SMART VILLAGES
New thinking for off-grid communities worldwide

Sustainable energy sources for rural development and climatic resilience of off-grid communities in Central America, the Caribbean, and Mexico

Workshop Report 28

PUNTA CANA,
DOMINICAN REPUBLIC

November 2016

Key words:
Energy access, Rural energy, Resilience,
Natural Disasters, Renewable energy

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.

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

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

Publishing

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

MALAYSIAN COMMONWEALTH STUDIES CENTRE

CAMBRIDGE MALAYSIAN EDUCATION AND DEVELOPMENT TRUST

TEMPLETON World Charity Foundation, Inc.

Contents

Summary

Although the energy situation in Central America, the Caribbean, and Mexico is not uniform across all the countries in the region, many of them face some common issues and challenges. With some exceptions, nearly all countries in Central America and the Caribbean are net oil and fossil fuel importers, putting them in an uncertain position regarding energy security. Rural areas consume high levels of wood for cooking (especially in Central America). There is a lack of technical expertise, regulations, and policies to encourage renewable energies as a substitute for fossil fuels. Around 16 million people in the region have limited or no access to electricity services and, in general, the countries are highly vulnerable to natural disasters and climate change.

To launch its engagement programme in Central America, the Caribbean and Mexico, the Smart Villages Initiative co-organised a workshop in the Dominican Republic in November 2016 with the National Academy of Sciences of the Dominican Republic. The aim of the workshop was to promote discussion between key stakeholders on accelerating the provision of cleaner energy services in rural communities in the region. The workshop aimed to facilitate analysis of renewable energy systems and energy efficiency measures as drivers for development in rural communities, as well as to evaluate ways to increase resilience to natural disasters in countries of Central America, the Caribbean and Mexico. More than 40 experts from 16 countries in the region came together to discuss the challenges and opportunities.

Regarding the provision of energy, participants noted that both large- and small-scale energy projects should take into account the economic, environmental, and social costs and benefits of the interventions. For example, large-scale hydroelectric schemes have encountered social consequences where indigenous communities have had to be evacuated. In some countries, such as Haiti and Nicaragua, electricity provision is mainly constrained by infrastructure deficiencies. Off-grid communities that have diesel-generators are paying high prices for electricity, which can be up to three times more than the electricity costs in urban areas. However, elsewhere—in Costa Rica, for example—the government has made considerable efforts to improve the electricity infrastructure of the country.

It was noted that an inclusive approach is key to the success of rural energy projects. An approach where the community can learn the different roles that are necessary to implement the projects has shown considerably improved impacts and endurance. A family-centred approach should be adopted, involving them at every stage from planning through to implementation.

In another context, there have been problems due to weak alignment between energy access initiatives and the intentions of local governments. For example, on electoral campaigns local politicians have promised the provision of clean cook stoves for free, damaging the work that NGOs, cooperatives, and other institutions have done so far to promote clean stoves using a more sustainable, market-based approach. This has contributed to the paradigm that some technologies are "charity for the poor" instead of emphasising the environmental and life-quality benefits.

The workshop evaluated the technologies that can be used in off-grid communities. Solar power and micro-hydro are appropriate options. An issue for solar home systems is that the batteries typically need to be replaced after two to three years and villagers are often not aware of the dangers of disposing of them incorrectly.

There is also good potential for the use of manure from animals and human waste to produce

combustible gas for cooking (at a small scale) or to generate electricity (at a larger scale). Local culture, however, is one of the main hurdles for the implementation of these innovations. People cannot conceive that gas from a latrine can be used for cooking, for example. Therefore, to implement these types of innovations, project developers need to explain in simple language and with examples that these technologies are healthy, safe, and do not cause diseases.

Stimulation of productive enterprise in villages is key to their development and the financial sustainability of off-grid electricity systems. It should therefore be the focus of rural development initiatives alongside the provision of key services.

The region is vulnerable to climate change: more severe droughts, cyclones and El Niño events have been experienced over the last decade. Large hydro-electric schemes have been compromised by droughts. The risk of natural disaster events is high and every event means a step backwards in development by tipping people back into poverty. Therefore, appropriate actions to reduce risks and to increase resilience in communities to minimise impacts of natural disasters are necessary. Electricity generation facilities should be designed with an appropriate level of resistance to anticipated natural disasters.

Regarding the health sector, telemedicine can make an important contribution to providing high-quality, safe, and affordable health services in rural communities. The experience of the Dominican Republic demonstrates the feasibility of offering X-rays, mammography etc. in rural clinics with relatively low levels of local skills, and connection to medical experts in central hospitals for diagnosis.

Introduction

The Smart Villages Initiative started its series of workshops for Central America, the Caribbean and Mexico with the Dominican Republic workshop held in Punta Cana on 16-18 November 2016. The workshop aimed to facilitate the analysis and exchange of knowledge between the public sector, non-governmental organisations and the private sector, based on experiences in the field of rural electrification through sustainable energy sources. It explored the role of renewable energy and energy efficiency measures in boosting rural communities' development, in improving social services such as health and education, and in mitigating the risks of natural disasters. Additionally, it evaluated the opportunities and challenges for the private sector in the arena of rural electrification and considered how supportive regulatory frameworks should be established.

The event was organised jointly between the Smart Villages Initiative and the Academia de Ciencias de la República Dominicana (Sciences Academy of the Dominican Republic), and brought together more than 40 people from different sectors with a wide range of experience in off-grid communities. The countries represented in the event included Antigua and Barbuda, Barbados, Bolivia, Brazil, Canada, Costa Rica, Dominican Republic, Ecuador, Germany, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Trinidad & Tobago, and the United States. Over three days, the workshop provided a space where these stakeholders could share their experiences, opinions, and recommendations regarding the issues around smart villages. In the discussion sessions the participants discussed the role of governments in increasing energy access, and the need for coordinated energy strategies across the region, especially across the Caribbean islands. They reviewed the risks of natural disasters and the appropriateness of technologies in vulnerable places, the feasibility of financial strategies, the innovations in energy storage technologies, and the use of sewage as an energy resource.

The presentations were grouped in seven blocks, with a total of 29 presentations over the three days. The first block started with the topic "*Renewable energies for energy security and rural development*", which was repeated on the second and third day as well. This was followed by the "*Renewable energy sources for risk management and natural disasters*" block. On the second day there were two blocks for the topics "*Technological innovations*" and "*Rural energy access and the private sector*". On the third day the topic "*Access to energy and health*" was addressed. Each day had a block for discussion to allow the development of ideas and opinions based on the presentations given.

In the afternoon of the second day, participants were invited on a field trip organised by the company Consorcio Electrico de Punta Cana-Macao (Electric Consortium of Punta Cana-Macao). The group visited a plant with six fossil fuel CHP (Combined Heat and Power) engines rated at 6 MW each and a 2 MW biomass plant that consumes 5,200 tonnes of biomass per year. Both the diesel CHP and biomass plants provide thermal energy for air-conditioning and hot water at three major hotels nearby, and provide power to commercial entities and households in the area.

Welcome addresses

Milciades Mejia, National Academy of Sciences of the Dominican Republic

With a warm welcome, Milciades Mejia presented the National Academy of Sciences, a non-profit organisation that links the country's leading researchers to academicians from Canada to Argentina through the IANAS network of 24 science academies across Latin America, the Caribbean, US, and Canada. Milciades Mejia talked about the relevance of this workshop due to the important issues that the Dominican Republic is facing regarding electrical energy generation. The country is highly affected by climate change and lately the demand for electricity has increased considerably. In order to satisfy this increase in the demand for energy, the Dominican Republic had to implement coal plants that are expected to run from 2017, contradicting the country's goals of reducing CO_2 emissions. He made a call to think of an electricity mix with cleaner energies for the Dominican Republic.

Ernesto Vilalta, Vice Minister of the Ministry of Energy and Mines, Dominican Republic

The Vice Minister, Ernesto Vilalta, emphasised the importance of renewable energy access for rural development and of initiatives such as Smart Villages that facilitate knowledge exchange between experts and between countries. He mentioned that this workshop is relevant not only for the objectives of Smart Villages, but also because the theme of this event is aligned with the national strategy for development of the Dominican Republic, as well as with the global objectives for sustainable development. It therefore creates a crucial space to explore the challenges and opportunities for achieving energy access in rural communities. Currently, the challenges are created by the remote locations and scattered nature of these groups of people, resulting in high costs for grid extension. It is for this reason that the spectrum of solutions needs to be expanded to achieve access to modern forms of energy and improve the quality of life in rural zones of this country.

The Dominican Republic has undergone an important economic transformation in the last decade. It has benefitted from competitive advantages compared with many of its neighbouring countries, such as its strategic location (which acts as a commercial point in the Caribbean), abundance of natural resources, political stability, modern infrastructure of ports, and a favourable climate. The Dominican Republic economy is one of the fastest-growing economies in Latin America and the Caribbean, with an average annual GDP growth of 5.4% between 1992 and 2014. The government energy strategy provides for a transition to cleaner, secure, and efficient systems through the use of renewable energy and the promotion of energy efficiency measures. By the end of 2016, it is expected to achieve 22% of the total energy capacity from renewable energies, generating 589 MW from large-scale solar and wind projects.

The demand for electricity has increased by around 40% in the last decade, and although the electricity coverage is around 94%, the challenges of remoteness and energy poverty are difficult to overcome. According to studies, energy poverty in 2014 was 43.8% with a big proportion of these people located close to the borders with Haiti. The Ministry of Energy considers this point of vital importance, not only as a matter of justice but also to promote the economic development of rural communities. Among the energy access projects that the Ministry has been implementing are the mapping of the geographical distribution of hydro-electric resources and the creation of a new renewable resources database, which will permit the expansion of the programme of 31 micro-hydroelectric plants and provide more information for investors. Moreover, the country is studying the potential of biomass to generate electricity, which includes the exploitation of sugar cane and forestry residues.

The promotion of more governmental programmes for the electrification of rural zones, the guarantee of good quality and reliable electric services, the creation of new policies to diversify the energy matrix towards more renewable energies as well as the update of current norms and policies, and the simplification of the bureaucracy processes of the sector, are important challenges today that need to be overcome. Nevertheless, the Dominican Republic will utilise all its potential energy sources to improve the electricity access of the nation and to fight against climate change.

Participants came from across the Caribbean and Central America for the workshop on sustainable energy.

Session I

The Smart Villages Initiative

Dr. John Holmes, Smart Villages, UK

Worldwide there are still 1.1 billion people with limited or no electricity access, 3.0 billion people who are cooking with firewood and 4.3 million people, mainly women and children, who die prematurely every year from inhaling smoke and fumes. For the Smart Villages Initiative this is an unacceptable situation. So, inspired by the United Nations Sustainable Development Goal (SDG) 7 which aims to achieve energy access for all by 2030, and acknowledging that energy access is an important driver for the rest of the SDGs, the Smart Villages Initiative was created. The term *Smart Villages* has been developed as a corollary of *Smart Cities*, an initiative that has received great attention, but since nearly half of the world population and 70% of the poorest people live in rural communities, Smart Villages should be as ambitious as Smart Cities.

The initiative seeks to develop a bigger picture of how energy catalyses rural development. The concept "Smart Villages" refers to the key services that are enabled by energy access; for example, in education electricity allows children to use computers, to have light to study, and teachers are more likely to stay in the villages; health services can benefit from refrigeration systems for vaccines, sterilised equipment, as well as clean water for drinking and sanitation; entrepreneurs can develop and grow their businesses, and farmers can access agricultural information and use water pumps, which translates into more income coming into the village. Smart Villages are more resilient communities that respond better to economic and natural disasters. To achieve the SDGs, Smart Villages has to become the norm and be replicated across the developing world, reflecting the distinctive needs, aspirations, and opportunities of each individual community. A key measure of the level of development that characterises smart villages is that people will prefer to stay there rather than move to the cities.

