SMART VILLAGES
New thinking for off-grid communities worldwide

# Sustainable energy sources for off-grid rural communities in Bolivia: opportunities, challenges, and perspectives

**Workshop Report 17**

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## Smart Villages

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

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## Publishing



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## Contents

## Summary

As a result of an active government-led rural electrification programme, 82% of Bolivia's households (in both urban and rural areas) had access to electricity in 2012. However, 2.5 million people still live without a clean and sustainable energy source and rely on diesel, kerosene, and candles for lighting. The lowest levels of rural electrification in the country are found in the Departments of Beni and Pando, which are isolated and sparsely populated, and where access to rural communities is particularly challenging and expensive. Rural households in the whole country depend largely on biomass as a source of energy and traditional wood burning stoves for cooking, which has important environmental and public health consequences, in particular for women and children.

The Political Constitution of Bolivia establishes that access to electricity is a citizen's right, and the country aims therefore to achieve 87% electricity coverage in rural areas by 2020 and to be fully electrified by 2025, objectives set out in the National Development Plan. Key challenges to achieve universal access include reaching "last mile" communities where remoteness and isolation make rural electrification technically challenging and expensive; ensuring the sustainability of energy access initiatives; and promoting productive uses of energy to foster rural development.

The Smart Villages Initiative organised a workshop on access to, and use of, renewable energy sources for rural communities in Bolivia on April 28, 2016, in La Paz, Bolivia to facilitate analysis and exchange of experiences of electrification of off-grid rural communities in Bolivia. The workshop brought together representatives of the public sector, international, and regional organisations, NGOs, academia and the private sector institutions.

The current energy set-up of the country was outlined by Raúl Villarroel Barrientos, representative of the Vice Ministry of Electricity and Alternative Energies (VMEEA). The national grid system supplies eight of the country's nine departments, and its energy matrix is 72% thermal generation derived from natural gas, 26% from hydroelectric power plants, and 1.8% from renewable energy, with a total capacity of 183.1 MW. Bolivia is aiming to increase the contribution of renewable energy to the matrix and to develop as an energy exporting country in the region, and Bolivia is currently developing the regulatory framework for the use of renewable energy.

The electricity programme "Vivir con Dignidad", or "Living with Dignity", (PEVD) was established as the operating branch of the VMEEA to achieve universal access to electricity in rural areas by 2025 with the participation of municipal governments and the private sector. In her presentation, Isela Bermúdez described the different programmes within PEVD. Four of these were completed between 2011 and 2015, benefiting 64,800 families with an investment of US$46 million. Seven more are currently being executed, three of which are to be concluded in 2016 and are expected to benefit 74,600 families and 21 health posts, with a total investment of US$129.2 million. These include the Project of Decentralized Infrastructure for Rural Transformation II (IDTR), which is extending electricity grids, increasing their densification and distributing home photovoltaic systems; and the Global Partnership Output Based Aid (GPOBA).

In his presentation Miguel Fernández, from Energética, described the technological improvements in the third-generation photovoltaic systems that are currently distributed through the IDTR, in terms of increased efficiency and also because of a significant reduction in the cost and weight of the systems. He also presented the results of a study to validate their performance, which involved 120 families in Bolivia and Argentina from three different ecoregions in each

country: high plateau, valleys, and the semi-arid lowland. Edgar Terrazas, also from Energética, focused in his presentation on the challenges in the implementation of the IDTR and GPOBA projects.

Ivan Fernandez described the initiative for the electrification of social facilities, which was carried out between 2009 and 2014 as part of the global programme Energising Development (EnDev), implemented in Bolivia by the German Cooperation Agency (GIZ). The programme aimed to improve schools, health centres, and community centres through the provision of solar photovoltaic and solar thermal energy systems. Key requirements for the long-term sustainability of projects were discussed.

Mónica Cuba from Practical Action, an international NGO, described the construction of a 60 kW micro-hydro scheme in the village of Amaguaya in the Municipality of Guanay, which involved the active participation of the community. The project resulted in the creation of a community electricity utility, which is managed by the community itself according to national standards with local procedures for the users. David Whitfield introduced Cedesol, a Bolivian NGO that since 2003 has disseminated clean technologies for cooking with a strong emphasis on training and capacity building of the targeted communities.

Representatives of the private sector included Ronald Cavera from Phocos, a company that delivers technological proposals to supply power to off-grid communities, who described an approach of delivering basic energy solutions as a first step to the energisation of off-grid communities. Ivailo Peña, from Servicios Integrales de Energía (SIE), a private company based in Cochabamba, described the project Punto Solar, which aims to establish a network of suppliers of renewable energy technologies in rural areas of Bolivia. Finally, Rodolfo Astete from Sico Sol, a company distributing solar water heaters, related their experiences in providing hot water solutions to community facilities in rural, off-grid communities in Bolivia.

Key points discussed included the need to achieve much better levels of communication and coordination to deploy integrated solutions that address simultaneously the complex sets of challenges that rural communities face. These include improving access to clean water for household consumption; developing better water management solutions to increase the availability of this resource for agriculture; waste management solutions; improvements in basic infrastructure (such as roads and public services); and strengthening local value chains and access to markets. Integrated solutions require cooperation across different government ministries and agencies as well as cooperation among professionals from different disciplines.

