coffee, which needs to be a high quality product otherwise the price achieved is much reduced. Drying the coffee outdoors is time-consuming and makes the product vulnerable to degradation. The cost of a 120-litre solar water heater is around US$500.

7. Smart Hydro Power GmbH
Karl Kolmsee

Karl Kolmsee outlined the activities of Smart Hydro Power GmbH, which is a member of the Alliance for Rural Electrification (ARE). The company was started in 2010 and aims to develop and sell innovative technologies for remote power generation. Informed by their experiences in Latin America and elsewhere in the world, the company has developed a set of standard packages using solar PV, biogas and micro-hydro.

A smart control system has been developed which is pre-wired, making substantial time savings on approaches that undertake wiring on site and helping to ensure quality. A second proprietary product is a hydro-kinetic turbine which floats just under the surface of a river. To operate it requires a minimum river depth of two metres and water velocity of 1.2 m/s. One example of the deployment of this hydro-kinetic turbine is in a remote community in the Amazon basin in Peru. Here it is used in a hybrid scheme with solar PV and the smart control system.

Responding to questions, Karl Kolmsee indicated that the hydro-kinetic turbine requires a fast river but not a large river. Bio-gasifiers require a system to be in place to collect the biomass and are more complicated to operate than solar PV. Installation generally takes one week and is undertaken with the local villagers, to whom training is provided. The company's operatives stay on site for a further week and a follow-up visit is made after three months to check how the system is working. Monitoring and control is undertaken remotely, for example with the use of satellite systems.

Plenary Discussion

Two questions were posed for the plenary discussion: to consider the relative roles of government

and the private sector in respect of rural energy access for development, and to discuss how intelligent subsidies can be designed and used.

With regard to the **first question**, it was proposed that regulations designed for electricity provision through national grids need to be appropriately adapted to isolated electricity provision in consultation with electricity distributors. In Cuba, electricity access rates have reached around 99%, but many rural communities still only get around four hours of electricity per day. The state therefore needs to continue to invest, particularly to serve the poorest communities where it is very difficult to make a viable business proposition.

It was considered that electricity provision to isolated rural communities is not attractive to governments or to the private sector. There are not many votes in rural electricity and it is difficult for private companies to develop economically viable projects given the transport challenges. Funding from corporate social responsibility (CSR) initiatives may be one way to attract the private sector. A community can set up a cooperative, but it generally won't have the resources to be sustainable. Governments therefore have to provide upfront capital grants: the community can then set tariffs at a level which pays for operation and maintenance.

Governments have an important role to set quality standards and to establish a regulatory framework that supports effective and honest companies, but penalises those which are not. Tax breaks should be given to enable the necessary technologies to be imported. The state should also play the role of communicator, informing rural communities of the technologies that exist. It was suggested that an important role for governments is to create the environment in which different technologies can be successful. The state should also promote programmes that enable small companies to be set up and to sell energy equipment and services, rather than give equipment away. In Peru, private companies have been contracted to take on the operation and maintenance of solar home systems for a period of 15 years.

It was proposed that governments should foster public-private alliances: the private sector can often make faster progress than governments.

In respect of the **second question,** on intelligent subsidies, it was suggested that subsidies to capital costs are preferred to subsidies to operating costs. Tariffs need to be set according to villagers' capacity to pay. In Cuba, some form of government assistance remains necessary to improve electricity supplies to the poorest communities. It is better to talk about 'public support systems' than 'subsidies'. The history of developed countries tells us that electricity access for rural areas and the establishment of the major companies that now run electricity services were made possible because governments took the first step. In considering the merits of subsidies for rural energy access, we should not forget the high levels of subsidies enjoyed by fossil fuels in many countries.

In Chile, electricity access projects for rural communities are not profitable for the private sector, but if the wider social impact is taken into account such projects are justifiable. It is therefore appropriate that the state provides sufficient subsidies that private sector concessionaries can be profitable provided that they provide a quality service. The state needs to be competent in conducting the required tender exercises.

There are opportunities to be creative in setting up subsidies: for example, in respect of mini-grids, to set up subsidies in a way that recognises the time varying capacity to pay through the year in relation to the timing of harvests. Intelligent subsidies should reduce to zero over time, rather than grow. They should be set at the lowest level required to achieve the desired outcomes.

In more general discussions, the point was made that energy is much more than electricity and that meeting needs for thermal energy, including for

clean cooking, should be given more weight. It was also proposed that an important challenge is to help villagers, smallholder farmers and village-level enterprises to develop a credit history in order to demonstrate to the financial sector that risks are low. This will help to attract greater investment.

Dr Ana Belio from ObservEH in Haiti shares her point of view in a group discussion.