The quality of the electricity supply is very important to be able to run all the services required in a village. Technology is progressing fast in this regard, so entrepreneurs can rely on the system for productivity.

The Smart Villages Initiative aims to generate policy advice by creating an insightful "view from the frontline" of the challenges and opportunities for the provision of electricity in villages. The initiative brings together key players, which includes policy makers, villagers, NGOs, financiers, and scientists, in order to explore the barriers that each of them face and to identify the key messages that would contribute to increasing access to electricity. Therefore, the Smart Villages Initiative makes the connections and interprets, syntheses, and then communicates the arising information to the policy communities, development agencies, and other stakeholders so that they can catalyse more effective policies and interventions to make development happen in villages.

The team of the Smart Villages Initiative has a base in the Universities of Cambridge and Oxford, and the initiative is funded by two charities: the Cambridge Malaysian Education and Development Trust and the Templeton World Charity Foundation. It organises workshops in six regions of the developing world, collecting valuable data. All the recommendations generated are distributed among the participants and the main stakeholders of each region, and communication between regions is facilitated as well. Furthermore, the initiative organises media events to work with local journalists in creating wider awareness of the issues and entrepreneurial competitions to generate new ideas on how to tackle energy access in villages.

The Smart Villages Initiative also explores ways to leverage the public sector's funds and encourage the private sector to invest. Integrating energy access with other sectors (health, education, clean water and sanitation, etc.) is crucial to achieve development in the rural world, so mechanisms to achieve this integration are a key and ongoing concern for the Smart Villages Initiative.

Regional overview of renewable energy use for rural electrification

Alexandra Arias, OLADE

Alexandra Arias presented an overall view of the energy sector in Latin America and the initiatives and pilot projects that OLADE has developed in the region so far. Latin America is blessed with great renewable energy sources and many countries are currently producing an important proportion of their energy mix from renewables. Nevertheless, the majority of this generation comes from hydroelectric sources and lately the hydro-power plants have been affected by severe droughts and climate change, forcing the countries to find alternatives in order to satisfy electricity demand.

On average, energy access in Latin America is around 96%, where 85% of the countries have over 85% electricity coverage. Alexandra Arias pointed out that it is the region with the highest potential to achieve SDG 7 by 2030, but US$ 700 million are required annually to make that happen. Currently, 26-30 million people do not have electricity, of which 6 million are in Central America and Mexico and 8 million in the Caribbean nations. Insufficient attention is being given to electricity access for this large number of people living off-grid due to energy reforms that are discouraging investment in this sector. The little funds that have been designated to energy access have been granted to the distributor companies, and the majority of the projects have failed due to—among other things—the lack of training in the use of technologies and for not respecting the cultural aspects of the communities.

In Latin America 20% of the population live in rural areas and, although the use of firewood is declining, there are still over 10 million people who utilise biomass for cooking, causing serious health problems in the region. The lack of electricity access is mainly due to the challenges

Marc Antonie Archer, Molly Hurley Dépret, Julian Despradel, Roberta Mutschler, Bernie Jones, John Holmes, Claudia Canales, Modesto Cruz

posed by remote geographical locations, and the scattered nature and low density of the communities. Extending the grid to these remote areas is economically unjustified; therefore the only viable options are the off-grid renewable technologies. However, renewable energy systems have many challenges to overcome to make them a sustainable and scalable solution. An important issue is that villagers cannot afford to pay for the full cost of the electricity services. Their incomes are still too low and, at the same time, the costs of electricity are higher than in the cities, therefore it is even tougher.

OLADE has implemented three pilot projects for rural electrification in Bolivia, Guyana and Guatemala. Alexandra Arias showed a video of the case of three isolated communities in Guatemala: Batzchocola, Laguna Batzchocola, and Visiquichun. In this case study, the idea of installing a micro-hydro power plant was originated by the leaders of the villages, who, with the support of OLADE and other international organisations, created a local community enterprise of electricity generation called ASHDINQUI. This enterprise is responsible for the administration, operation, and maintenance of the micro-hydro plant and has performed its job with great success. OLADE identified six elements for the sustainability of this kind of project, including working with the community leaders, creating a local company for the electricity provision services, and giving external support for financial management to create revenues and assure the payments from customers.

Guide to a sustainable energy future for the Americas: a book of IANAS

Claudio Estrada, Inter American Network of Academies of Sciences (IANAS), Mexico

Claudio Estrada presented on the activities of IANAS on sustainable energy since its creation up to the recently launched book "Guide to a sustainable energy future for the Americas: a Book of IANAS".

In 2007, Inter-Academy Council (IAC) published the book "Lighting the way: Towards a sustainable energy future" which established the best practices for a global transition to a clean, affordable, and sustainable energy supply in both developing and developed countries. The book exposes the global risks if the population do not change their current energy-consuming habits, addresses incentives that can accelerate the development of innovative solutions, provides recommendations for financial investments in research and development, and explores other transition pathways that can transform the landscape of energy supply and demand around the globe.

Among the conclusions the book mentioned were: that the developed world has a moral responsibility to meet the basic energy needs of the poorest countries; the need to improve the energy efficiency and reduce the carbon intensity of the world's economy; and the necessity of promoting the development and use of technologies to capture and sequester carbon dioxide from the use of fossil fuels (especially coal). The book also concludes that the competition for oil and natural gas supplies may potentially create geopolitical tensions and economic vulnerability in several nations in the future. The immense number of opportunities that renewable energy offers for technological progress, the potential of biofuels in Latin America, and the development of effective energy storage technologies could secure a more optimistic view of the future.

Inspired by the IAC's book, the IANAS project was created with the aim of drafting a new report on the role of sciences in addressing the sustainable energy future of the Americas. The study panel is composed of the presidents of 15 leading science academies of the world, initially co-chaired by Steven Chu from the Lawrence Berkeley National Laboratory and later by Professor Jose Goldemberg from the University of Sao Paulo. In the initial meeting held in Rio de Janeiro in 2008, the board panel identified five areas of high priority in the Americas:

1) Energy efficiency

2) Energy for unserved populations

3) Renewable energy

4) Bioenergy

5) Capacity building

The IANAS energy programme pursued the elaboration of a new book called "Guide Towards a Sustainable Energy Future for the Americas", which seeks to tackle, from the Academy's point of view, the challenges of these five points. These challenges include bringing adequate energy to underserved populations, locating renewable energy sources, creating a biofuel revolution, and the role of gender in the energy economy. The global action plan recommended by this book includes:

- Accelerate low-carbon transformation by integrating climate into core economic decision-making processes.
- Enter into a strong, lasting, and equitable international climate agreement.
- Phase out subsidies for fossil fuels and agricultural inputs, and incentives for urban sprawl.
- Introduce strong and predictable carbon prices.
- Substantially reduce capital costs for low-carbon infrastructure investments.
- Scale up innovation in key low-carbon and climate resilient technologies.
- More connected and compact cities are the preferred form of urban development.
- Stop deforestation of natural forests by 2030.
- Restore at least 500 million hectares of lost or degraded forests and agricultural lands by 2030.
- Accelerate the shift away from polluting coal-red power generation.

RENEWABLE ENERGY FOR ENERGY SECURITY AND RURAL DEVELOPMENT I

Central American Fund for Access to Energy and Poverty Reduction (FOCAEP)

José María Blanco, Fundación Red de Energía (BUN-CA), Costa Rica

José María Blanco presented on Bun-Ca and the achievements of the organisation. Bun-Ca works in partnership with organisations that have direct contact with the communities that benefit from the fund. The FOCAEP fund is one of the partnerships of Bun-Ca that creates a bridge between financing and the social aspects of sustainable energy projects. They strongly focus on clean cook stoves technologies, micro hydro plants, and solar thermal systems for productive uses in communities off the grid in Central American countries. Inspired by GIZ/EnDev, Bun-Ca manages the implementation of the FOCAEP projects, providing technical advice across the whole value chain of the technologies. It considers the supply of products, the financing access schemes, and the demand features.

The financing schemes seek to establish the economic viability of the projects through two lines: repayable financing and non-repayable financing. The repayable scheme corresponds to a conventional micro-credit approach for the supplier companies of the clean stoves. The non-repayable scheme relates to a co-financing system of around US$120, where 33% of the initial investment on imported materials is subsided by FOCAEP (such

as the steel, chimney, heat chamber, etc.), a further 33% is donated by a project partner (such as the council or NGOs), and the last 33% is paid by the community in workmanship. A new leasing scheme is in a trial phase in Guatemala, where the credit reimbursement is made through the firewood saved. Although it has not been progressing at a good pace, this concept resolves the problem for people incapable of paying back.

To date 20,000 clean stoves have been deployed with repayable financing schemes. The repayable scheme has been replicated in other markets of the region, which is taken as a positive impact by the Bun-Ca members. It is estimated that around 102,000 Central American people have improved their quality of life with this project, of which 60% are women, children and elders. It is calculated that with the clean stoves families can save close to 50% on firewood compared with the open fire techniques, which is translated to US$3,000 annually.

A key challenge for this project is the difficulty of shifting the paradigm that clean cook stoves are "charity for the poor". People think that the clean stoves should be free and there is a poor understanding of the environmental and life-quality benefits. Local politicians have contributed to this mind-set too, since on electoral campaigns they have promised these stoves for free. Furthermore, FOCAEP cannot work alone on this initiative; the unification of more actors is required to create a consistent impact. The region is very vulnerable, with high levels of drug trafficking and poverty creating a difficult barrier for the introduction of this technology. The creation of carbon markets could also promote access to modern cooking technologies.

Growing clean energy access in rural communities in SIDS: The role of data and analysis

Rebekah Shirley, University of California, Berkeley

Rebekah Shirley presented the research developed by the Energy and Resources Group on energy access in rural communities. The Group's research focuses on the design and dissemination of low-carbon energy systems in industrialised and developing countries. The team is working on modelling a blend of capabilities to support decision making by governments and planning agencies on low carbon energy development. To this extent, the group has developed energy system modelling to optimise the technologies (e.g. the SWITCH model), policy analysis tools to support analysis of carbon footprints (e.g. the Cool Climate Network) and grid mapping modelling with geographical simulation tools (e.g. MapRE). The projects are big and global, with presence in developing countries in South and Southeast Asia, East Africa, Central America, and the Caribbean.

The team has learned several lessons, and to describe them Rebekah Shirley took the Borneo experience as an example. Borneo is an island located in Southeast Asia characterised by the rural and dispersed nature of the communities living there. The Malaysian government has planned an ambitious hydro project of 20 GW that will take place within the next 10 to 15 years, causing controversy with local communities. The region is inhabited by a large number of indigenous communities that will need to be displaced in order to build these mega-hydro dams, a situation that has happened in Central America and the Caribbean as well (e.g. Costa Rica and Guatemala). The University of California got in contact with these communities and protesters to develop some data analysis to, eventually, create an alternative energy development plan for Borneo.

The research started by investigating the feasibility of an alternative energy mix for the State of Sarawak with an integral solution that contemplates industrialisation growth, sustaining local communities, and protecting forests and local resources. The group explored the potential for renewable energy to satisfy rural energy needs and utility needs, the implication of different energy market scenarios, and the creation of an ecological impact index.

The economic projections of this research revealed that the government's energy plans overestimate the needed capacity. The government projections of the annual energy consumption in 2030 for the region are 60% higher than the team's Business-As-Usual (BAU) scenario, which is a scenario even higher than the industrial development of China. If the 20 GW dams are built, the excess capacity will double the worst-case scenario demand, questioning the methodology used to estimate future energy demands. Furthermore, simulations of the Borneo grid showed that, even under the assumption of a high demand, future energy needs could be met with solar and biomass waste energy resources, some short extensions of the grid, plus existing natural gas and carbon capacity.