Participants agreed that sharing and learning from experiences, both successful and unsuccessful, are very important, and this implies establishing more extensive and systematic evaluation and monitoring activities. The long-term sustainability of projects also requires a commitment beyond the implementation phase since long-term engagement with communities is critical for their ownership of the project and for building up capacity to maximise the potential use of energy systems and ensure their maintenance.

Participants reflected that several recent energy access initiatives have promoted the establishment of rural enterprises to encourage productive uses of energy, yet these have failed to remain in operation after the implementing agencies withdrew support at the end of the projects. Greater emphasis is needed on fostering an entrepreneurial spirit in rural communities, building local capacity to run and manage enterprises, and making sure there is a demand for the outputs of the enterprises that are created.

The government plays a critical role in the process of rural electrification, agreed the participants,

both directly through promoting integrated interventions and indirectly by establishing the conditions that allow the private sector to invest and operate in the rural energy space. In this respect, "intelligent subsidies" were discussed as a possible solution to increase the reach of new technologies by resource poor people without negatively impacting the market in the long run.

Smart Villages' John Holmes discusses energy solutions with participants from the workshop.

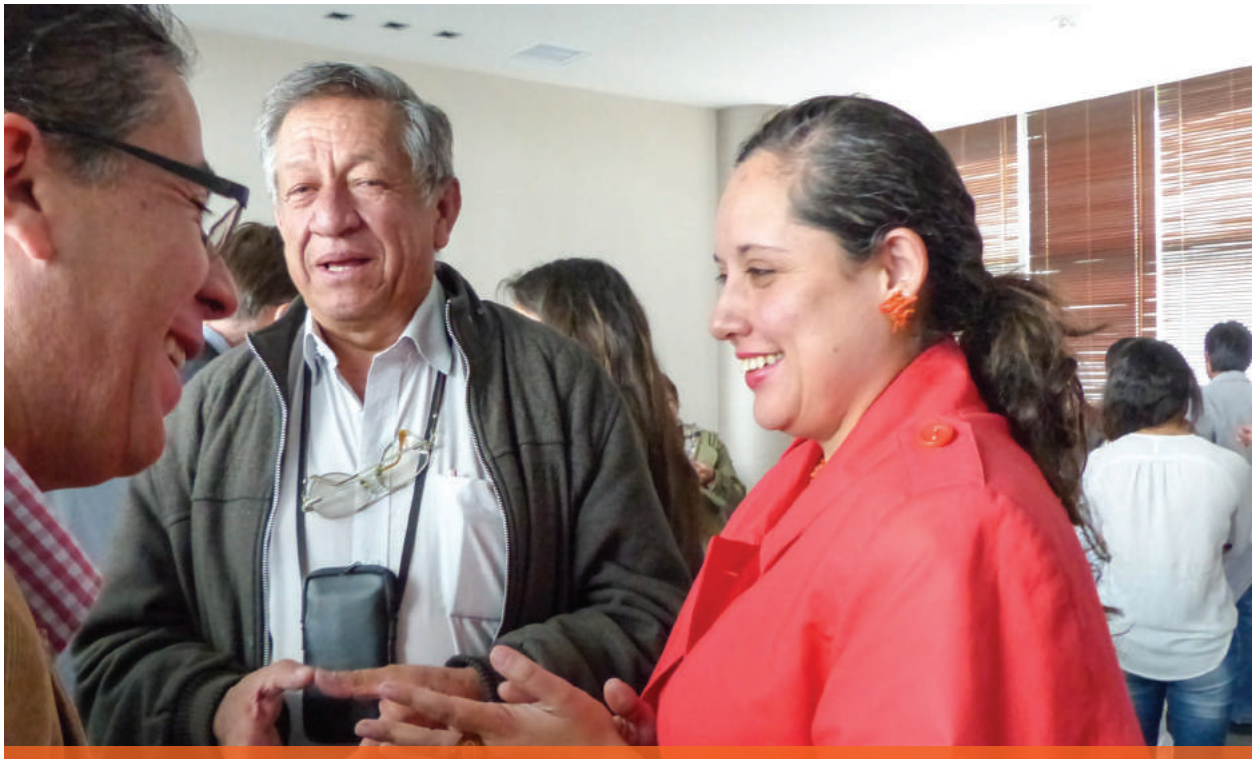
## Introduction

Bolivia has the aim of achieving universal access to electricity by 2025, a goal set in the country's constitution, and which all stakeholders target. Typically, households affected are in remote areas with sparsely populated communities. The efforts of international organisations and NGOs are also geared towards supporting the government's efforts for universal access to electricity, with an emphasis on sustainability and on productive uses of energy.

The Smart Villages Initiative organised a workshop on access to, and use of, renewable energy sources for rural communities in Bolivia on April 28, 2016, in La Paz, Bolivia. The aim of the workshop was to facilitate analysis and exchange of experiences of electrification of off-grid rural communities in Bolivia. The workshop brought together representatives of the public sector, international and regional organisations, NGOs, academia and the private sector.

Workshop participants described some of the opportunities and challenges of working in rural energy access in Bolivia. The topics discussed included distributed generation and the penetration of renewable energy sources (RES) in the energy matrix; the productive use of energy in rural communities; clean cooking technologies; the use of efficient heating; and entrepreneurship in the rural energy sector. A key concern was to outline new approaches for poverty reduction through access to, and use of, sustainable energy sources.