Session 2

8. Renewable energy for rural electrification in Latin America: an overview

Alexandra Arias, Principal Specialist, Electricity, Latin American Energy Organization (OLADE)

Alexandra Arias began her presentation by sharing the history of the Latin American Energy Organization (OLADE) with the audience. It has over 40 years of experience and 27 member countries. They aim to contribute to integration, sustainable development and energy security in Latin America by encouraging cooperation and coordination among OLADE's member countries. OLADE is currently working on the implementation of the 2030 Agenda, cooperation, and energy integration throughout the region. They aim to encourage technology and knowledge transfer within the region as well.

In terms of information, OLADE has a database with information on all 27 countries, which is publicly available on their website. This database highlights that 25% of electricity in Latin America and the Caribbean is renewable, compared to only 9% globally. In terms of electricity access, in 1970 around 120 million people did not have access; however, that figure is now less than 30 million.

She noted that OLADE is currently proposing a new methodology for energy access initiatives that aims to go beyond technology and to take culture and social norms into account. Social-corporate responsibility is crucial because companies are often close to communities and can develop plans that benefit the company and the communities.

Key points for sustainability include the organisation and financing of rural electrification projects, capacity building, and effective working with governments, the private sector, and communities. Moreover, sustainability requires projects that use energy productively and promote gender inclusion. It should be noted that taking an inclusive approach does not only focus on women but also on young adults, adolescents, people who need further education, and so on. She pointed out several projects that have incorporated the productive use of energy in Bolivia, Guatemala, and Guyana. In Guatemala, for example, a small micro-hydro plant was built that powers 10 communities. The total cost was US$780,000.

She noted that community priorities generally do not include electricity. But energy can help to meet some of their priorities, including cell phone connections, clean water, and healthcare access.

In the Q&A there was a discussion of energy access in Latin America, where 95% of people already have access to energy, although 30 million people still do not have access. Alexandra Arias emphasised the role of governments in providing energy access to remote communities. These people will need some sort of subsidy so they can have a better quality of life. While there are already government subsidies, they are not necessarily sufficient for the long term, and other types of organisations will also need to get involved, including the private sector.

In terms of the right to energy access, a participant asked whether a single family living in a remote area has the right to have access to energy. Alexandra Arias replied that everyone has the right to energy access. It is important to find the right solution for their needs and not only provide lighting.

9. Renewable energy and energy efficiency in Central America

Máximo Fernández, Technical Assessor GiZ, Costa Rica

Maximo Fernandez is the technical advisor for GIZ's Central America programme, 4E: "Programa Energías Renovables y Eficiencia Energética en Centroamérica" (Programme for Renewable Energy and Energy Efficiency in Central America), which began in 2010 when GIZ found a high potential for renewable energy in the region. Their objective for the 4E programme was to improve the implementation and diffusion of 4E as well as investment in renewable energy. At the macro level, they focus on energy policy, regulation, and standards. In addition, they also undertake capacity building in institutions. At the micro level, they invest in 4E, including technical assistance, public-private partnerships, etc. They also train trainers and teachers. This type of training can be sustainable over time, since recipients of training programmes can subsequently act as trainers themselves.

In Panama, they have focused especially on technical assistance, teaching / training, and the diffusion of information and dialogue with important national actors from both the public and private sectors.

The 4E Programme has helped the Technical University of Panama to strengthen its training programmes and to develop an awareness campaign focusing on women in engineering. One goal of 4E / GIZ is to expand this type of training to all of Central America.

10. Examples of work in Africa and how it is different from Latin America

Sebastián Rodríguez, Infrastructure for Sustainable Development (I4SD)

Sebastián Rodríguez explained that Infrastructure for Sustainable Development (I4SD) is a private company, with a team experienced in large infrastructure projects, financing, and the implementation of technology. I4SD staff met and worked together in the implementation of the Millennium Villages project in fourteen African countries. The company now works as part of a network which combines smart technology and telecommunications.

Products include advanced measurement infrastructures, clean energy options (renewables and gas), and intelligent logistics. These products were all developed for the African market, which is characterised by the near ubiquitous presence of pay-as-you-go solutions. This requires developing a certain type of technology, communication solutions for metering, and a whole range of supporting services. One product is a metering solution for a pay-as-you-go solution to access bottled natural gas.

A bottle of gas costs over US$100, explained Sebastián Rodríguez, and is too expensive for most households in Tanzania, including those in urban areas. The metering solution for pay-as-you-go is therefore an enabler for poorer households to access a cleaner source of energy for cooking. Smart metering solutions are also offered to other gas distribution companies, since they cut the costs of personnel time and travel to determine usage.

Energy projects often make five common mistakes: black-boxed, closed systems are used; design is often not centred on the user, and the diversity of uses is not properly considered, including gender differences; street lighting and universal access are not planned (for lighting, establishing responsibility for payment is usually a problem); solutions are often too expensive so users cannot afford them; and regulations are often inadequate for the project, and lack transparency and clarity.

The I4SD business model in Africa changes these parameters: users are placed first and they decide the level of payments they can afford, enabled by pay-as-you-go solutions (the costs of implementing pay-as-you-go are only one to two per cent

of those of energy distribution); technological solutions are newer; and since there are many small private companies there is greater freedom to operate than in Latin America, where the market is dominated by large, established companies with a monopoly established by law.