On a smaller scale, the research studied 30 villages that are currently generating their electricity with diesel generators. They performed energy audits of the villages and studied the potential renewable energy resources available locally. This evaluation showed that villagers are paying three times more for electricity than urban households, and that they could save more than half of their expenses if they use micro-hydro technologies instead.

Intensive work has been done to communicate these findings to the community as well. The group wrote a brochure explaining the procedure and findings with simple graphics and language style. They translated them into several languages and distributed them across the region. The project has attracted a great deal of media attention and many articles have been written about the Sarawak polemic.

Potential renewable energy use in rural communities in Haiti

Marc Antoine Archer, Observatoire de l'Énergie en Haïti (ObservEH), Haiti

Marc Antoine Archer described the energy situation in Haiti and the activities of ObservEH on the development of renewable energy there. ObservEH was founded in 2015 with the aim of overcoming the absence of energy data in the country. The lack of information is due to the indifferent attitude of the government for sharing with society the energy system flaws, meaning that the formalisation of the energy data is not currently taking place. Energy policies and regulations for energy security, quality, and affordable tariffs are not being articulated according to realities in Haiti. The current energy data in Haiti is generated through estimates and over-estimations, generating poor quality data with high levels of errors. Hence ObservEH strives to provide the required data for the provision of modern and clean forms of energy that society demands.

The energy system of Haiti should satisfy the needs of 10.5 million people distributed in 10 departments, 42 districts, 140 communes, and 570 communes sections. More than half of the population lives in energy poverty without lighting, clean cooking technologies, and transport. Haiti data resources point to an energy mix comprising 71% solid biomass, 5% hydro, 4% sugar cane (which gives more revenues with the production of alcohol) and 20% refined oil. The latest publication of the consumption balance was in 1995 when the consumption mix was 72% by the domestic sector, 10% by industry, 13% transport, and 5% commercial services. Since then, no new balances have been published.

The ObservEH data collected so far shows that with the current energy infrastructure it will be impossible to provide energy access to the entire

population of the country: a new energy model is urgently required in Haiti to stop the asymmetry and instability of the energy services. Marc Antoine Archer concluded his presentation by stating that concepts such as Smart Villages and Smart Cities are the most promising for Haiti.

Overview of the development of renewable energies in the Dominican Republic

Julian Despradel, Independent Energy Consultant

Julian Despradel presented an outlook of the development of renewable energy in the Dominican Republic considering the political, economic and legal aspects of the sector. Even though within the last few days the Dominican Republic has been facing a national emergency due to the persistent rains, overall the country is facing important droughts showing the recurrent signs of climate change. In the Dominican Republic a large number of people have been moving from rural areas to urban areas, pressuring the cities' infrastructure to adapt to this fast change.

The legal framework of the electricity sector in the Dominican Republic started in 1997 with the law of general reform of public enterprises, which established the first aspects of energy. However, it was not until 2001 that the first law of electricity (law 125-01) was created, where certain operational modifications raised some disapproval from the private sector. Later on, climate change impacts started to concern the government and studies showed that the energy and transport sector were the greatest contributors to carbon emissions in the Dominican Republic. Therefore, in 2007 the first law promoting renewable energies (Law 57-07) was established. In 2010 the constitution was revised and climate change was incorporated into the legal framework as an incidence; the law indicated that both the public and private sectors must shift to environmentally friendly organisations and reduce their carbon emissions.

Currently, the structure of the Dominican Republic electricity subsector comprises a coordinating entity controlling electricity transmission across stakeholders, a governmental company for the operation of the system, the generators, and the regulated and unregulated users. The regulated users are those with contracts with the distribution companies, and the unregulated users are those who consume more than 1 MW and hence produce their own electricity.

The interconnected national electrical system has a total installed capacity of 3,742 MW with 82% thermal, 16% hydro and 2% wind energy. The maximum demand is estimated to be close to 2,100 MW, but due to the droughts of the last few years the maximum demand has not been satisfied lately. The scarce water has had to be shared between energy generation and crop irrigation, creating some conflict between the two sectors. In 2015 the annual energy consumption added up to 14,970G Wh, 92% generated by thermal energy and only 6% by hydro. The total electricity coverage was 92% of which 7% was off-grid systems.

Regarding renewable energy, the Dominican Republic has four wind energy projects with 134.5 MW of capacity, one solar project of 30 MW and one biomass project using the wastes of sugar cane processing. The programme of Net Metering was launched by the government in 2010, subsidising 70% of the capital investment of renewable energy projects in domestic and industrial sectors. Nowadays the support has been reduced to 40%, but even with that reduction 28 MW have been installed so far in the country. Pilot biofuels projects have been implemented but this has not led to significant scale-up. In the Dominican Republic, rural community projects exist mainly with the help of NGOs and international organisations, since no relevant initiatives have been implemented by the government so far.

Legal framework of renewable energies in the Dominican Republic

Blas Minaya, Blas Minaya & Associates, Office of Lawyers and Superior Latin American Academy (ALAS), Dominican Republic

Blas Minaya talked about the legal aspects of sustainable energies in the Dominican Republic. After the creation of the renewable energies incentive in 2007, the law has suffered several modifications in order to be adapted to the Dominican Republic's situation. The former law aims to increase the energy diversity of the country, reduce the dependency on imported fossil fuels, promote the development of non-conventional energies, and boost private investment to diminish the negative impacts in the environment. Under this law, the companies that develop alternative energy projects are entirely exempted from importation taxes for all the equipment and technologies used in the project, including ITBIS (Tax on the Transfer of Industrialized Goods and Services) and final sale taxes.

To discourage the use of fossil fuels the government created the law of hydrocarbons No 112-00. This regulation imposed a 5% differential tax on fossil fuels, a fund that is afterwards used for programmes to promote the development of renewable energies and energy saving measures.

In 2012 the country created the first National Strategy for Development by the year 2030 and the following year the Ministry of Energy and Mines created the law 100-13. This contemplates regulations for the application of renewable energy laws, the resolutions issued by regulatory bodies, administrative law and common law. Additionally, in 2013 article 67 was created, which determines that it is a duty for the Dominican Republic to protect the environment and promote cleaner energies. This means that any Dominican Republic citizen has the right to demand the development of alternative energies. Fortunately, up to date the State has been complying with its obligation in this matter.

There are two types of authorities that grant authorisation to operate energy production facilities: the Provisional Concession and the Definitive Concession. The Provisional Concession concedes the power to enter public or private land to carry out studies of electrical works. The Definitive Concession grants the interested party the right to build and exploit the electrical works. In addition to these two entities, every project has to be approved by the Superintendence of Electricity according to its legal statutes, comply with the environment permit, and be approved by the National Interconnected Electrical System. Sanctions apply to energy producers if they do not comply with their obligation and norms, which include for instance using the equipment and machinery favoured with the tax exemption for other purposes, revocation of licences or concessions, or attacks against the national energy system.

Community projects implemented by the National Energy Commission

Yderlisa Castillo, National Energy Commission (CNE), Dominican Republic

Yderlisa Castillo presented two projects that have been implemented by the National Energy Commission: the Light Bulbs project and the photovoltaic development plan for depressed areas. The National Energy Commission is responsible for enforcing the renewable energy incentive law 57-07 of the Dominican Republic. The Commission has duties in respect of the development of programmes and projects of renewable energies, and programmes of energy efficiency and rational use of energy.

The community project "Bombillas de Sol" (Light Bulbs) aimed to encourage the efficient use of energy through the use of sunlight. The concept used for this project was the solar lights made of plastic bottles filled with water and bleach that are stuck to the roof. According to Yderlisa Castillo,

this solution can provide up to 70 lumens of solar light during the day. Between 2014 and 2016 the National Energy Commission installed 4,046 bulbs in rural Dominican Republic, benefitting a total of 27 communities.

The second project implemented by the Commission was the distribution of 506 photovoltaic panels to 506 homes located off the grid. The beneficiaries included schools, forest centres, a church and a club. For this project US$71,112 was invested by the Alianza de Energía y Ambiente con Centroamerica (Energy and Environment Alliance with Central America) and the remaining US$100,000 was funded by the National Energy Commission.

RENEWABLE ENERGY SOURCES FOR RISK MANAGEMENT AND NATURAL DISASTERS

Conclusions of the Smart Villages Workshop in Singapore

Bernie Jones, Smart Villages

Smart villages have a number of key features which enhance their resilience to natural disasters: a decentralised infrastructure, connectivity through modern information and communication technologies, innovative remote service provision, community empowerment, and economic and social development. In considering resilience, a range of shocks can be envisaged: natural disasters, economic failures, conflicts, epidemics, and infrastructure failure. Bernie Jones summarised the findings of a workshop held by the Smart Villages Initiative in Singapore in May 2016 which explored the issues around building resilience to natural disasters in rural communities.

Elements of the physical infrastructure which can increase resilience include decentralised electricity generation systems, innovative access to services, local health centres, lighting which can survive natural disasters, and communication links which can provide early warning of impending disasters and which can support recovery activities after the event. Just as important is the building of social capital through capacity building initiatives, provision of information, and through training. Building capacity in the form of environment stewardship can reduce the vulnerabilities of communities.

Attention needs to be given to the maintenance of infrastructure, not just its construction, and to the wider context given the potential for unintended consequences and for new technologies to introduce new risks. Resilience needs to become part of everyday discourse, and an integrated approach to policy-making is required. More real-world experience needs to be collated and communicated.

Bernie Jones gave four examples of resilience issues in villages:

1. The earthquake in Nepal in 2015 caused major damage to infrastructure because typically buildings were not well constructed. However, strong community identities in many villages supported their recovery: such communities have relevant indigenous knowledge and are sensitised to resilience issues through experiencing regular smaller-scale shocks. ‘Build back better’ is an important national slogan.

2. The Ebola outbreak in West Africa in 2014-16 killed 11,000 people and could have been averted if the response had not been so delayed. In smart villages good communication links and telemedicine could have enabled the early detection of an outbreak and rapid intervention measures.

3. Long supply chains for islands in Tuvalu in the Pacific exacerbate the challenges of resilience and post-disaster recovery. Appropriate technologies are needed which are hardened against threats posed by typhoons.

4. In Pondicherry in India, Swaminathan village knowledge centres enable peer-to-peer sharing of information. The sharing of early weather and sea condition warnings between fishermen is estimated to have saved 90 lives in recent years.

Countries in Central America and the Caribbean are exposed to a range of natural disasters—hurricanes, earthquakes, floods and volcanic eruptions. Building resilience should be a policy priority taking a regional approach. The concepts inherent in smart villages can be an important component of the necessary initiatives.

Rural electrification characteristics and resilience to climate change and risk mitigation in Central America and the Caribbean

Marco Antonio Rodriguez, World Bank

Reflecting initially on the impacts of climate change in Central America, Marco Antonio Rodriguez pointed to the impacts of more frequent and severe droughts and cyclones, and to more severe El Niño events. Agriculture and hydroelectric power generation are consequently negatively affected. Caribbean islands are threatened by sea level rise, by storm surges and hurricanes, and reduced productivity of fisheries due to ocean acidification. Freshwater sources will decline, becoming unable to meet demand in some cases, and agricultural yields will be reduced.

Across the region, there will be impacts on power generation, often reducing capacity and in some cases requiring power generation equipment to be moved. Threats to power generation from extreme weather events will increase. If power supplies are interrupted, strategic facilities such as health centres, schools, and government offices may not be able to function effectively, communication and transport systems may cease to operate, and drinking water/food may run out. There will also be economic losses in the industrial, commercial, and tourism sectors.

Historically, power systems in the region have not been designed to withstand extreme weather events. Looking forward, there is a need to evaluate the potential impact of climate change and in particular more severe weather events, but insufficient information is available. Scenarios need to be evaluated to determine necessary system reinforcements. There needs to be good coordination with meteorological forecasting centres and with civil defence organisations.