This report summarises the presentations made in the workshop and the consequent discussion. Annex 1 sets out the workshop programme and Annex 2 adds the list of participants. Copies of the presentations (mostly in Spanish) are available on the Smart Villages website: www.e4sv.org.



Participants discuss their work at the break.

## The field visit

The workshop was preceded by a visit to the Centre for the Demonstration of the Use of Renewable Energies of the Catholic San Pablo University of Bolivia (Universidad Católica Boliviana San Pablo). The facility was established in 2010 in the Academic Farming Unity (Unidad Académica Campesina, UAC) to provide a platform for the display of different renewable energy technologies for lighting and for productive use, and also to serve as a training centre for students and members of the community, notably nearby Batallas. The Centre is the result of the Joint European-Latin American Universities Renewable Energy Project (JELARE) with funding from the European Union, and was a collaboration with the University of Applied Sciences of Hamburg, Germany, and the University of the South, Santa Catarina, Brazil.

Systems tested at the centre include a solar home system, a solar drier, solar panels for refrigeration units (the community produces cheese and meat products), a thermal water heater, a biogas digester, a solar irrigation system. However, five years after the completion of the project, most of the systems are no longer operational.

The problem of long-term sustainability of projects was discussed during the field trip, in particular when the financial resources needed for follow-up and for maintenance of the equipment are not allocated at the start of the project, and when users do not fully understand how to use and maintain the equipment. Also discussed were the practical problems of replacing obsolete technologies (such as inefficient light bulbs) and of collecting and recycling components of the technology no longer in use, especially when they contain toxic elements (such as lead batteries or parts with asbestos). Participants agreed on the importance of follow-up activities and of information gathering on unsuccessful initiatives to learn from past mistakes.

Workshop participants had the opportunity to visit solar projects in Bolivia.

## Session 1

### The Smart Villages Initiative

Claudia Canales, Smart Villages Initiative

Claudia Canales opened her presentation by pointing out that more than one billion people lack access to electricity worldwide, and around three billion people prepare their food using dirty and dangerous stoves. As a result, four million people die each year, and the majority of them are women and children. The rationale behind the Smart Villages Initiative, which focuses on off-grid rural communities, is to study the ways in which universal access to affordable, safe, sustainable and modern energy can be ensured by 2030. Energy is not considered an end goal in itself, but rather a catalyst for development in areas such as food security, education, health services and welfare, communication and democratic participation, as well as a promoter of new undertakings involving the supply and use of energy services. These are the characteristics that determine whether a village is "smart".

To achieve this, the Smart Villages Initiative works with stakeholders in the public and private sectors who are involved in rural electrification programmes. Through a range of activities that includes workshops, communication activities, political interaction and impact studies, the initiative links the different experiences of political leaders, donors and development agencies to create more effective policies and interventions for energy access. These activities provide the various stakeholders with new perspectives and ideas—technological, financial, and political—to overcome obstacles and increase their projects' impact.

The smart villages concept has been developed as a corollary to smart cities, a concept that has received great attention from the major stakeholders in energy and development policies. It should be noted, however, that 47% of the world population and 70% of the people living in poverty live in rural areas: rural energy poverty, therefore, cannot be ignored. Many technological developments currently enable rural areas to benefit from the same opportunities as cities.

The Smart Villages team is based at the Universities of Oxford and Cambridge in the United Kingdom and has six regional programmes in West and East Africa, South East and South Asia, and South and Central America. The initiative is funded by two non-profit organisations: the Cambridge Malaysian Education and Development Trust and the Templeton World Charity Foundation. The national science academies and their regional bodies are key partners together with the non-governmental organisation Practical Action (Soluciones Prácticas in Latin America).

To date, the Smart Villages Initiative has determined several conclusions, including the need to maximise the impact of public funds used for investments in infrastructure. This requires providing access to new sources of financing, simplifying the necessary procedures and joining other development initiatives. In regard to research and technology, what stands out is the importance of promoting research and the development of new technologies to reduce costs and increase durability. Quality assurance has become an essential issue for consumers to accept new technologies. Also, the scale of energy systems such as solar home systems, direct current nano-grids, and alternating current mini-grids must be appropriate to the community's level of use.

Regarding financing, the emphasis is on strengthening the private sector through policies that enable better access to credit, the creation of regulatory frameworks, integration with other development initiatives, and the exchange of experiences between the public, private and community sectors. Finally, the United Nation's

Sustainable Development Goal 7 was emphasised: ensuring access to sustainable energy for all. To achieve this goal, it is essential to establish better collaboration between different programmes and promote capacity building and the sharing of information.

The need for more detailed information about the hydrological potential in different areas of the country was discussed in the ensuing Q&A session.

## Alternative energy in Bolivia's electricity sector by 2025

Raúl Villarroel Barrientos, Vice Ministry of Electricity and Alternative Energies

Raúl Villarroel explained that Bolivia has two electrical systems: the first is the national grid system (SIN in Spanish), which supplies eight of the country's nine departments, except for Pando. Its energy matrix is 72% thermal generation with natural gas, 26% hydroelectric power plants, and 1.8% alternative energies, with a total capacity of 183.1 MW. The second is the off-grid system (SA in Spanish), which supplies the department of Pando, and is 92% thermoelectric and diesel, 3% solar and 5% hydroelectric, with a total capacity of 162 MW.