Another important difference between the regions is that in Latin America many communities do not offer the possibility of establishing viable businesses, due to their small size, distance between houses, remoteness and predominance of older inhabitants (the children have migrated to the cities). For private companies operating in Africa, developing a market is easier due to the higher level of investment in rural electrification initiatives. Since distribution costs in Africa are high, products need to be sold at twice the price they cost to make a profit, which makes them expensive. There is, however, a market demand and customers are happy to pay because of the absence of cheaper solutions. Mobile telephony is used as a marketing tool, for payments, and for the collection of data.

In the ensuing discussion, Sebastián Rodríguez explained that the cost of the meters for gas bottles is between US$80 and 100, but these costs are recovered in three years since they remove the need of staff to travel to remote places to measure use. Pay-as-you-go systems have had a very strong impact in Africa, but less so in Europe and in Latin America.

11. Latin American research networks for the development of renewable energies in rural areas

Miguel Latorre Zubiri, Director CEDER-CIEMAT, Spain

Miguel Latorre Zubiri explained that his work focuses on developing methodologies and solutions for rural areas by using renewable energy via micro-grids and smart controls. His organisation also participates in various networks and associations that carry out research and development, and facilitate exchanges with other teaching institutions as well as other public and private institutions.

One example of these networks is ERANet-LAC, which involves researchers from the European Union, Latin America, and the Caribbean. Its objective is to strengthen the cooperation of these regions in science, technology, and innovation and to carry out activities together, such as pilot projects and participating in joint calls for wind and solar thermal energy.

Another programme is CYTEC, the Iberoamerican Programme for Science and Technology for Development. This was created in 1984 via an accord signed by 21 Iberoamerican countries. Likewise, this programme aims to encourage the exchange of knowledge, collaborative research, and further integration of the Spanish- and Portuguese-speaking scientific community.

Miguel Latorre Zubiri also discussed the work of a network focusing on mini-hydro that brought together research groups from 11 countries with the objectives of systematically assessing the potential for mini-hydro in these countries; identifying a cluster of local businesses for developing and creating the necessary components; the development of a prototype turbine; and the creation of best practice guidelines.

He closed by discussing biomass as an important way forward for renewable energy. He noted that it allows energy to be generated in different forms for different uses. The system is relatively simple and can be economically viable because of its simplicity. It can have a positive local impact by creating access to new technologies that are simple and transferable, creating employment and improving infrastructure, among other benefits.

Members of the audience asked questions about the impacts and benchmarking of the projects as well as how communities can be shown that renewable energy is not a second-rate technol-

ogy for the poor. Regarding biomass, audience members noted that logistics can be complicated and that inter-sectoral solutions are needed. In answer to a question regarding efficiency in biomass systems it was considered that systems should be simple, inexpensive, and robust—and able to be used in many places.

12. Behavioural energy efficiency and flexible demand opportunities in low-carbon resource constrained environments

Diego Ponce de León Barido, Renewable and Appropriate Energy Laboratory (RAEL)

Diego Ponce de León Barido began his presentation by discussing California and its system of energy. One of the exciting prospects for renewable energy is that so-called developing countries could leapfrog and skip directly to solar and wind, unlike California, which went through a long process to integrate renewable energy. In Nicaragua, in fact, the country already produces up to 60% of energy from wind when the conditions are right. RAEL researchers want to ask how to move forward with the low-carbon energy transition in Nicaragua and other places.

He conducted a survey with 500 shops and households and noticed a big difference between summer and winter electricity needs. Air conditioning in the summer doubles the consumption of electricity, and people live under constant stress of how to pay their electricity bills. People are paying two to three times more than residents of California per kW hour. Perception also plays a role because many people do not know how much they are paying for energy. From the 500 shops and households surveyed, RAEL chose 60 people to be part of treatment and control groups to gather good baseline information. They used wireless sensors to measure energy usage and other information (e.g. temperature, humidity) and used two different algorithms to predict peak prices and sudden wind energy drops.

When RAEL shared the information from the sensor networks with participants, many women used the data to tell their husbands how to manage energy use within the home. The remaining challenges include the lack of public policies to support energy efficiency and the need to help users save money and access financing for new devices.

In the discussion, Diego Ponce de León Barido explained that with respect to using the data to discuss energy usage with their husbands, some women said they had an idea regarding the times of day when they saved the most energy, with the refrigerator in particular. Women would tell their husbands, "I want to turn it off from x time until x time…", and the data helped to support the argument of when to turn it on and off. This meant there was potentially more agency for the women, who were happy to tell researchers that they could convince their husbands. Another woman also started using this method in her business and her household.