In conclusion, Marco Antonio Rodriguez stated that it is not possible or economically feasible to strengthen power systems to resist all events. A balance needs to be achieved between system reinforcement, prevention, and restoration. It is necessary to define what level of risk of interruption and damage can be accepted, and to design the system accordingly. It is easier and less expensive to extend design conditions to new components or replacement components than it is to reinforce components in current operation.

Disaster risk management and renewable energy

Dennis Funes, United Nations Development Program (UNDP)

Dennis Funes opened his presentation by reflecting on the fact that unsustainable patterns of energy production and consumption threaten health and quality of life, while affecting ecosystems and contributing to climate change. Therefore, sustainable energy can be an engine for reducing poverty, enabling social progress, and improving equity, resilience, economic growth, and environmental sustainability.

UNDP is part of the SE4all initiative and supports countries like Honduras in the design and implementation of their national declared contributions under the Paris Agreement. Amongst the Sustainability Development Goals, Goal 1 on ending poverty, Goal 7 on access to sustainable energy, and Goal 13 on action to combat climate change are particularly relevant.

With regard to evaluating risks from natural disasters and their links to access to renewable energy, risk depends on the threat and vulnerability to that threat. Vulnerability in turn is based on exposure, susceptibility and capabilities.Communities in areas at high risk of natural disasters may lack facilities and food, and have few assets: they may find themselves in a vicious circle, becoming less and less able to recover from shocks. For example, they may have to sell their assets in order to survive. All investments in renewable energy require a disaster risk analysis and dialogue to resolve potential conflicts, such as in respect of access to water.

Renewable energy infrastructure (generation, transformation, and distribution) may be located in areas that are vulnerable to a range of natural disasters including floods, hurricane winds, tides, high seismicity, tsunamis, volcanic eruptions, landslides, fires, and droughts. Recent disasters in Honduras include Hurricane Mitch in 1998, which left 80% of the population without access to electricity. Hydroelectric plants could not generate power in 1994 and 2015 due to droughts and very low levels of water in the rivers.

Consideration should be given to the materials and techniques of construction of renewable energy infrastructure to minimise susceptibility to natural phenomena. The potential environmental impact of natural disasters also needs to be taken into account. Where the livelihoods and sources of income for people are dependent on electricity or climate services, they may be badly impacted by the consequences of a natural disaster if the electricity services are interrupted.

Steps that can be taken to increase the resilience of affected communities include:

- Organisation and training, and enhancing educational levels, so that the community can manage its resilience response.
- Improving access to supplies and materials for restitution after a disaster, and ensuring resources are available quickly.
- Diversification of livelihoods and increased access to additional resources, including to affordable financing.
- Developing an architecture of policies which are supportive, and increasing the capacities of state institutions.
- Establishing agile operative mechanisms.
- Effective early-warning systems.

Appropriate actions to reduce risk include:

- Creation of a manual for the screening of investment projects at the pre-investment stage.
- Establishing early warning systems to enable timely actions to safeguard investments.
- Providing temporary alternatives for access to electrical energy in emergency situations for strategic purposes of economic recovery and social services, such as health and education.
- Temporary conditional transfers of money to enable the recovery of investments in renewable energy in the community, or for access to income for food security purposes for poor families.

Discussion session I

A panel was formed comprising speakers from the previous session who responded to questions and points raised by workshop participants.

The point was made that rural communities should have similar opportunities to people living in cities, but there is an enormous gap and the costs of developing the necessary infrastructure will be high. The question was raised whether we

should leave everything to the rural communities themselves, or is there an obligation on the state to provide the necessary infrastructure and services? Workshop participants were reminded that in the 1960s and 1970s centralised systems were established in the region, made possible by subsidised finance from the development banks; a similar approach should be adopted now to establish the necessary infrastructure for rural communities. Many states see it as their role to support the creation of rural infrastructure so that the necessary services can be provided. States need to implement policies and enforce laws, not just make them.

A concern was expressed that natural disasters and other shocks can tip people back into poverty: it is estimated that some 150 million people in Latin America face this risk. A recent World Bank study indicated that 20 million people each year fall back into poverty due to natural disasters; for many people, the welfare benefits of development are not sustained over time. So the issues of resilience need to be tackled—otherwise as one part of the population is lifted out of poverty, others are falling back into it.

An integrated approach needs to be taken in order to build in the appropriate level of resilience when developing rural infrastructure and renewable energy systems. For example, a high-tech PV panel is often installed on a primitive house which will be destroyed in the event of a hurricane or earthquake. Using the example of the extremely expensive high-tech pen developed for astronauts in the Apollo programme versus the pencil used in the Russian space programme, the point was made that resilience may lie in simplicity of design. Another example was given of the value of older technologies: VHF radios were used by people to communicate with each other in the past (and could still be used in the event of a natural disaster) but governments have restricted their use.

The point was made that it is often easy to make individual things resilient, but harder to make communities themselves resilient. And while it may not be possible or economically feasible to entirely eliminate risk, the chances of being able to survive and recover from a natural disaster can be increased through appropriate design and investment. A useful concept from the field of psychology is 'living and building for the future'.

An issue which is rarely talked about is the problem of corruption in the development of public infrastructure. Such corruption can take many forms but includes, for example, local politicians who allow houses to be built in high-risk areas because it brings them more votes, and buildings may be erected in earthquake zones that do not meet the relevant codes.

A concern was expressed that the World Bank may be seen as dogmatic in its approach. A range of renewable energy technologies can complement each other. In response, it was observed that the World Bank has sectoral visions but in recent years the challenge has been to interpret and respond to development issues in an integrated fashion. It is important to analyse risk when investing but we often lack the methodologies—for example, in respect of risks from climate change. All elements should be included in designing for resilience; an integrated vision is needed. There may be helpful read-across from what we know about resilience in biological systems.

In respect of the distinctive issues faced by Haiti, it was considered that there is no magic wand. What is needed is help to build the economy—establishing new businesses and raising incomes—not donations that can create a dependency culture. Haiti could be an excellent laboratory for World Bank initiatives.

Session II

RENEWABLE ENERGY FOR ENERGY SECURITY AND RURAL DEVELOPMENT II

Lessons learned from the implementation of off-grid energy systems with sustainable energy sources

Hugo Arriaza, Rural Electrification and Resilience Consultant, Guatemala

Hugo Arriaza began by pointing out that people are essential to off-grid energy projects, and they determine the project's success. Different beliefs and paradigms need to be taken into account in various places, including Guatemala, where CIDTEC works. For example, when a project is about electricity, it is not just for lighting; it goes beyond light and comfort to using energy to increase productivity. People need options that allow them to diversify their sources of income. Equally, the management of systems can be done by people. They do not have to be managed by a large company or a government—inhabitants can be the owners and managers. One can find excellent examples in Costa Rica, where electrical cooperatives exist.

Another belief is that people are too poor. Access to credit is often a barrier, but creative credit models allow families to have access to financing, such as the build-operate-transfer model (BOT). People need to have not only capacity to pay but also the will to pay.

In Guatemala, there are frequent social conflicts around renewable energy projects, including strong opposition to dams and wind energy projects. Some people think turbines take away oxygen from the air or water to use as fuel and that they and their families may suffer health problems from this. Others believe that water that goes through turbines becomes "dead water" and kills fish. Some also fear that solar panels' light could cause cancer. People can become afraid of projects and unfamiliar technologies. These beliefs are deeply rooted and most energy professionals have encountered them in projects.

A new approach to rural electrification needs to be promoted. CIDTEC focuses on the family, and people of all ages. Men, women, and children are involved from the planning stage all the way up to the management of the project. Participatory and inclusive techniques are important to help avoid conflicts around energy projects. This inclusive approach been promoted by project developers who work with communities to try to create less hostile environments and to give people support. Communities must work hard to apply what they have learned and to follow safety and building norms. CIDTEC and others teach people to work with safe procedures and practices, and how to use the project after it has been built. Sometimes failure is due to technology transfer without any support or teaching afterwards. Knowledge has to be disseminated for these systems to work.

The design of facilities needs to be logical and natural for the people using them. There is, of course, a learning curve. This happens by sharing lessons and experience from people who have gone through it. The transfer of popular knowledge is the main factor for success. The traditional way of doing things needs to be changed. Maybe people are not aware that they are wasting money on systems that are not efficient. They need to be taught to have the will to pay rather than receiving energy for free and without further commitment. Once the system is installed, equity and equality also have to be taught vis-à-vis energy: people have to be aware they have equal access but that if they use more, they have to pay more.

In terms of improved cook stoves, there is state-of-the-art technology, but people are still cooking with open fires, and their homes are full of smoke. It is not only the cook stove that has to

be improved: everything has to be improved, including the way of cooking, design of meeting places, etc. Some people use the cables to hang their clothes. They need to learn more respect for indoor installations and the dangers of misusing them. In the field, when people are first put in contact with new technologies, one has to be prepared for all kinds of things. CIDTEC has seen lead acid batteries covered with damp clothing to dry out. People need to be taught that equipment needs its own space. The best way to teach them is as a community so they commit themselves in front of their neighbours. It is also difficult to cut off electricity when people stop paying, but it still must be done.

Education at all levels must be carried out: with community leaders, the maintenance team, and users—including children at school and adults at parent meetings. The rules related to the equipment need to be clearly defined. Not everybody should touch equipment—appointed technicians, for example, are the only ones allowed to enter homes and check status of equipment.

Hugo Arriaza also highlighted the seven principles of cooperatives:

1) Open and voluntary participation
2) Democratic processes
3) Quota for membership
4) Independent and autonomous
5) Continuous interaction and education
6) Concern for the community
7) Cooperation between cooperatives

In summary, what needs to be improved? There needs to be more permanent support; more presence of the State; social responsibility, which allows the number of beneficiaries to be increased. The law of incentives is only meant for large projects, not small ones. CIDTEC is trying to adapt it now and to stimulate more productive activities.

Dennis Funes, Herwin Speckter, Modesto Cruz, Julian Despradel

It is important to involve banks, provide access to credit, and create sustainable markets.

Renewable energy and the GEF small grants programme

Ita Jah Simmons, Department of Environment, Antigua and Barbuda

Ita Jah Simmons highlighted the target of the Government of Antigua and Barbuda. By 2030, the government aims to meet 100% of demand for electricity in the water sector and other essential services through off-grid renewable energy sources. Presently, there is 10 MW being installed that includes a 3 MW PV system which will offset 75% of the electricity demand at the new international airport; a 4 MW PV system at Bethesda; doubling the installation at public buildings from 1 MW to 2 MW; installing 2,000 solar-powered lights along the roads; and installing 14,500 LED street lights. Off-grid renewable energy is also being used in hospitals and schools. By linking health to energy and education to energy, they are bridging gaps that have not been bridged. By 2030, they will have installed 25 MW of renewable energy, primarily wind and solar energy.

In another innovation, they have created a reverse osmosis plant that supplies over 75% of the nation's potable water. It requires 4 MW of energy; the plan is to install wind turbines and use that energy to take this plant completely of the grid and reduce fossil fuel consumption.

There is also a small programme where the link between disability and renewable energy is being made. This is a group where Ms Ruth Spencer has been working to install PV in some homes and a meeting space. The government is also planning a hydroponics projects with a disabled group in which they hope to achieve information exchange, capacity building, and system transition. Alex Spencer of Carisun is the technical person who has been explaining PV and how it can help their lives. Carisun developed a solar tracking system that makes solar PV more efficient, which is currently being used in Antigua.