The 2012 census established that the coverage rate for access to electricity in rural and urban areas totalled 82.3%. It is projected that by 2020, coverage will increase to 87% in rural areas and by 2025, there will be full coverage and universal access. The power distribution grids have greater presence along the main axis of the electricity network due to the higher concentration of population. Departments like Beni and Pando have very low levels of electrification due to their demographic composition and the fact that their populations are widely scattered and isolated.

The Ministry of Hydrocarbons and Energy (MHE) is at the head of the energy sector in Bolivia. The Vice Ministry of Electricity and Alternative Energy (VMEEA) operates from within the MHE, controlling the National Electricity Company (ENDE), the National Load Dispatch Committee (NCDC) and the Electricity Authority (AE). The Electricity Program "Vivir con Dignidad", or "Living with Dignity", (PEVD) was established as the operating branch of the VMEEA. Through this, the Ministry works in coordination with the Departmental and Municipal Autonomous Governments, native peoples, and other related entities.

Articles 378 and 379 of Bolivia's political constitution establish the regulatory framework for alternative energies, including the types of incentives given, project development, research incentives, production guarantee, etc. The Patriotic Agenda establishes the guidelines for achieving total energy coverage by 2025 and for meeting and accompanying growth in demand, ensuring the supply of electricity in the short-, medium-, and long-term. Bolivia also aspires to be able to export energy and position the country as South America's energy hub, supporting scientific and technological sovereignty with their own identities. The Economic and Social Development Programme 2016 -2020 presents the strategic results framework and the actions to be undertaken over this period.

Alternative energies in the country include solar, wind, geothermal, biomass, and hydro energy; hydro energy has a capacity of 2 MW, which could be expanded to 10 MW. Bolivia also has high solar radiation in the high plateau area. In short, the country has great energy potential, enabling it to diversify the energy matrix, avoid greenhouse gas emissions, and generate more economic savings. The project for the regional integration of the electricity system will provide the opportunity to develop these alternative sources and provide access to electricity in rural areas. At the same time, Bolivia has alternative energy policies and a development plan through four programmes: electricity generation, access to electricity, the development of the regulatory framework, and

the promotion of initiatives with the participation of universities and other institutions related to the sector.

Despite all the potential mentioned, there are numerous constraints to the development of alternative energies. One of the problems is that investments do not pay for themselves, and many of these energy sources are intermittent, with diurnal or seasonal variations. The processes for obtaining financing are very time consuming, making it necessary to establish much more streamlined funding mechanisms. On the other hand, available information on the energy potential of the different regions of the country is rather limited, so that neither the water potential nor the availability of biomass is well known, hindering the development of these sources.

## EnDev experiences

Iván Fernández, Monitoring Technical Advisor

EnDev is an energy access partnership undertaking part of the global programme "Energising Development". EnDev is funded by a number of international and country agencies and the project is implemented in Bolivia by the German Cooperation Agency Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Bolivia is one of 24 countries where this programme is being carried out, and since 2005 EnDev has been working on lighting, the use of improved stoves, and the use of energy for productive systems and social amenities in Bolivia.

Iván Fernández described the project for the electrification of social facilities, which was carried out between 2009 and 2014 with the aim of improving the use and coverage of services in social amenities such as schools, health centres and community centres through solar photovoltaic and solar thermal energy systems. EnDev assists in the project's implementation providing technical assistance to its counterparts, offering training to beneficiaries and co-financing the costs of implementing technologies, while at the same time supporting private companies so they can disseminate and promote their technologies in different municipalities. The technologies used are photovoltaic systems (PVS) for electricity, and 100 to 400 litre solar thermal systems (STS) for hot water. Stakeholders in the public sector include the municipalities, community assemblies, community centres, the Vice Ministry of Alternative Energies, the Ministry of Health, and school boards. The private sector includes NGOs, companies that install and supply solar systems, and industry associations. The Energising Development programme initially financed 40% of the project's costs, but in 2013, a strategy of zero financing was implemented. Technical assistance included the project's development, design, planning, and support in award procedures. It also provided for user training post-installation on the benefits and uses of the technologies to facilitate their replication in other municipalities.

A total of 175 social amenities have benefited from 100 photovoltaic systems and 82 solar thermal systems. Among the lessons learned, those that stand out are the importance of checking that municipalities have adequate infrastructure (e.g., suitable areas in which to install showers) and making a good projection of energy needs to avoid oversizing the systems. It is important to commit the municipality to allocate technical staff to monitor and support private companies in the installation of the systems, especially in processes involving the public sector.

For the sustainability of the project, a very important point is the creation of guidelines for the administration of the services, including a system to charge for services and a system to provide maintenance for the equipment to prevent breakdowns (for example, out of order solar thermal systems or closed bathrooms). Technical staff in charge of maintenance and inspection must be local people trained to do this work, and all the training conducted must be re-evaluated and updated each year according to its evolution and impact.