Other participants were eager to discuss energy theft. Some people do not want their energy profile to be studied. However, RAEL researchers didn't find anyone stealing electricity in poor neighbourhoods. A further complication was that in certain Central American countries, the study of communications is also a very sensitive issue for the state due to connotations of intelligence and spying. There is a certain sensitivity around these studies of communication profiles and interaction with the cloud.

13. Rural electrification in isolated areas of Chile

Rosa Argomedo, Global Changes

Rosa Argomedo began by giving an overview of the electrification of rural Chile, including the role of the government, the institutional responsibility for rural electrification, and the current situation. The government's role has been to create socially "profitable" projects. They have also played a

leading role in creating incentives for investment, including public policies, regulatory frameworks, providing technical assistance, improving local capacity, and financing. In terms of the current situation in Chile for rural electrification, coverage has increased from 53% in 1992 to 98% in 2015. Only 12,000 people now live without electricity compared to 238,000 people in 1992.

She then described the first regional photovoltaic project that included 3,064 solar home systems (125 Wp, 12 V DC). The project began in 2005, and in a 2014 evaluation the batteries were replaced for everyone. Figures showed that 97% of those participating paid their tariff. However, they will need more power in the coming years as demand will increase.

In another project involving solar home systems, the Ministry for Energy worked with an indigenous community in Isla Huapi, where they installed 136 solar home systems and connected a generator (which was not part of the project) of 1,800 Wp to power to a bank of batteries to allow for a continuous energy distribution at 220V. The local community of Isla Huapi created a committee that manages the operation and maintenance of the system. Similarly, a mini-hydro project in the region of Los Lagos powers 117 homes and was created in 2010. It operates without any subsidies.

The challenges that remain include encouraging the government to consider the need for energy for productive uses, not only basic needs. A regulatory framework needs to be developed for the operation of small, independent systems. Moreover, energy needs beyond electricity need to be considered, such as for cooking.

14. Sustainability in rural energy with renewable sources

Jesus Gomez, APROTEC SAS

APROTEC SAS was founded in 1992 in Colombia and specialises in the development of projects that use sources of renewable energy, including solar photovoltaic, solar thermal, wind, hydroelectric, and biomass.

Jesus Gomez noted the importance of going beyond lighting and providing energy for televisions, phones, and schools. He described a hybrid solar diesel system, noting that this is one possibility for achieving more reliable electricity generation, and mentioned 160+ street lighting systems that are also powered by a solar-diesel hybrid. They found that by 10pm the energy was depleted, so they simply added two solar panels.

He described a solar system for a community centre, which also powers a crafts workshop, a productive use of energy. He emphasised technological sustainability in all its dimensions, and the need to install mature, robust technology. We cannot experiment with communities.

In the Q&A, when asked about the payment of members of the village who are involved in running a community energy system, Jesus Gomez explained that they normally receive a modest monthly payment, which is determined by establishing a tariff that covers the upfront costs of the project and its operational costs. Most of the projects implemented deployed simple technology, and community members received training to deal with its operation themselves. For larger repairs they had to turn to the contractors who set up the system.

Discussion

The discussion session was opened by a reflection on what the minimum size of a "smart village" should be to justify the costs of introducing basic services in view of the limited amount of public funding available for rural development. Should inhabitants of remote and isolated villages be encouraged instead to migrate to larger communities to benefit from basic services?

One important consideration is to determine what interventions and types of services clearly impact

the quality of life in remote rural communities, as opposed to providing fewer essential goods and services in urban areas. Also important is to consider the technology used to deliver the services, both in terms of size and of cost of deployment. Sustainable Development Goal 7 makes explicit the universal right to have access to reliable and sustainable energy services. However, the limited availability of funds does not make it possible to provide for everybody at once with the ideal level of services, and therefore a phased access along the energy ladder may be most practical approach.

The changes in the quality of life provided by accessing the most basic level of energy services—basic illumination and clean energy for cooking (both leading to the eradication of indoor pollution)—are very significant and potentially life-saving, argued a participant. The fast provision of basic energy services through small, inexpensive systems can make an enormous difference to millions of people, while access to higher level services, although still important and required, is relatively less impactful. It is important for governments to think in an integrated way, and consider how investments can be made so as to have the highest possible impact.

There is also a need to target subsidies in a better way: there are numerous examples in the continent where communities have been the recipients of subsidised but inappropriate technologies multiple times, and where subsidies do not target the people who really need support.

The point was made that subsidies are used to support many different services, and we have come to accept them as the norm in certain sectors, such as education. And it is important to remember that the oil and gas industries receive yearly subsidies totalling US$5.3 billion, commented a participant. The debate should focus on how public investment can be made more effective and sustainable in addressing the urgent needs of the population. For example, Argentina has between 100,000 and 150,000 households without access to electricity, and providing a basic solution would cost the government between US$400-500 for the technology, which would translate to US$4-5 per household per month. The households concerned are not able to make upfront payment for the technology, but they spend on average US$15-20 per month on kerosene and candles, which provide low quality, polluting sources of light. The benefits provided by basic access are large and very obvious: what is required is better prioritisation of public funding, although progress up the energy ladder and in the integration of services is more complex. It is important to acknowledge that there is not a sufficiently strong market in rural electrification to drive electrification by itself, and therefore the government plays a critical role in the process.