In another group, there is the Potters Seventh Day Adventist Youth group in Antigua. After three years of drought, they are finally getting some rain. While most people are heavily dependent on the reverse osmosis plant for water production, this group constructed a community cistern of 100,000 gallons. A reservoir in Freetown has been abandoned for quite some time; the government is seeking to restore it and install renewable energy-operated pumps for clean water access. This is necessary because of the drought. Water harvesting is a very high priority to combat climate change.

In terms of issues and barriers they have encountered, in some of the areas dedicated to PV systems, some of roofs were not up to standard. So instead of buying solar PV, sometimes the funds need to be used first to refurbish the roof and then install a system. They ensure that the roof can bear the load prior to installation. If not properly secured, the technology could be damaged and money wasted. PV systems often take up a lot of space and land. The production of electricity and the occupation of land have to be balanced, so roofs are important spaces for PV. People have to be more pragmatic in the use of energy and make compromises between more production and more efficiency—and they must always ensure social sustainability, including environmental, social, and economic.

Renewable energy for energy security in St. Vincent and the Grenadines

Ellsworth Dacon, St. Vincent and the Grenadines

St. Vincent and the Grenadines rely on fossil fuel and hydroelectricity, with just under 1 MW of solar PV. People are currently paying US$0.42 or 0.30 per kWh. There are 110,000 people, with 50% in urban areas.

Ellsworth Dacon noted that they have to look at their renewable energy potential in the Caribbean, which is up to 890 MW in geothermal, 10 MW in hydro (5.6 presently), 8 MW for wind, and 23 MW in solar. Climate change is the main concern on these islands with small populations, which are very remote and depend strongly on tourism and agriculture. Temperatures are increasing, and in 2015 there were flash floods during which 12 people lost their lives within two hours on Christmas Eve. Climate change is also affecting the islands' economies—marine life, forests, health, agriculture, water, and tourism are all interlinked and negatively affected by climate change.

How does St. Vincent and the Grenadines adapt to climate change? As an island, the only way they can approach climate change is via renewable energy and reducing their dependence on fossil fuels. They are moving toward geothermal energy—by 2018, they will operate a 12 MW plant. This geothermal development project will cost US$83 million, but US$21 million of energy costs would be saved annually. They are also increasing the use of solar energy by installing PV panels on government buildings like the airport, and have plans to increase the capacity of hydroelectricity.

It is also crucial to address energy efficiency, too, since it is the low-hanging fruit. Their approach is to first improve energy efficiency, then increase the use of renewable energy. They are working closely with IRENA, DfID, the Caribbean Development Bank, and other energy- and development-focused organisations to reach their energy goals.

Renewable energy projects and climate change

Ana Sofia Ovalle, Fundación Sur Futuro

Since 2003, Fundación Sur Futuro has implemented several energy- and climate change-focused projects in the Dominican Republic, including tortilla-making projects with improved cook stoves. In this project, they sought to make kitchens safer since they are often family gathering places. Though family unity occurs in kitchen, many ended up with respiratory diseases and issues with eyesight. By using stoves with chimneys, they sought to eliminate these health issues. They have also implemented solar panel projects in schools, including a kit with a refrigerator. They received support with funds from the European Economic Community and followed a competitive process to choose the supplier.

The foundation is also training teachers about climate change as part of a new programme in the Dominican Republic. Almost 4,000 teachers have now been trained in this pilot scheme, which has been approved by UNESCO as a climate change training programme. In addition, they are training micro-businesses to utilise solar water purifiers, and a community is selling its own water.

In the Q&A, audience members asked about the number of people in the communities and whether they have animals—if so, have they considered using the animal manure and human waste for biogas for cooking and to produce a bit of energy?

Often the homes are isolated, and that is why solar panels have to be installed in each home. These are small farms with around two to three animals each. Something important to add is that in these projects, 50% is financing that has to be paid by the user. The user contacts the foundation and commits to pay half; the foundation uses the contribution to continue its work. Fundación Sur Futuro is collaborating via a programme on harvesting water from river basins and non-contaminated water. In cooperation with the Brazilian development cooperation agency, they are sharing their successful experience with the Dominican Republic. The foundation received an award for their water conservation efforts.

TECHNOLOGICAL INNOVATIONS

Research in the solar cells field

Arturo Fernandez Madrigal, Institute of Renewable Energy, UNAM

Arturo Fernandez Madrigal started his presentation by explaining that in Mexico 97% of people haveaccess to electricity. The 3% that is off the grid corresponds to 3.5 million people located primarily in the centre and south of the country. Since 1955, the ratio of rural to urban population has changed from 70% rural and 30% urban to 30% rural and 70% urban. There has been a dramatic migration to cities and agriculture has been abandoned. This change is a reality in Latin American countries and something needs to be done about this migration. The Institute of Renewable Energy wants to develop agricultural and livestock communities.

In Mexico, there are several programmes by various public and private organisations, including important PV programmes for water extraction, especially for water for livestock. Bio-digesters have also been developed to use manure from cattle and sheep for energy access and PV cells have been provided to schools—creating "tele high schools"—to electrify schools in remote, rural areas. However, these programmes have not continued.

Arturo Fernandez Madrigal then moved on to the technical part of his presentation, in which he described a solar cell and discussed the work of Mexican researchers on this subject. The photovoltaic effect is the process through which solar radiation is converted to electricity. The devices in which this transformation is carried out are called solar cells, which is the minimum unit where the transformation takes place. The basic structure of a solar cell is the "p-n junction". The generation of electricity happens inside the depletion zone of the p-n junction (the area between the n-type material and the p-type material), so when solar radiation in the form of photons is absorbed it will create a free electron and a hole. Both have sufficient energy to jump out of the depletion zone. If a wire is connected from the n-type silicon to the p-type silicon, the electrons will flow through the wire creating electric current and re-joining the hole at the end of the wire in the p-type silicon zone.

Solar cells are classified according to three different generations:

- First generation: they are based on silicon wafers and are mainly the mono- and poly-crystalline silicon types.
- Second generation: They are the cells based on amorphous silicon in the form of a thin film, deposited in a rigid or flexible substrate. The thickness ranges from a few nanometres to a decimal of microns.
- Third generation: Also called emergent solar cells. They represent innovations based on organic or inorganic compounds. (Sensitised solar cells, organic cells, microspheres, etc.)

In terms of advances in silicon-based solar cells, researchers have worked on improving production processes. Arturo Fernandez's team is exploring how to reduce the costs of the manufacturing technologies of cells made of various types of silicon (poly, mono, and amorphous). They are also exploring the possibility of using silicon pores to improve the photovoltaic features. Silicon is being developed in the form of very thin tape. In amorphous silicon, it is possible to achieve efficiencies of 5–7%, but by using double or triple unions, it is possible to increase it to 8–10%. Amorphous silicon carbide (A-SiC), germanium amorphous silicon (a-SiGe), microcrystalline silicon (μc-Si), and amorphous silicon nitride (a-SiN) are being studied as well.

Regarding thin film solar cells, the most important from a technological and commercial point of view are:

- Cadmium Fluide (CdTe)
- Indium copper gallium gallium (CIGS)
- Sensitised solar cells (DSC)
- Organic solar cells
- Silicon thin films (TF-Si)

Arturo Fernandez Madrigal then described the efficiencies of several different types of solar cells, including thin film solar cells (Cu(In,Ga)Se2), solar cells made with antimony sulphide and tin sulphide, solar cells sensitizsd with dyes, and hybrid solar cells.

In terms of the work of the group on hybrid solar cells, they have researched both organic and inorganic materials including:

- Conductive polymers
- Sulphides and oxides
- Metallic
- Pervoskite

Methods of synthesis and deposit have included:

- Chemical baths
- Microwave
- Spin-coating
- Evaporation

He closed by highlighting the various efficiencies of solar cells. At the moment, multi-junction concentrators and single-junction GaAs are the most efficient, followed by crystalline Si cells, thin-film technologies, and emerging PV, such as dye-sensitised cells and organic cells.

Model of sustainable energy matrix: wind, solar and biogas energy for rural schools with extended teaching hours

William Ernesto Camilo Reynoso, APEC University (UNAPEC)

William Camilo outlined his initiative which is concerned with technological developments for the efficiency of energy sources such as solar, wind, and biofuels (biogas) as a sustainable package or matrix to supply the needs of rural communities and their extended day schools that are isolated from commercial networks. These will be managed in a way that respects the environment and the community.

The daytime hours have been extended in the schools to eight hours of educational work to guarantee a quality education. These schools have a flexible and open curriculum and seek better learning outcomes, greater equity, efficient organisation of resources, and more time for cultural, scientific, technological, artistic, and recreational activities. Approximately 482 schools participated during the 2013-2014 school year with an enrolment of 165,402 students. At present, there are 579 centres operating with an extended day, benefiting 198,685 students.

Showing a diagram, William Camilo explained their proposal that consisted of a hybrid system for sustainable energy for a rural school. The school's total electrical green power per day is calculated to be 584 kWh. The generation mix will include the majority from photovoltaic panels (400 kWh), and the rest from biogas (120 kWh) and wind power (64 kWh). For biogas, the raw material will come from manure and human waste at the school. He noted that they will still need a diesel backup or another type of backup.

One of the biggest challenges remains the storage of the energy that is produced in such sustainable energy systems. Academia has developed some innovations in this matter. It is possible, for example, to store the energy produced by wind and solar

technologies in tanks. The surplus energy from renewables can be used to pump underground water to tanks above ground. Then, to recover that energy, the water can be returned to the underground tanks by passing it through a hydro turbine, thus regenerating the electricity. Another energy storage system is the Gravity Power Module, which uses heavy weight stacks that go up when the energy is being stored; the electricity can then be generated by pulling them down.

Hence, in the example above, if a school in a semi-rural area has four buildings with a total roof area of 1,058 m2 it would be possible to install 127.4 kW of photovoltaic panels. This could power services such as pumping water, lighting, central telephone offices, computer and multimedia centres, and alarm systems, among others. For wind power, the calculations were based on 32 wind turbines of 0.4 KW each, giving a total wind capacity of 12.8 kW. The power generated could be used in external lighting in the corridors and other areas. However, this would require eight batteries of 12v, 855 Ah as a backup and four inverters of 3kva, 24v to provide lighting in the corridors of the four school buildings.

Another part of the hybrid system is the biogas. Biogas is a fuel produced by the anaerobic fermentation (in the absence of air) of organic waste of animal or vegetable origin, within certain limits of temperature, humidity, and acidity. The chemical composition of the biogas is:

- Methane (CH4), 50-70%
- Carbon dioxide (CO2), 30-50%
- Hydrogen sulphide (H2S), 0.1-1%
- Nitrogen (N2), 0.5-3%

The bio-digesters will be powered by the waste of the 4,250 people who use the school bathrooms. According to their calculations, the production could result in 95.6 m^3 of biogas per day, which is the equivalent of 15.3 gallons of diesel oil per day. This could result in a capacity of 14.9 kW from the bio-digester.

Discussion session II

During the second discussion session, participants commented on the intermittence of renewable energy and the challenges this poses. Storing energy remains a hurdle, but it was noted that pumping water upstream has allowed intermittent lapses to be managed and the use of renewable energy and a diesel backup can give an uninterrupted supply of electricity.

The region has experience of using many technologies; for example, after the Haiti earthquake in 2010, there were efforts to promote the use of a parabolic solar cooking device and water heaters by thermosiphon, but it didn't work out despite their best endeavours. On the other hand, scientists and experts have pointed out an important potential for biogas in the region. They tried to show that the same technology used to obtain drinking water from the sea was also useful for latrines, which are widely used in rural areas. Cultural problems, however, are still an important barrier for this resource. People cannot conceive that gas from a latrine can be used for cooking or to obtain drinking water, thus project developers need to demonstrate that these technologies are healthy, safe, and do not cause diseases. A good example might be the case of smart cities in Finland, where the human waste of more than 100,000 inhabitants passes through a big bio-digester and people do not perceive it in a negative way. Mexico City was also planning large bio-digester projects for its sewer system, but there is no concrete implementation yet.