Finally, it is important to involve the beneficiaries and make sure they have the knowledge necessary to operate solar technology; it is necessary to ensure the proper allocation of funds for maintenance, assess the role of the person responsible for maintenance and operation, and establish a quarterly monitoring of the systems installed. It is also important to keep a record of failed projects and the reasons why they failed, to develop publications such as information brochures and user manuals, and to design a sustainability study.

Responding to questions, Iván Fernández indicated that 50% of the installations are currently operational and that there are several systems that were installed in 2012 that are still operational thanks to annual funding allocated for their maintenance by the municipality. He explained that pipes must be insulated so that they are resistant to cold and altitude. So far, the presence of asbestos has not been taken into account; however, it will be taken into consideration in the future.

## Electricity for Living with Dignity Programme (PEVD)

Isela Bermúdez Gutiérrez, Vice-Ministry of Electricity and Alternative Energies

The presentation by Isela Bermúdez described the Electricity for Living with Dignity Programme (PEVD), which was created by Supreme Decree No. 29635 of 9 July 2008 to achieve universal access to electricity in rural areas by 2025 and in accordance with the provisions of the National Development Plan. The programme aims to improve the quality of rural life through the use of alternative energies and services through the participation of national and municipal governments and the private sector. The first four individual programmes within PEVD were concluded between 2011 and 2015, benefiting 64,800 families with an investment of Bs. 319.8 million (US$46 million). Seven more programmes are currently being executed, three of which are expected to be completed in 2016. 74,600 families and 21 health posts are expected to benefit from all of these programs, with a total investment of Bs. 897.3 million (US$129.2 million).

These initiatives include:

- The Rural Electrification Program (PER), which is building high-, medium-, and low-voltage networks, solar-diesel hybrid systems, and pico photovoltaic systems: a total of 20 ongoing projects that will benefit 31,000 families.
- The Implementation Program of Rural Electrification Projects (IPER) is another ongoing initiative with 11 rural electrification projects that will benefit 4.5 million families with an investment of Bs. 37.6 million (US$5.4 million).
- The Access to Modern Energy Sources (AFEM) project will provide pico photovoltaic systems to 14 municipalities in the department of Pando (supported by funds from Denmark), benefiting 5.5 thousand families.
- The Project of Decentralized Infrastructure for Rural Transformation II (IDTR II) is extending electricity grids and increasing their densification. It is also distributing household and social photovoltaic systems, with 27,000 beneficiary families and an investment of Bs. 348 million (US$54 million).
- The KFW Renewable Energies Programme involves the construction of mini- and micro-hydroelectric plants benefiting 1600 families with an investment of US$8 million.
- The Programme of Rural Electrification with Renewable Energy will implement photovoltaic and solar thermal systems for 5000 families in La Paz, Oruro, Potosí, Beni and Santa Cruz, with an estimated investment of US$5.05 million.

- Finally, the Programme of Photovoltaic and Solar Thermal Systems in Health Posts of the Department of Pando (S.F.T) plans to benefit 21 health posts with photovoltaic panels and solar thermal systems with a total investment of US$188,000.

## Perspectives of photovoltaic electrification

Miguel Fernández, Energética

Miguel Fernández began his presentation by indicating that 85% of people in South America have access to electricity. This means that there are still countries with significant shortages, leaving more than 30 million people without access to electricity, mainly due to the complexity and high cost of extending the electricity grid to remote areas. Over the past 10 years, there have been important technological innovations in the field of energy. Technological changes in photovoltaic systems range from: lead-acid batteries being replaced by rechargeable lithium ion batteries; compact bulbs being replaced by LED bulbs; electromechanical regulators being replaced by integrated electronic systems; and to new connectors being used in what is known as Third-generation Photovoltaic Systems (3GPVS). The differences in efficiency, price, and weight of the systems are considerable: the 3GPVS weigh six kilos instead of the 60 kilos of traditional systems and offer more intuitive connectors which facilitate their installation and use. While with a traditional system 240 watts were needed to meet the basic demands of a family, with 3GPVS only 80 watts are needed. Besides, they cost between 30% and 50% less than traditional systems and can be used modularly, enabling them to adjust to increases in the energy requirements of a family.

Energética, in conjunction with the World Bank, conducted a study to validate third-generation systems that involved 120 families in Bolivia and Argentina from three different ecoregions in each country: High Plateau, Valleys and Chaco (the semi-arid lowland). In each region, 3GPVS were installed with four- to eight-hour battery-life, all supervised by experts. Users were trained in 1.5 hour workshops and quarterly visits to the communities were carried out. The study determined that over 98% of the lamps were installed correctly, and 95% of users placed the battery correctly. In regard to the installation of the solar panels, their orientation and tilt were correct in 90% of cases, and the assembly and affixing of the panels in 93% of cases. 100% of the systems were operational a year later.

It was also determined that self-installation is possible as long as the users are trained and there is supervision during installation. With the installation of these systems, families located in the High Plateau saved on average 82% of their monthly energy costs, those in the Valleys saved 94% and those in the Chaco 70% of their monthly costs. As for the users' opinion, satisfaction with the intensity and quality of light is positive in 98.5% of cases. Overall, householders are pleased to have an incorporated flashlight with adjustable intensity and an external battery that enables them to charge cell phones and other devices at the same time. It was determined that the batteries, with a capacity of less than 6 Ah have limitations and generate additional costs to families, and that cables for fixing lighting points should be at least 8 meters long. The study also identified that the desire to have access to television is high and that there is also a desire, though to a lesser extent, to access other devices such as laptops.