Education is a key component for successful and sustainable initiatives, since communities may not initially have the required experience and information to make the most of the electricity provided, or to fully appreciate the potential links between different services, such as education and increased productivity, or the link between poor indoor air quality and health. Collective discussions with the community are useful to determine the most appropriate technology, to discuss the advantages and disadvantages of different options, and to establish the level of electricity services required by the community.

Participants also discussed issues related to access to energy services, and how statistics do not always reflect accurately the situation on the ground. For example, although electrification rates in the continent are very high, some communities only have access to a couple of hours of a very unreliable and low quality service. Therefore, in addition to access, more emphasis is needed on establishing minimum standards of service.

Strategies to promote an increase in efficiency in energy use were proposed, including increasing the price of electricity to promote savings. How-

ever, it was also argued that the price of electricity is already too high for many poor households, and these would suffer disproportionally from further price increases. It was remarked that the problem of low efficiency in electricity use pertains mainly to urban populations: consumption in rural communities is often significantly below the capacity of installed systems, because people are worried about costs, often do not understand the technology, and do not fully appreciate the benefits that using electricity can bring to them. Education is critical for successful and sustainable communities.

Rosa Argomedo takes questions from the audience on her work in Chile.

Session 3

15. Critical factors for attaining universal energy access in Latin America

Julio Eisman, Acciona Microenergía, Spain

Acciona Microenergía (AM) aims to serve 50,000 people in 11,500 households in Peru and in Mexico (and soon operations will start in Panama), explained Julio Eisman. In Mexico AM operates as part of a public-private partnership (PPP) targeting 50,000 people in 11,500 households in the state of Chiapas, since the government recognises it would not be able to serve remote rural locations alone. Benefits include US$1 million savings to users (previously spent on candles, batteries and diesel), and an increase in time for productive uses and education due to illumination. Environmental benefits are also critical: a three-year study on the effect of introducing solar panels showed that they resulted in a reduction of over 2.7 tonnes of CO_2, and over 14 tonnes of used batteries.

However, these results mean nothing, continued Julio Eisman. In Latin America alone there are over 20 million people with no access to electricity, and the basic problem is that small, independent efforts will not be able to attain universal energy access. Collective action by a wide range of stakeholders is needed to achieve this ambition, and the SDGs represent a commitment by governments to reduce poverty, with SDG7 recognising specifically the role of energy access in development. Grid extension is not viable for many of the under-served populations, so a change of paradigm is required. Latin America has achieved great progress in electrification rates, but a persistent problem is the disparity between communities, with a proportion of people lacking very basic services, including electricity.

A critical question is to establish the minimum level of energy access to promote rural development, with consideration of the limited nature of the resources available. Resources could be used in two ways: to cover basic energy needs for now (level 2) for all the population, or investing them for maximum returns in a subset of the population. Basic energy needs should be provided for now, argued Julio Eisman, rather than aiming to provide improved services in the future. The continuous development of energy-efficient appliances also means that the level of service provision enabled will increase over time with a constant energy supply. In some cases, newer and more efficient technology (such as smart grids) is being used in developing countries first, to be subsequently adopted by developed countries. It is important that the relevant legislation is adapted to include off-grid solutions, since the current regulations are inherited from the way electrification was carried out historically.

What are the key requirements? The following are essential and a key responsibility of governments, argued Julio Eisman:

1. Off-grid energy solutions based on renewable sources need to be included in national electrification plans and in rural electrification programmes, with clear measurable objectives

2. Isolated solutions should also be included in national plans aiming to increase the presence of renewables in the energy mix

3. Legislation appropriate for off-grid solutions needs to be developed and enacted

4. It is important to develop an ecosystem favourable to isolated solutions (including transparency in government plans to extend the grid). For example, social tariffs for energy access in many Latin American countries are currently only available for users connected to the national grid

5. There is a need for new models for the provision of services and for the inclusion of new actors in the sectors.

6. New financing schemes favourable for isolated solutions based on renewables need to be developed, and there is a need for greater investment in the sector (e.g. less than 1% of the financing made available for electrification by the World Bank is devoted to off-grid solutions).

The following discussion focused on estimates of the required level of investment to achieve universal electricity access. The first organisation to publish a figure was the International Energy Agency (IEA), who estimated that off-grid solutions would provide for 60% of the population currently lacking access to electricity. This has been challenged by other groups, since cost comparisons can change due to changes in the level of subsidies of fossil fuels and reduction in the prices of the technology. Often government budgets are designed with old technologies in mind, which makes them much more expensive than they should be.