Regarding how the concept of Smart Villages can contribute to development in Central America, the Caribbean, and Mexico, participants considered that practitioners should start focusing more on technological innovations and motivate undergraduate and post-graduate students to apply these innovations. They also called for greater

attention to transportation, since mobility and connectivity are further aspects that challenge large urban centres and development. For instance, coffee production is still done by hand. Access to electricity could shorten the process of transporting the coffee to drying stations.

The issue of transport needs to be a key part of being smart, but we need to think of transport and the challenges of remoteness in holistic and innovative ways. For example, a smallholder farmer or SME manager in Africa could avoid a time-consuming and relatively costly trip to the bank in the nearest town if she was able to use mobile money. A remote village in the Borneo rainforest may face challenges in getting produce to markets in towns and cities, but may be able to profit from sustainable tourism through homestays in which the remoteness is a distinctive selling point. And technology can make a difference. For example, to obtain a spare part, one possibility is 3D printing in the village rather than transporting the part from a town—or, for a high value, low-weight item, use a drone.

There was interest in sharing knowledge about third-generation solar panels. This generation of solar technology has developed a lot worldwide with a whole series of new materials and devices that have a broader range and lower cost. However, the efficiencies achieved are not much better than silicon and cadmium telluride. Although more economic techniques will be necessary, especially for the region's countries that are less advanced technologically, new prototypes such as hybrid cells and semi-conductors are promising and can be integrated into homes. Silicon has been good but has problems of stability that have had to be solved. Some participants expressed concern that scientists and solar panel manufacturers have depended too much on silicon.

The legal aspects of renewable energy were also mentioned. Often there is legal ambiguity around renewable energy in Latin American and Caribbean countries. Legislative harmonisation for renewable energy remains an important goal. CARICOM has tried to harmonise legislation and to have strategic energy planning at a re-

Marc Antoine Archer and Ana Belio, Julian Despradel, and Viceminister Peralta

gional level, but this has been difficult. Likewise, OLADE and others have tried to unify agendas without much success either. There is also the United Nations project to eliminate incandescent light bulbs that it expects to implement by 2017, but this has not gone any further. Haiti and the Dominican Republic, two countries that share the same island, are expecting to reach a total population of almost 30 million people in 20 to 30 years' time, which might become a problem if there is not a common framework.

Moving to the question of maintenance of renewable energy installations, it was noted that support must be given to make them economically viable. It is important to consider the costs over the life cycle of the equipment, not just the up-front costs. Micro-hydro projects, for example, need investments of US$6,000-8,000 ; something as simple as sediments in the water can lead to deterioration of the turbines, undermining the project's viability. One organisation noted that they have been working with communities to create a culture of paying for electricity to cover the system operational costs, where households pay 250 pesos (US$5) per month for energy. When there is damage, the communities are able to pay for the turbine wheel or wheel repairs themselves. Likewise, in solar projects, tariffs allow for the repair not only of the batteries, but replacement of all components over time. Other communities created a fund that they use for productivity activities such as to plant crops, etc. They use this fund to make small loans at an interest rate of 1% per month, which allows them to have a sustainable financial model. The key is for energy to be used to generate wealth, not just something that makes people spend more.

On the issue of the battery life cycle, it was mentioned that some old batteries were used as chicken feeders, which can seriously damage people's health. When thinking about the recycling of solar cells or silicon, there have been some developments—such as companies that produce the cells agreeing to recycle the panels in 20 years' time. Recycling in general, and recycling batteries in particular, are both tremendously important. Batteries and renewable energy are good technological developments, but they also pose a social problem: creating a system for effective recycling of batteries.

Participants offered examples of their experience with local innovation. One organisation distributed devices to make water potable in 3–4 hours. One month later, they found that some women not only used them to disinfect the water but put chili there to dry it, so they began looking for other applications. Communities sometimes improve products for another use.

RURAL ENERGY ACCESS AND THE PRIVATE SECTOR

Sustainable social inclusion through renewable energy projects

Geovany Pineda, Renewable Energy Producers S.A (PERSIAN), Honduras

Geovany Pineda described a 99 MW windpower project being developed in Honduras, some two hours' drive from the capital city. The project places a strong emphasis on local participation in order to ensure its sustainability. A feasibility study was initiated in 2011, which mapped wind speeds in the area over a three-year period and established that it had good potential for power generation. The wind mapping also identified the best locations within the area to position the 30 turbines: they are located in several pockets of land distributed across the area. It is estimated that the set of wind turbines will have a capacity factor of 46% overall. It is planned to start construction in 2018.

Ensuring appropriate title to the land has been a key concern. The project has a 50-year concession from the government, but rather than buy the land required for the wind turbines it is leased from local landowners. This will provide the landowners with a regular income and help to

secure their support of the project. US$800,000 will be distributed each year to over 150 land-owning families. This is a major contribution to local incomes given that there is a high level of poverty in the area.

In order to get the required environmental licence from the government it was necessary to undertake a programme of engagement with local communities. The project will also undertake social assistance projects for local villagers. It is anticipated that a contribution of US$8 million will be made to local health, education and water projects over a 30-year period.

Wind- and solar-powered water pumps will enable irrigation of farmland and improve crop productivity. This includes irrigation for an avocado farm; Honduras spends 12 million USD each year on avocado imports, so the project will help the country's balance of payments. Biofuel projects are also being undertaken: the cultivation of Jatropha for oil, and domestic biogas digesters. A 3 m^3 digester costs US$850. They provide gas for homes— a simple gas cooker providing 3.25 kW of heat (and consuming 0.7 m^3/h) costs US$22 and a gas-powered lamp (consuming 0.07 m^3/h) US$6. Gas can also be provided for domestic water heating and for small gas engines.

The cost of the project is US$240 million in the form of foreign direct investment. In addition, a grant of US$50 million has been received for grid reinforcement: a 33 kV line will connect the generators to the national grid. A fixed price over 30 years has been agreed for the power generated. Employment during the 18-month construction period is anticipated to be 300 to 400 people.

Sustainable scenarios for Jamaica and the Caribbean, and the Caribbean Association of Sustainable Energy Professionals (CASEP)

Stephen Rhoden, Rho-Energy Consulting LLC, Jamaica

Stephen Rhoden outlined some key issues and opportunities for sustainable development in the Caribbean. Sustainability is not just for developed countries: it needs to be a key concern of all nations, not least countries such as Jamaica. Populations around the world are becoming more concerned about issues of sustainability. For example, in Jamaica there has been significant public opposition to a proposed aluminium smelter which would require an electricity supply of 1000 MW, more than the entire generating capacity of the island.

While fossil fuel has some advantages in being readily available and flexible, it pollutes and is often noisy. There is a range of sustainable alternatives, including new technologies such as hydrogen production and use. Energy efficiency is a key concern, and an important mechanism for greenhouse gas reductions. However, it is often neglected: for example, the indicator light on a microwave oven uses more energy than the microwave uses for cooking as it is on all the time. Recycling should be an integral part of system design, and can be a source of energy for the generation of electricity.

The energy water nexus is an important area: substantial amounts of energy are required to purify and deliver water and to treat wastewater. Countries that have good rainfall and elevation generally have high potential for hydropower generation. Globally, theoretical hydroelectric potential is 5.8 TW; in practice, economic potential is 1.0-1.4 TW, still a very large amount.

Stephen Rhoden concluded that there are many types of sustainable solutions and many applications. Systems should be designed with end users in mind, and public-private partnerships can make a good contribution.

PRESENTATION AND FIELD TRIP: ELECTRIC CONSORTIUM PUNTA CANA-MACAO

District Energy Project

Oscar San Martín, Electric Consortium Punta Cana-Macao, Dominican Republic

Prior to the field trip an introduction to the company and its activities in the Punta Cana area was given by Oscar San Martín, Commercial and Distribution Director of Consorcio Eléctrico de Punta Cana Macao (CEPM - Electric Consortium Punta Cana-Macao). Workshop participants then travelled to the nearby power generation and district heating plant where they made an informative tour of the facilities.

Six fossil fuel engines, each rated at 6 MW, operate in combined heat and power mode providing power and hot water (at 120 °C) to three major nearby hotels, and power to around 25,000 commercial customers and households in the area. Five of the diesel engines use heavy fuel oil; the sixth uses liquefied natural gas. They have an overall efficiency of 80%: 40% power and 40% heat. Supplemental heating is provided by a separate biomass plant rated at 2 MW which uses acacia wood chippings from a nearby plantation. The hot water is transferred by a 7 km pipeline to the three hotels, where it is used to drive absorption coolers for air conditioning and to provide hot water for use in the hotels.

The system operates in isolation from the national grid. When it was first set up over 20 years ago with a single diesel engine, there was no grid connection to this area in the east of the island. Tourism has increased rapidly over the subsequent 20 years, and the power generation and distribution system has expanded accordingly. While the electricity from the system is a little more expensive than that which would be available from the national grid (11 US cents/kWh as compared to 9 US cents/kWh), the quality and reliability of the power supplied is better than that which would be available from the national grid. Customers, particularly the hotels, are happy to pay this premium for the better quality service which is essential for their businesses. Operation independent from the national grid therefore remains an appropriate approach.

The consortium undertakes corporate social responsibility activities; for example, donating electricity to schools and health centres, investing in signalling and surveillance cameras for roads, and retrofitting safe electrical systems in homes. Representatives of the company also give lectures in local schools on environmental and power issues.

Smart meters are being installed, the aim being that all customers will have them and be able to choose between pre- and post-pay arrangements. The power generation plant and transmission lines are designed to withstand winds of up to 220 km/h.

Fior Daliza Bastardo Jimenez, Vilmaria Melna, Federico Grullon

Session III

HEALTH AND ENERGY ACCESS

The importance of the hospital information system and radiological information system (HIS/RIS) in rural areas

Modesto Cruz, ACRD, Dominican Republic

Modesto Cruz introduced the importance of radiological and hospital information systems—RIS/HIS (Radiology Information System/Hospital information System)—for health provision in rural areas. One of the problems in most countries, not only developing ones, is that specialised doctors generally live in urban centres, while rural areas tend not to benefit from the same level of health care facilities and also lack specialised medical staff. The Dominican Republic is currently setting up a health system using satellite connection and providing rural clinics with a simple X-ray and mammography system to enable the provision of radiology services all over the country. This is following the example of Japan, which faces a similar challenge as the level of health provision is not uniform across the different islands that make up the country.

About 47 rural clinics have been established to date in the Dominican Republic. These centres face a double challenge: 1) the lack of sufficiently good quality electricity to run the equipment; and 2) the lack of qualified personnel. Challenges also include the inability to take complex/advanced images that require more sophisticated equipment.

RIS is used to follow up patients remotely. It consists of a combination of all the information available for a patient (including all the medical records, images, and diagnosis). The information is password protected. RIS allows specialised medical personnel to access, provide a diagnosis and recommend treatments based on a patient's information from anywhere in the country. At the site where the images are collected technological requirements are kept to a minimum, while great storage and analytical capacity is developed in the central hospital where the analysis is done. The system enables multi-tasking, from the collection of images to reconstructing them in three dimensions (from image stacks), and creating filters. The speed of collecting and analysing images is reduced by viewing four images in one, which reduces the amount of data required for storing them and makes it possible to use a single server. Images do not need to be printed, and can be viewed on a smartphone, which also facilitates provision of services everywhere in rural areas.

The potential use of renewable energy sources for rural clinics

Julian Despradel, IANAS/ACRD, Dominican Republic

Julian Despradel reminded workshop participants that rural clinics have several requirements in order to be able to provide a good quality service to the communities they serve. These include sustainable energy sources; access to clean water and to hot water; refrigeration facilities for vaccines and medications; the provision of minimal medical and IT equipment; and of course, trained medical personnel.