One of the possible models for photovoltaic electrification in Bolivia would involve a combination of subsidy and microcredit, where the state would provide a partial subsidy for the initial investment, the operator would seek its own market in a given area offering two- to four-year contracts for operation and maintenance, and the user would be responsible for the sustainability of the system after this period. The weakest link in the system is the battery, which lasts about four years and costs US$180 to replace, an amount that may be too high for many households.

Rural electrification models in Argentina and Peru are based on adjustable rates: an operator is responsible for the system, the service, and the replacement of parts, while the user only pays a monthly fee for the service. The State operates as a watchdog, awarding service areas, paying a subsidy to the operator and intervening if something fails. In this model, however, the requirements of a regulated operator result in high costs with full rates between US$17 and US$27 per month, while users pay between US$3–US$4 per month.

The cost of a 3GPVS in Bolivia is around USD 400, with an operating life for most systems of between 10 and 25 years. The cost over 20 years would be US$1,527, while a conventional system would cost US$3,000. It is, therefore, important to contemplate the use of third-generation systems in countries where resources are limited, considering components with a 20-year durability. At the end of year five, the system would require the replacement of cells in its lithium ion battery. After this, the system would be operational until the end of year 10. In year 11 it would be necessary to change the whole lithium battery, enabling the system to operate for five more years. In year 15 the lithium ion battery cells would need to be changed again, leaving the system operational until year 20, when it would have served its operating life.

Miguel Fernandez answers questions during the Q&A session.

Finally, Miguel Fernández Stated that universal access to electricity is not possible without the participation of the State or the joint and coordinated participation of the users. Technological changes and the development of innovative solutions are also needed.

Responding to questions, **Miguel Fernández** explained that a total of 25,000 photovoltaic systems were distributed and more than 80% are still operating.

With regard to the optimal size of the solar panel, theoretical calculations show that 16-watt panels and a battery of 6 amperes are needed. The largest system on the market has 20-watt panels and 72 solar cells, and these are the systems that have resulted in the most savings (nearly 100% of the cost). However, if users wanted to watch more than the two hours programmed on these systems for TV, a 30-watt panel and a 10-amp lithium battery would be needed.

Considering the issue of waste materials, Miguel Fernández indicated that lithium ion batteries are made of an inert material that does not present the same problems as the lead-acid batteries that were used in traditional systems.

## Soluciones Prácticas experiences

Mónica Cuba, Soluciones Prácticas

Soluciones Prácticas is an international technical cooperation institution based in eight countries. Mónica Cuba explained that in Latin America, it has a regional office in Peru and a central office in Bolivia. As an institution, Soluciones Prácticas focuses on energy poverty with the objective and mission of seeking technological justice so

that vulnerable populations may gain access to technologies that enable them to improve their quality of life.

In Bolivia, 36% of families continue to use lighters, candles, and fossil fuels as sources of lighting, and firewood and dung for cooking. This energy poverty arises because of several factors such as local governments that lack the capacity to promote energy development, the absence of local support for the operation and maintenance of energy equipment, the gaps existing between different institutional levels on issues related to information and decision making, and a lack of clarity regarding electrification needs. Soluciones Prácticas' approach is based on benefiting families, communities and productive businesses with total energy for lighting, cooking, productive activities, and heating, as well as for social amenities and basic services.

A project involving a 60 kW micro-hydro scheme, implemented in the community of Amaguaya in the Municipality of Guanay, has benefited 90 families, an educational unit with 110 students, and a health centre that serves the five adjacent communities. Access to this area is difficult because of its geographical location, so the residents live in a situation of extreme vulnerability. The slope of the area was used for the construction of the micro-hydro scheme, digging a trapezoidal canal to collect water at the highest point, which goes through a turbine and is then returned to the river to avoid causing harm to downstream populations.

The population actively participated in its construction, which made it possible to promote local ownership of the project and also increase its sustainability. A community electricity utility was created, which is managed by the community itself according to national standards with local procedures for the users. At the same time, 10 people were trained in workshops on the operation and proper maintenance of the equipment, 60 families on the importance of energy and its efficient use, and another 60 families on a model of administrative management with regulatory instruments.

According to the project's follow-up, it was established that many people returned to their community as a result of its electrification. Now that they have electricity, the community has requested a dentist, children can study at night, and there are four production units: two involving crafts and two involving fabrics. A scale of "differentiated rates in descending blocks" was established for payments, where each user is connected to a meter to make his/her payment.

The project for Renewable Energies, Productive Use and the Promotion of the Organization of Women and Young People was carried out in isolated areas of the high plateau of Peru and Bolivia, where the population's quality of life improved through the strengthening of local productive chains. In Peru, the work involved the transformation of alpaca fibre and the population received production equipment. In Bolivia, the work was done in conjunction with the Vice Ministry of Tourism and SDC to promote tourism, installing solar thermal panels to heat water and providing training in hospitality, gastronomy, and first aid.

Soluciones Prácticas also works on technologies for resilience, using several of the systems that may be used by communities that are vulnerable to flooding. It distributes at the same time portable photovoltaic systems and easy to install lithium ion batteries for lighting and communication.