16. Technological and management innovations to achieve universal access

Miguel Fernández, Energética, Bolivia

Miguel Fernández began his presentation by sharing important technological innovations that have taken place in recent years in the field of photovoltaics. In terms of storage, there has been a transition from lead to lithium batteries, while for illumination fluorescent bulbs gave way to LED bulbs. With respect to control systems, solid state regulators were replaced first by integrated electronics and then by microelectronic regulators; fixed connections also gave way to "plug-and-play" systems. Most importantly, the price of the new systems, termed "third generation photovoltaics" (3GPV), decreased by about 30-50%, and their weight from 60 kg to 5kg without a loss in efficiency.

3GPV are considered an integrated solution for basic supply of electricity: lighting, charging phones, use of radio and perhaps television. Installation of the systems is easy enough for users to do it themselves without the need for technicians; and in case of a problem, the system can be unplugged and taken for repair, greatly cutting operation and maintenance costs. By contrast, conventional PV systems require installation technicians and expensive after-sales support, which over 20 years amounts to two-thirds of the overall costs. This means that when such systems are distributed through government schemes that restrict the amount customers can be charged, the tariff paid by users is often not sufficient to cover real costs, and subsidies are required to bridge the gap.

The availability of 3GPV calls for a reassessment of the different modes of rural electrification, argued Miguel Fernández, from promotional distribution (i.e. systems donated directly to users) to a regulated approach in which the government determines key parameters of the scheme such as tariffs and quality standards. The direct donation of systems to users is fast, but the approach is not sustainable as it does not ensure the equipment will be used, nor promote a sense of ownership in users. Regulated distribution provides a number of advantages: the emphasis can be on the fulfilment of demands (rather than the provision of energy *per se*); technologies can be certified to ensure minimum standards are achieved; the user is actively involved in the operation and maintenance of equipment; fixed points for technical support and assistance for users can be set up for repair of the system and for replacement of broken parts; and interaction with local governments can help identify priority areas for interventions. Smart financing options are required to ensure the technology is accessible to users and encourages ownership. Options include reducing upfront

investments, partial subsidy of the technology, and payment in instalments.

To conclude, Miguel Fernández underlined the importance of governments' role in attaining universal energy access. It is, however, very important to have clarity on the respective roles of the government, private sector, and users.

In the ensuing Q&A session, the luminosity of the 3GPV compared to conventional systems was challenged by a participant, but Miguel Fernández explained that the new technology is simply more efficient, so that less energy is required for the same services. In terms of payment options, three models are currently being explored for the dissemination of the systems. These are: 1) the user takes the lithium battery to a technical assistance and sales point, and pays for it to be activated; 2) payment is made through a USB connected to the system, which is unplugged and also taken to designated points for payment (the advantage of both of these solutions is that both the battery and USB collect users' data and hence provide very valuable information); and 3) a unique code is allocated to users which they can use for payments. This last method has the disadvantage that users' data are not collected, but this is the simplest for users (although it can introduce errors).

In response to the time required to train users on the installation of the systems, 1.5 hours is enough provided users also receive printed materials to guide them through the process. Addressing the question of the proportion of time the systems do not provide electricity to users, Miguel Fernández explained that a study had indicated that, on average, users ran out of electricity before the end of the day only 15% of the time.

17. Photovoltaic rural micro-grids: lessons and success factors

Unai Arrieta, Trama TecnoAmbiental

Unai Arrieta began by introducing Trama TecnoAmbiental (TTA), a Spanish private sector company involved in the design and project management of renewable energy-hybrid micro-power plants and micro-grids for the electrification of rural communities worldwide. Other areas of activity include energy efficiency, sustainable building, and distributed urban PV. The project cycle of a mini-grid starts with the identification of projects, data collection and assessment of needs, then moves on to the identification of appropriate business models, implementation, capacity building of stakeholders, and service operation.

Successful projects require attention to different aspects. Social issues are important, and these include identifying energy needs and demands, and mechanisms for sharing energy among users without generating conflicts, which may require data collection before the implementation of projects. It is important to consider socio-economic data in the design of solutions, and to incorporate learning from previous projects.

The management of individual electricity demands is also critical, and may require incentives to be established to use the available energy during periods of generation surplus, storing unused energy independently for different users, and improving the energy use habits of users to increase efficiency.

A final component is the technical-economic sustainability of service, which requires ensuring that key components (e.g. batteries, inverters, etc.) operate within design thresholds to extend their operation life; reducing tariff collection uncertainty; and ensuring tariffs reflect real operating costs (including maintenance, replacement of parts and unforeseen costs), which is critical for attaining financial sustainability. It is important to establish simplified financial planning and trans-

parent contracts between the operator and users.

In terms of the legal framework, success relies on several factors, explained Unai Arrieta. These include creating or adapting regulation to the reality of off-grid areas, both in terms of socio-economic aspects and technology requirements; assessing different tariff schemes and methodologies to set schemes/rates; and establishing how subsidies may be applied (favouring subsidies on capital costs that may be conditional on attaining specific results, as opposed to subsidies on operational costs, since customers' willingness to pay is key for a project's sustainability). Key factors are the recognition of the "right to exist" for private, local micro-grid operators and the simplification of administrative and bureaucratic processes for small projects.