Renewable energy sources are the most flexible and sustainable form of energy provision in rural areas not connected to the grid. Solar panels can be used for the generation of electricity and for heating water, while other technical solutions, such as wind micro-turbines and micro-hydro power stations can also be used, either in isolation or as hybrid systems, which may also include diesel generators.

Julian Despradel also shared with the participants the experience of the Barefoot Initiative in India, which trains older, illiterate women in villages to become solar energy technicians. The women

leave their communities and train for six months in the Barefoot College before returning to their villages.

Telemedicine

Herwin Speckter, CEDIMAT, Dominican Republic

Health provision everywhere in the world is centralised. For this reason, explained Herwin Speckter, local solutions are required to provide high quality, safe and affordable health services in rural areas. These could in part stem the migration of people from poorer to richer countries and from rural to urban areas in search of better services, which include health.

In the Dominican Republic, while there is a concentration of people in the two main cities, two thirds of the population live in rural areas. The health sector of the country has greatly increased in the last two decades. However, two pervasive problems are that distance and cost limit access to specialised equipment (such as resonance) which tend to be in hospitals in urban centres, and that the best doctors and specialised medical personnel live in cities. Telemedicine can improve access in three areas; 1) tele-diagnostic; 2) tele-treatment, such as remote surgery, an incipient area since people distrust robots; 3) education of local doctors by the best, specialised national and international doctors in urban hospitals.

The focus in the Dominican Republic has been tele-radiology, where satellite centres with simple technologies are connected via the internet to a diagnostic centre, such as CEDIMAT, equipped with advanced technologies and specialised doctors. Images can be collected in satellite centres and transferred to the diagnostic centre where they are processed and analysed. Doctors can also access the information, which is password protected, via a smartphone for diagnosis or to provide a second opinion. A key concern is the handling and safe storage of personal, confidential data to prevent its inappropriate access and use. Tele-radiology allows rural clinics to provide a specialised service even if the local medical personnel are not specialised.

There are several IT systems for health: tele-radiology; PACS (Picture Archiving and Communication System); RIS (Radiology Information System), a "clinic without paper" where all the information is digital; HIS (Hospital Systems Information); and teleconferencing. The patients' data is centrally stored and accessible to all the medical staff with a password, and can also be shared with doctors from specialised hospitals abroad for a second opinion on the diagnosis. Telemedicine is also very important for training and capacity building.

In the Q&A, a participant enquired about the source of funding for CEDIMAT. It is registered as an NGO and a not-for-profit organisation, directed by a patronage composed of several prominent people in the country. It is independent of the country's politics. With a large social programme, it provides treatment for free to low-income patients.

What has to be changed in the health systems of countries in the region to make telemedicine a reality? This question is pertinent in particular in countries in Central America where even some of the urban hospitals are not adequately equipped to provide radiology and ultrasound services. Very often patients are referred to private health centres with a coupon and have to pay for the services. For expanding telemedicine, advanced equipment is installed in rural health centres with no specialised medical staff and therefore the private sector makes the virtual connection with doctors in urban hospitals. Modesto Cruz added that establishing the appropriate legislation in the country is critical to support telemedicine in rural areas. The Dominican Republic created two legislations: 1) the 87-01 law, which pertains to the national system for social security, and 2) the law 46-01 which applies to the national health system. This led to the decentralisation of

the health service nine months ago. The medical staff members are not directly appointed by the Minister of Health in the capital, and hospital directors are chosen through national competitions. Positions were not only open to medical doctors but also to other professionals with relevant qualifications. This has been a very positive change for the sector.

A participant enquired about the coverage of health centres in the country, and the number of active doctors. Also mentioned was the situation in Mexico, where current policies are leading to the establishment of very large and well-funded hospitals that have had a significant impact in dealing with certain medical conditions. However, a criticism of this approach is that specialised medical attention is sometimes given priority, in terms of funding, over primary health needs. Modesto Cruz explained the health system of the Dominican Republic. The country has adopted a system of national social security cards, which covers the health needs of all the people whose resources are below a given threshold. People with higher means have to partly finance interventions. The health system in the country is constituted by 1) a public network of hospital and rural clinics (which are not necessarily free); and 2) private health institutions which also benefit from some government contributions, and where services can also be obtained using the social security card; 3) hospitals for government institutions, such as police, army, etc. In the last few months the task of integrating all the hospitals and health centres has started. Coverage in the country, to date, is about 60%.

In terms of health provision in rural areas, the quality of the electric current is important since changes in the current can produce distortion in the medical images and negatively affect diagnosis. Unstable currents can also break expensive equipment. The continuous need to rely on the physical transportation of medical images from rural health centres to urban hospitals currently costs the country between US$0.5-1 million each month; therefore it is essential to consider alternative forms of health provision.

RENEWABLE ENERGY FOR ENERGY SECURITY AND RURAL DEVELOPMENT III

Awareness of sustainable energy use in formal environmental education

Jose Amado Rodriguez, Ministry for Education, Dominican Republic

Jose Amado Rodriguez described the education system in the Dominican Republic, which currently has fewer than three million students, and the current government plan to introduce extended schooling days for all ages. The number of students currently under this scheme is just above half a million. Substantial funding has been allocated to this scheme, which includes the provision of meals to students. Education on environmental issues is part of the curriculum, promoted by two laws. The government is providing training to teachers in workshops and organising events for students on the importance of renewable energy sources for the country's development. New didactic material is being developed with an emphasis on inter-disciplinarity and a number of projects to train personnel are underway. A challenge is the high turnover of staff, which means that training has to be ongoing.

In the Q&A, a question was posed as to whether there are schemes for students and university staff that require them to engage in rural areas. Students have a minimum requirement to spend 30 hours doing social services (e.g. hospitals) and 30 hours providing environmental services (such as engaging on reforestation activities). The longer school day was also established for social reasons, following a big increase in the investment in education which led to a doubling of classrooms. Longer school days benefit poor households headed by single women, by enabling women to work and by providing meals to children.

Decentralised energy systems for clean energy access

Isa Ferrall, University of California, Berkeley

Isa Ferrall introduced the Renewable and Appropriate Energy Laboratory (RAEL) of the Energy and Resources Group (ERG), established in 1999 by Dan Kammen in Berkeley, California, which aims to develop and implement science, engineering, and policy tools to solve problems of inequality in access to energy services around the world. The group has over 25 researchers from several disciplines, partnering governments, non-profits, and several companies and institutions around the world.

Why is energy access important? Access to electricity is closely linked with improvements in human development, including productivity, health and safety, gender equality, and education. Work published last year in the Nature Climate Change journal indicates that access is a first order linear predictor of human development index.

Major recent developments in terms of supporting technology for energy access include the recent increase in light source performance (LED lamps) and ICT/mobile phone penetration access. The latter is particularly important in promoting Pay-as-you-go (PAYG) financing systems for energy employed in Africa by several solar power companies, including M-Kopa and Off Grid Electric, and increasingly being used in other parts of the world. PAYG accelerates access (~2-3x higher uptake) by: 1) providing financing for customers and supply chain players; and 2) improving trust in off-grid power by spreading risk.

The large data sets generated by companies present an unprecedented opportunity to examine individual behaviour with respect to household energy usage, payback time, and uptake, over time and over large geographic areas. Large data sets can: 1) predict micro-trends through macro analysis; 2) identify relationships between energy profiles and other variables; 3) provide a feedback loop for optimising future designs.

Off Grid Electric (OGE) operates over 100,000 systems in Tanzania, Rwanda and Cote d'Ivoire. The collaboration will generate insight into household energy usage patterns and influencing factors and lead to better system design.

Third generation photovoltaic systems

Wendy Guerra, World Bank, Bolivia

Achieving universal access in Latin America will require a further five to 10 years; what remains now are most remote and harder to reach areas, making the provision of sustainable access to energy more expensive, explained Wendy Guerra. In terms of technology on PV systems, the first generation of the 80s usually had hybrid technology—an adapted car battery—weighed about 60 kg and cost about US$1000. Improvements in the second generation (developed in the 2000s) included the incorporation of a lead battery, allowed charging of mobile phones and other appliances, and cost about US$700. Further improvements led to third generation systems: the battery is lithium ion, the system uses LED instead of fluorescent lamps, and importantly both the cost and the weight are much reduced: US$350 and 6kg.

An analysis was carried out of the existing institutional models for the distribution of traditional (second generation) PV systems. In Bolivia, with the projects IDTR and GPOBA, with 17000 beneficiaries, distribution followed the development of markets, with a partial subsidy from the government (60%, with the beneficiary having to pay the rest). The company had to find customers, and the sustainability of the system was the responsibility of the users after the end of the operation and support contracts, which typically lasted two to four years. The most common problem was the battery, which determined the useful life of the systems. In Argentina and Peru, the system was

regulated, which implied an obligatory service provision. The responsibility and maintenance of the system fell on a specific distribution company, and users were only responsible for paying a monthly tariff. The State's role was to regulate the service, pay a subsidy to the distributors, and determine the areas of intervention.

Regulated access has several advantages: the distributing company has the responsibility for the provision of the service and for maintenance and support, while the user only needs to pay a tariff, which should ensure the sustainability of operations. This distribution model also allows the determination of priority areas and can introduce a quality control step in the technologies deployed. Problems include the costs and time of maintenance; the costs of administering delayed payments; and the fact that the monthly tariffs are usually lower than the operation costs, which means that the system relies on subsidies from the state.

Third generation systems have several advantages, in terms of performance but also in terms of costs and ease of transport and installation (plug and play technology) which can be done by the users. A challenge remains how to deploy this technology to maximise the number of people who benefit from it. The cost of these systems was determined in the three countries, both in terms of the initial investment and the replacement of parts and maintenance over time. In conclusion, it is important to reconsider the technological solutions and the different distribution models available to achieve universal energy access.

In the Q&A session, a participant observed that the third generation photovoltaic systems would be very appropriate for the Caribbean islands, not necessarily only in places with no connection to the grid, but for households that are connected but cannot afford the cost of electricity. In terms of joining a project run by the World Bank, national governments have to make a formal request for a loan, and once granted the government will be in charge of managing the project.

Another participant pointed out that it is important to reflect on how much access to very basic levels of energy can contribute to achieving SDG7, since these may not be sufficient for productive uses. While the third generation photovoltaic systems distributed are intended to cover the most basic energy systems, their modularity does allow capacity to be increased to support productive uses.

In order to achieve smart villages it is important not to remain at the lowest level of energy access and to define the quality of life that people in smart villages should have. Sustainable financing systems are essential for the provision of energy services, and more research is needed on small, autonomous, and cheaper energy systems. In the consideration of the choice of technology in off-grid systems, it is important to consider cost implications to select the most appropriate technology mix.

Discussion session III: Policy recommendations

How useful is the Smart Villages concept for the region? What policy changes are needed to allow off-grid systems to contribute to universal energy access?

It is important to define the dimensions and the objective of the initiative, with financing mechanisms being key. One problem is that a large proportion of the funding available for energy access is spent on bureaucracy (sometimes on the creation of a new organisation or a secretariat), leaving very little funding for implementation activities. Another problem for countries in the region is that most no longer qualify for funding for developing countries. However, national governments often do not have the resources and the capacity to take over development projects. A problem specific to Haiti is that while the country

does qualify in terms of development index, it cannot access financing because it fails to qualify for credit.

In terms of the Smart Village concept, it is important to define where the gaps exist, and how these can be filled. By the middle of the century, 70% of the population will live in urban areas: smart villages provide an opportunity for the remaining 30%. In addition, clean technologies contribute to rural development, but can also mitigate the effect of climate change. It is important to position people in the centre of an intervention, and select the appropriate technologies and financing mechanisms to suit the beneficiaries. It is also essential to streamline and improve financing mechanisms for development to optimise it, since currently there is a lot of duplication and loss of impact.