## Cedesol experiences

David Whitfield, Cedesol

David Whitfield introduced Cedesol, a Bolivian organisation that since 2003 has been developing tools to transform the lives of people living in rural communities and to protect the environment. It values the transfer of technology and practical knowledge from experts to the people, as well as the use of energy and resources to solve problems

and create change. Cedesol operates in seven departments of Bolivia, where it has installed more than 10,000 improved cookstoves and trained 54 technicians in their assembly and installation. 80 municipalities have benefited from this project, and 10,000 women have better lives.

In the municipality of Yamparaez, Chuquisaca, a modular environmental training programme on the use of wood stoves was carried out, and 720 stoves were delivered to more than 20 beneficiary communities.

The methodology consists of visiting the communities and demonstrating the operation of the stoves to draw the audience's interest. Those interested fill out a form and then an agreement is signed with the beneficiaries, where they commit to participate in an educational programme on the maintenance of the stoves. The programme is one-year long and is divided into bimonthly modules. Most of those who receive training are women, with the objective that they will later repeat the process in their villages. As well as learning to maintain, repair, and recycle the stoves, they are taught environmental concepts, principles of hygiene and health, nutrition, and food safety. Tuition includes how to replicate the technology with thermal stoves and how to use insulating materials for better cooking.

The types of stoves installed are chosen bearing in mind the type of stove that was previously installed and the type of fuel it used. 77% of the installed stoves were "rocket" stoves, and 23% were solar stoves, 98% of which were domestic and 2% institutional. As for the type of fuel used, 57% of the stoves use wood, 13% gas, and 15% use both.

In 2015, a study about the gathering of firewood was carried out in Yampares and in some areas of Cochabamba, and it was determined that this activity takes a considerable amount of time, as each family spends approximately three hours per day gathering firewood. Improved stoves save much of this time and, at the same time, they also save fuel and money. An inspection of stoves installed in 2011 found that they are not in bad condition but do need maintenance.

## Satellite classrooms

Enrique Rodríguez, Luces Nuevas

Luces Nuevas is the social branch of Phocos Latin America, which focuses on finding practical solutions for rural areas. Enrique Rodríguez explained that one of its concerns is improving access to Information and Communication Technologies (ICT) in rural areas, where lack of access to the electric grid eliminates digital learning opportunities and sets significant constraints to teaching and learning methodologies.

The solution presented by Luces Nuevas is "satellite classrooms". A satellite classroom is a simple concept involving a TV connected to a satellite through a satellite decoder, powered by a third-generation solar home system. Community telecentres are considered a good solution for access to ICTs in rural villages; however, investment costs remain high in some cases. The benefit of the satellite classrooms approach is that they are much cheaper; 10 satellite educational classrooms can be set up with the same initial investment needed for a telecentre.

The connection to the satellite provides improved digital learning and support for teachers; it also provides multimedia teaching methodologies and many other tools. The approach enables dissemination of learning materials and methods, as any programme developed by a teacher in a school can be replicated at a departmental level. It also enhances the capacity for reflection and analysis of students and the community. Challenges of this solution, however, include the need for teachers to provide effective support and for parents to be involved in community learning.

To establish these classrooms, a diagnosis is first carried out of the level of equipment of the educa-

tional institutions, including whether they already have solar panels. If they do, the work focuses on improving and updating the equipment, relocating it maybe, and evaluating the possibilities of modernising it with third-generation systems.

In the ensuing Q&A, Enrique Rodríguez reflected on future plans, focusing on families having access to lighting and new technologies. Pilot projects are planned in different municipalities, and the next step would be to replicate at home what was developed in classrooms

The cost is about US$1,500 per classroom, which is much less than the cost of implementing a telecentre. To choose the communities, it is important to find social advocates in the municipalities, people who are concerned about solving their communities' problems.

## Discussion session

**Moderator:** Mónica Cuba, Soluciones Prácticas

The discussion session initially focused on the productive use of energy, the sustainability of projects, and the interaction between project initiatives and ongoing activities. The points made by workshop participants are summarised in the following paragraphs.

**Intervention 1**

When there is electricity, even if the amount is low but provided that it is reliable, productive activities and small businesses become possible. Photovoltaic systems have not been sufficiently developed and exploited in Bolivia to date. It is necessary to assess what types of productive undertakings require small amounts of electricity, bearing in mind that photovoltaic systems have certain limitations. This is a cross-sectoral issue that needs to be worked on with the relevant ministries.

The government has currently established that undertakings need to be comprehensive. They cannot only focus on energy-based issues, but should also intervene to improve access to clean water and the environment of beneficiary households. For example, the Vice-Ministry of Electricity created the programme "Reaping life sowing light", a comprehensive initiative that includes interventions in the areas of environment, water, and energy. It is important to establish comprehensive projects with institutions from different areas, and these workshops should be the source of guidelines to formulate this type of initiative.

**Intervention 2**

What still needs to be discussed is the relationship between urban and rural areas, to establish how to encourage young people and adults in rural areas to be more enterprising. Entrepreneurship must emerge, and it is important that a connection should be created in rural areas that encourages the provision of services with a strengthened economic channel.