In terms of mini-grids, there is a great diversity in terms of modes of operation, as well as in terms of logistics and the types of services offered to the community, which greatly affect the final costs of the operation. At the moment, TTA is carrying out a study to determine these factors in Africa, and a similar study in Latin America would be very beneficial.

In the subsequent discussion, a participant commented that the government could promote an energy initiative by reducing taxes on consumption and on value addition, and asked if TTA had any examples of this type of intervention. They had the inverse experience in Ghana, Unai Arrieta explained, where the tariffs were agreed with the community and the government so as to make operations sustainable, but were subsequently reduced by the government which caused problems for the mini-grid operator.

In response to a question about the range of costs of electricity per user from mini-grids, he said that although many factors affect costs, having a valid range of metrics was very important for planning and to establish where to allocate available resources, and therefore these types of studies are needed. Per-connection costs range from US$1,000 to US$12,000. A participant also asked about the distance between households in a village beyond which individual solutions are more appropriate than connection through the mini-grid. Although distances are not set, typically for households separated by 500-800 m, stand-alone solutions are generally favoured. A challenge is to bring both mini-grid and isolated solutions under the same management system and operator.

Parallel working group sessions, report back to plenary and general discussion: key policy recommendations

Participants at the workshop were invited to discuss in groups two key questions, and to report back to a plenary session with a summary of their debate. These summaries are recorded as follows:

1. How could the sustainability of rural energy initiatives be increased?

It is important to first define the rural communities that would be the target of interventions—notably those living in remote areas, that are poorly connected by physical and ICT infrastructures, that lack access to basic social services, and/or where the state has little 'presence'.

Increasing the sustainability of interventions requires attention at several distinct stages. During the project's design, it is very important to gain knowledge of the community members to determine their needs, aspirations and desires, and to establish whether subsidies or other financing schemes are required for the project. Projects need to be aligned with the national legal framework and the design should also take into account the useful life of equipment.

During implementation of the project and installation of technology, sustainability can be increased by a financing approach that combines a contribution from users (facilitated by the de-

velopment of local markets to generate income), together with grants and subsidies. Sustainability during operation and maintenance is provided by empowering local communities, and through capacity building and education to run and take care of energy equipment. Also, management schemes need to be established with minimum quality standards (such as length of service provision), and that take into account relevant economic variables to cover the costs of operation and replacement of parts. Ideally, projects should be executed by local enterprises who have received adequate training.

Also critical is the need to define tariffs in a decentralised way (as opposed to a uniform tariff for the whole country).

2. How can investments in rural energy access programmes be prioritised to optimise benefits and promote a fair and equitable access to services provided?

This is a complex problem and a number of components need to be addressed at once. Before the project is designed, it is important to carry out a sufficiently detailed analysis of the community and to establish their needs and aspirations, as this is needed to determine the level of investment required to solve the problems identified. Electricity for lighting and for productive uses, and clean energy sources for cooking, need to be addressed. Governments play a critical role since market forces alone cannot drive rural electrification efforts. Appropriate public policies, long-term commitments, and region- and community-specific plans were also viewed as essential in effective project design.

The most debated point was how investments should be prioritised, since the available funding for rural energy access is limited. It was agreed that minimum services to all members of the population (level 2 in the energy ladder and clean cooking energy) should be prioritised, and further development should be financed if the resources are available. Basic social services (such as health, education, and sanitation) should also be provided. Critical factors are an integrated approach to rural development and ensuring that all the members of a community, including vulnerable groups, have access to the services provided.

A breakout group discusses rural energy options.

Annex 1: Workshop agenda

Off-grid Energy for Rural Development in Latin America and the Caribbean Closing Workshop

Wyndham Hotel, Albrook Mall, Panama City, Panama, 2-3 May, 2017

Workshop Agenda

Session 1

14:00 Welcome and workshop presentation

Bernie Jones, Smart Villages Initiative

14:10 The Smart Villages Project and lessons learned

John Holmes, Smart Villages Initiative, United Kingdom

14:30 Smart Hydro Power GmbH

Karl Kolmsee

14:50 Challenges in scaling-up rural electrification initiatives and considerations on sustainability

Lucia Spinelli, Senior Energy Specialist, World Bank Group, Argentina

15:10 Rural electrification initiatives in Bolivia

Joaquín Rodríguez, Vice-minister for Electricity and Alternative Energy, Bolivia

15:30 Coffee break

16:00 Energy for cooking

Ana Isabel Moreno, Director, Energising Development – EnDev Peru

16:20 Dynamisation of the market for thermal renewable energy technologies for productive use; FASERT's experience in Peru

Angélica Fort Meyer, National Technical Coordinator FASET, InterAmerican Institute for Cooperation in Agriculture (IICA), Peru