Critical for impact is not the provision of energy sources to off-grid communities, but rather supporting the development of these communities in all relevant areas, not only in economic terms but also in personal and social spheres. There is a need to give more emphasis on learning from past experiences to improve future interventions. A large number of studies have been carried out, and although the data and information exists it is not used effectively.

Many countries are actively increasing the proportion of sustainable energy sources in the national energy mix, through the development of supporting regulations. Similarly, the development of smart villages also requires the development of appropriate legislation to define objectives and specify a minimum level of quality. This is essential to promote the economic and social development of the target population. Energy provision needs to be accompanied by the provision of complementing services, such as education and health. Smart Villages should change its focus from energy delivery to the delivery of development, promoting synergy and cooperation between different actors in the sector.

Participants commented on the presentations in a Q&A session

Annex 1: Workshop Programme

Regional Workshop: Sustainable energy sources for rural development and climatic resilience of off-grid communities in Central America, the Caribbean and Mexico

Hotel Bávaro Palace Deluxe, Punta Cana, the Dominican Republic

16-18 November 2016

Workshop Programme

16 November

Welcome addresses

Chair: Modesto Cruz

09:00 Welcome and workshop presentation
Bernie Jones, Smart Villages
Milciades Mejia, National Academy of Sciences of the Dominican Republic

09:10 Opening of the Workshop
Ministry of Energy and Mines, Vice Minister Ernesto Vilalta; Dominican Republic

09:20 The Smart Villages Initiative
John Holmes, Smart Villages

09:40 Regional overview of renewable energy for rural electrification
Alexandra Arias, Latin American Energy Organization (OLADE)

10:00 Guide to a sustainable energy future for the Americas: a book of IANAS
Claudio Estrada, Inter-American Network of Academies of Sciences (IANAS), Mexico

10:20 Coffee break

Renewable energy for energy security and rural development I

11:00 Central American Fund for Access to Energy and Poverty Reduction (FOCAEP)
José María Blanco, Fundación Red de Energía (BUN-CA), Costa Rica

11:20 Growing clean energy access in rural communities in SIDS: the role of data and analysis
Rebekah Shirley, the Energy and Resources Group, University of California, Berkeley

11:40 Potential renewable energy use in rural communities in Haiti
Marc Antoine Archer, President - Director General, Observatoire de l'energie en Haiti

12:00 Overview of the development of renewable energies in the Dominican Republic
Julian Despradel, Focal Point Energy IANAS-ACRD, Dominican Republic

12:20 The legal framework of renewable energies in the Dominican Republic
Blas Minaya, Blas Minaya & Associates, Dominican Republic

12:40 Community projects implemented by the National Energy Commission
Yderlisa Castillo, National Energy Commission (CNE), Dominican Republic

13:00 Lunch

Renewable energy sources for risk management and natural disasters

Chair: Claudio Estrada

14:00 Conclusions of the Smart Villages workshop in Singapore
Bernie Jones, Smart Villages

14:20 Rural electrification characteristics and resilience to climate change and risk mitigation in Central America and the Caribbean
Marco Antonio Rodriguez, World Bank

14.40 Disaster risk management and renewable energy
Dennis Funes, United Nations Development Programme (UNDP)

15.00 Coffee break

15:30 Discussion session I

17.00 End of Day

19:30 Welcome cocktails, *La Palapa*

17 November

Renewable energy for energy security and rural development II

Chair: Julián Despradel

9:00 Lessons learned from the implementation of off-grid energy systems with sustainable energy sources
Hugo Arriaza, Rural Electrification and Resilience Consultant, Guatemala

9:20 Renewable energy and GEF small grants programme
Ita Jah Simmons, Department of Environment, Antigua and Barbuda

9:40 Renewable energy for energy security in St. Vincent and the Grenadines
Ellsworth Dacon, Director, St Vincent y the Grenadines

10:00 Renewable energy projects and climate change
Ana Sofía Ovalle, Fundación Sur Futuro, Dominican Republic

10:20 Coffee Break

Technological innovation

11:00 Research in the solar cells field
Arturo Fernandez Madrigal, Renewable Energy Institute, National Autonomous University of Mexico, Mexico

11.20 Model of sustainable energy matrix: wind, solar and biogas energy for rural schools with extended teaching hours
William Ernesto Camilo Reynoso, APEC University (UNAPEC), República Dominicana

11:40 Discussion session II

13:00 Lunch

Rural energy access and the private sector

14:00 Sustainable social inclusion through renewable energy projects
Geovany Pineda, Renewable Energy Producers S.A (PERSIAN), Honduras

14:20 Sustainable scenarios for Jamaica and the Caribbean, and the Caribbean Association of Sustainable Energy Professionals (CASEP)
Stephen Rhoden, Rho-Energy Consulting LLC, Jamaica

14:40 District Energy Project
Oscar San Martin, Electric Consortium of Punta Cana-Macao

Field trip to the power plant Electric Consortium Punta Cana-Macao

15.30 Depart hotel

17:00 Return to hotel and end of day

18 November

Health and energy access

Chair: Dennis Funes

9:00 The importance of hospital information system and radiological information system (HIS/RIS) in rural areas
Modesto Cruz, National Academy of Sciences of the Dominican Republic

9:20 The potential use of renewable energy sources for rural clinics
Julian Despradel, Focal Point Energy IANAS-ACRD, Dominican Republic

9:40 Telemedicine
Herwin Speckter, Diagnostic Center for Advanced Medicine and Telemedicine (CEDIMAT), Dominican Republic

10:00 Coffee Break

Renewable energy for energy security and rural development III

10.40 Awareness of sustainable energy use in formal environmental education
José Amado Rodriguez, Ministry for Education, Dominican Republic

11.00 Decentralised energy systems for clean energy access
Isa Ferrall, the Energy and Resources Group, University of California, Berkeley, United States

11:20 Third generation photovoltaic systems
Wendy Guerra, World Bank, Bolivia

11.40 Discussion session III

13:00 Closing of the workshop

Annex 2: List of participants

Title	Name	Surname	Organisation	Position	Country
Dr.	Marc Antoine	Archer	Observatoire de l'Énergie en Haïti - ObservEH	Presidente	Haití
Sra.	Alexandra	Arias Alvarado	OLADE	Coordinadora Electricidad	Ecuador
Sr.	Hugo Romeo	Arriaza Morales	Innovación Tecnológica /CIDTEC	Director	Guatemala
Dr.	Almas Taj	Awan	Global Young Academy	Elected Member and Co-chair GYA-SVI project collaboration	Brazil
Srta.	Fior Daliza	Bastardo Jimenez	Aurora 89.9 fm	Periodista	República Dominicana
Dr.	Ana María	Belio	ObservEH	Directora Ejecutiva	Haití
Sr.	Jose Maria	Blanco Rodriguez	Fundación BUN-CA	Director Ejecutivo	Costa Rica
Dr.	William Ernesto	Camilo Reynoso	Universidad Apec-UNAPEC	Docente investigador	República Dominicana
Sra.	Yderlisa	Castillo	Comisión Nacional de Energía	Encargada División Energía Renovable	República Dominicana
Sra.	Judi	Clarke	J F Clarke Consulting Inc.	Director	Barbados
Ing.	Arturo	Del Villar	Instituto Tecnológico de Santo Domingo	Decano de Ingenierías	República Dominicana
Ing.	Julian Oscar	Despradel Bello	Consultor Independiente en Energía	Consultor Independiente en Energía	República Dominicana
Dr.	Claudio A	Estrada	UNAM Tucson / IER	Director/ Investigador	México
Dr.	Arturo	Fernandez'Mad-rigal	Universidad Nacional Autónoma de México	Investigador Titular	México
Srta.	Isa	Ferrall	UC Berkeley, Renewable and Appropriate Energy Lab	MS/PhD Student	USA
Sr.	Dennis	Funes	Programa Naciones Unidas para el Desarrollo	Especialista de Programa Cambio Climático	Honduras
Sra.	Wendy Claribel	Guerra Navarro	Banco Mundial	Consultora	Bolivia

Dr.	S. Karly	Kehoe	Global Young Academy/ Saint Mary's University	Canada Research Chair in Atlantic Canada Communities	Canada
Dr.	Guillermo	Lagarda	Inter-American Development Bank	Country Economist/ Energy Economist	México
Sra.	Vilmania	Malena Nuñez	Ministerio de Relaciones Exteriores	Ministra Consejera, Diplomacia Urbana y Parlamentaria	Santo Domingo, Republica Dominicana
Sr.	John	Millhone	U.S. National Academy of Science	Energy Program Manager	United States
Lic.	Blas	Minaya Nolasco	Blas Minaya y Asociados, Oficina de Abogados y Academia Latinoamericana Superior (ALAS)	Presidente / Director General	República Dominicana
Ing.	Ana Sofía	Ovalle	Fundación Sur Futuro	Oficial de Cambio Climático	República Dominicana
Lic.	Evergito	Peña Acosta	Consejo Nacional para el Cambio Climático y el MDL	Director Administrativo Financiero	República Dominicana
Dr.	Amaurys Giordano	Perez Vargas	Caribe Cultural	Director	República Dominicana
Sr.	Geovany	Pineda	Productores de Energía Renovable S.A., PERSA	Gerente General	Honduras
Dr.	Stephen	Rhoden	RHO-Energy Consulting LLC / Caribbean Association of Sustainable Energy Professionals (CASEP)	CEO and Senior Sustainability Consultant/ Curator	United States of America
Lic.	María	Ripol Royer	Caribe Cultural	Responsable de comunicacion	República Dominicana
Sr.	Marco Antonio Joaquin	Rodriguez Corrales	Consultor Independiente	Consultor	Bolivia
Dr.	Carlos Manuel	Rodríguez Peña	Ministerio de Educación Superior, Ciencia y Tecnología (MESCYT)	Director Investigación en Ciencia y Tecnología	República Dominicana
Sr.	Jose Amado	Rodriguez Tiburcio	Ministerio de Educación	Director del Departamento de Educación Ambiental	República Dominicana

Ing.	Jimmy	Rosario Bernard	UASD	Director de Informatización	República Dominicana
Sr.	Alberto	Sanchez	Programa de Pequeños Subsidios	Coordinador Nacional	República Dominicana
Dr.	Rebekah	Shirley	University of California, Berkeley	Postdoctoral Researcher	Trinidad and Tobago
Ing.	Ita Jah	Simmons	Department of Environment	Engineer/ Technical Officer	Antigua & Barbuda
Sr.	Herwin	Speckter	CEDIMAT	Gerente Tecnología Médica	Germany / Dominican Republic
Ing.	Enrique	Toledo Toledo	Acciona Microenergía México	Gerente de Acciona Microenergía México	México
Ing.	Ernesto Angel	Vilalta Garcia	Ministerio de Energía y Minas	Viceministro de Energía	República Dominicana
Sr.	Horace	Williams	Hinterland Electrification Company Incorporated, Ministry of Public Infrastructure	Chief Executive Officer	Guyana
Smart Villages Team:					
Dr.	Claudia	Canales	Smart Villages	Project Manager	UK
Ms.	Sandy	Evans	Smart Villages	Administrator	UK
Mr.	Richard	Hayhurst	Smart Villages	Communications Director	UK
Ms.	Molly	Hurley-Dépret	Smart Villages	Storyteller and Policy Manager	US
Dr.	John	Holmes	Smart Villages	Project Co-Leader	UK
Dr.	Bernie	Jones	Smart Villages	Project Co-Leader	UK
Sra.	Roberta	Mutschler	Smart Villages	Research Assistant	Chile

Image Credits

Sunrise, Punta Cana, Dominican Republic/Joe deSousa/Public domain

SMART VILLAGES
New thinking for off-grid communities worldwide

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