16:40 Plenary discussion

17:30 End of session 1

3rd May

Session 2

9:00 Renewable energy for rural electrification in Latin America: an overview

Alexandra Arias, Principal Specialist, Electricity, Latin American Energy Organization (OLADE)

9:20 *Máximo Fernández, Technical Assessor GiZ, Costa Rica*

9:40 Examples of work in Africa and how it is different from Latin America

Sebastián Rodríguez, Infrastructure for Sustainable Development (I4SD)

10:00 Latin American research networks for the development of renewable energies in rural areas

Miguel Latorre Zubiri, Director CEDER-CIEMAT, Spain

10:20 Behavioural energy efficiency and flexible demand opportunities in low-carbon resource constrained environments

Diego Ponce de León Barido, Renewable and Appropriate Energy Laboratory (RAEL)

10:20 Q&A

10:40 Coffee break

11:10 Electrification of rural communities in Chile

Rosa Maria Agomedo Prado, Global Changes, Chile

11:30 Aprotec, Colombia

Jesus Eduardo Gómez Gutierrez

11:50 Q&A

12:45 Lunch

Session 3

14:00 Critical factors for attaining universal energy access in Latin America

Julio Eisman, Acciona Microenergía

14:20 Technological and management innovations to achieve universal access

Miguel Fernández, Energética, Bolivia

14:40 TecnoTrama Ambiental

Unai Arrieta

15:20 Coffee break

16:00 Parallel working group sessions

17:00 Report back to session and general discussion: key policy recommendations

17:30 Closing of the workshop

Annex 2: List of participants

NAME	COUNTRY	ORGANISATION
Howard Alper	Canada	InterAcademy Panel (IAP)
Karl Ampuero	Bolivia	Adviser to the Vice-minister
Marc Antoine Archer	Haiti	Observatoire de l'énergie en Haïti
Rosa Argomedo	Chile	Global Changes
Alexandra Arias	Ecuador	Organización Latinoamericana de Energía (OLADE)
Unai Arrieta	Brazil	Trama TecnoAmbiental
Ana Belio	Haiti	Observatoire de l'énergie en Haïti
Jose Maria Blanco	Costa Rica	Fundacion Red de Energia (BUN-CA)
Claudia Canales	United Kingdom	Smart Villages Initiative
Helena Carrilero	Panama	Acciona Microenergia
Modesto Cruz	Dominican Republic	InterAmerican Network of Academies of Science (IANAS)
Alfredo Curbelo Alonso	Cuba	Cubaenergia
Julian Despradel	Dominican Republic	Consultant
Fernando Diaz	Panama	Director for Electricity, National Energy Secretariat Panama
Julio Eisman	Spain	Acciona Microenergia (director)
Ricardo Espino	Panama	National Energy Secretariat Panama
Máximo Fernández	Costa Rica	GiZ, Costa Rica and Panama
Miguel Fernández	Bolivia	Energetica
Angelica Fort Meyer	Peru	Fasert (Fondo de Acceso Sostenible a Energía Renovable Térmica) - National Technical Coordinator
Jesus Eduardo Gómez Gutierrez	Colombia	Aprotec, director
Guadalupe Gonzales	Panama	InterAmerican Network of Academies of Science (IANAS)
Krisly Guerra	Panama	National Energy Secretariat Panama
Wendy Guerra	Bolivia	World Bank
John Holmes	United Kingdom	Smart Villages Initiative
Molly Hurley Depret	Luxembourg	Smart Villages Initiative
Bernie Jones	United Kingdom	Smart Villages Initiative
Karly Kehoe	Canada	Global Youth Academy
Karl Kolmsee	Germany	CEO, Smart Hydro Power GmbH
Miguel Latorre Zubiri	Spain	Director, CEDER-CIEMAT
Jose Gabriel Martín	Spain	Acciona Microenergia

Mauricio Medinaceli	Bolivia	Analyst hydrocarbons and energy for Latin America
Ana Isabel Moreno	Peru	Endev GIZ
Juan Jose Ochoa	Argentina	Coordinator, PERMER
Diego Ponce de Leon Barido	Mexico/Nicaragua	The Renewable and Appropriate Energy Laboratory (RAEL)
Tom Purekal	United States	Notre Dame Initiative for Global Development, Program Manager
Joaquin Rodriguez	Bolivia	Vice-minister for Electricity and Alternative Energies
Sebastian Rodriguez	Mexico	I4SD (Infrastructure for Development)
Jimena Sanchez	Bolivia	Inter-American Development Bank (IDB)
Rebekah Shirley	USA	The Renewable and Appropriate Energy Laboratory (RAEL)
Lucia Spinelli	Argentina	World Bank
Guillermo Velez	Bolivia	Coordinador de Proyecto Acceso a Energía Eléctrica y Energía Renovable - IDTR II

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SMART VILLAGES
New thinking for off-grid communities worldwide

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