**Intervention 3**

The issue of access is an important element that is difficult to solve. The first aim is that everyone should have at least one source of energy that solves basic problems, primarily lighting and communication; there are more cell phones in rural areas than electric power services. But it is a mistake to think that production problems are solved simply by the creation of micro-enterprises since members of rural communities often do not have the skills and experience needed for running these successfully. The first step should therefore be ensuring people have an entrepreneurial spirit and are trained to run a business. This also requires good access to relevant information.

**Intervention 4**

A complement of the programme "Cosechando vida, sembrando luz" ("Reaping life, sowing light") involves collecting rainwater, which does not require extra energy. But this programme is linked

to a modest use of energy to facilitate irrigation in small family vegetable gardens, and the state is working on this kind of initiative. This programme is expected to reach 45 families by 2017.

**Moderator**

The moderator reflected that the discussion up to this point had examined three important points: scale, production and its different facets, and issues related to entrepreneurship and information.

How can we ensure the sustainability of the link between technologies and production? How is sustainability conceived or projected?

**Intervention 5**

The link between rural and urban areas must improve so that both may interact and achieve sustainable development, insofar as urban areas depend on rural areas for the production of food, while cities may provide rural communities with new knowledge. The idea that rural areas are far from urban areas is a great shortcoming; in reality they are much more intertwined than believed.

**Intervention 6**

On the issue of development and entrepreneurship, it is very important that a political decision is made to make access to a business venture easier and simpler. These business ventures will only be sustainable if there is a political decision by the State.

**Moderator**

The moderator posed a further question: How do we get communities to achieve independence in the management and implementation of their own projects, so that they stop relying on NGOs and other institutions and are able to manage their own ventures as a community?

**Intervention 8**

When it comes to the issue of markets, the underlying problem is organisational capacities for production as such. Much emphasis is always placed on the productive side of things, delivering equipment for handicrafts for example, forgetting that it is also necessary for business sustainability that entrepreneurs learn to manage the logistics of their products. A first step would be to establish some type of community-based social organisation and generate comprehensive organisational structures for production. An important consideration is being able to meet product quantity and quality requirements and the maximum production times required by competitive markets.

**Intervention 9**

These interventions show the complexity involved in production, but those in charge of setting up electrical connections should not also have to address market, marketing, or image design issues, since these are fields in which they have no training. It is, therefore, important to recognise that energy is just one more factor among all those needed to make way for productive development. What needs to be developed are synergies based on a broader vision that seeks sustainability.

## Session 2

### Experiences with lithium systems

Ronald Cavera, Phocos Latin America

Ronald Cavera explained Phocos is a company that delivers technological proposals to supply power to off-grid communities. Its headquarters are in Germany, but the company operates in five continents and has production facilities in China, India, and Bolivia. In America, it has offices in the U.S., Brazil, and Bolivia (Cochabamba), from where it serves the three countries of Mercosur. For many years, the classic photovoltaic system used for lighting was based on lead acid batteries, which are reliable depending on their use: if not charged correctly, their lifetime is reduced by one to four years.

In Latin America, more than 30 million people have no access to electricity, and use candles and lighters that represent a significant expense for families, cause damage to the respiratory system, and pose fire hazards. No country has yet achieved universal coverage. Bolivia, Nicaragua, Peru, Honduras, Guatemala, and Haiti are among the countries with less than 80% coverage, the worst off being Haiti, where six million people (of a total eight million) have no electricity.

In Bolivia, the Political Constitution establishes that access to electricity is a citizen's right. Of a population of 11 million, however, 2.5 million families still live without electricity and with an average annual per capita income of only US$2,900. Nicaragua has a population of six million, and 1.5 million people have no access to energy (approximately 400,000 families), with an average annual per capita income of US$1,900. A large part of this problem is related to reliance on the use of candles: in Bolivia one in five people use candles for lighting, and a family that depends on candles and lighters is at risk of fire and of suffering irreversible damage to eyes and lungs. For children, studying with such low quality light is a big effort that results in poor school performance. In addition, the estimated annual spending on candles and batteries is US$60 million and US$120 million in Bolivia and Nicaragua, respectively.

Universal access to energy requires, first of all, that a decision is made by the State and that adequate policies are implemented to achieve access in a short time. Bolivia is the only country in the region with the goal of universal access to energy by 2030. Other requirements necessary to achieve this goal include the availability of technology, that users accept the proposed technology, and that adequate mechanisms for its implementation, dissemination, and funding are implemented.

Electricity goes far beyond lighting. Basic lighting solutions and high-quality communications are accepted by users, and although basic solutions are provisional, there is a risk that households do not progress beyond them. Access to energy can go from candles to pico lamps as the first step of the solution, and then to solar home systems with lithium ion batteries, in order to finally connect to the grid. Bolivia would need 500,000 pico lamps for the 500,000 families without electricity.

### Experiences with photovoltaic projects: Operational statistics

Edgar Terrazas, Energética

In rural areas of Bolivia, firewood is used for cooking and, depending on financial resources, candles, lighters, or generators are used for lighting. However, Bolivia has an excellent solar potential, and Edgar Terrazas indicated that the first photovoltaic systems were installed in La Paz in the 1980s, and the first management standards and models were developed in the 1990s with 20,000 installed systems. In 2001, Bolivia started manufacturing and exporting components, as well as training and certifying technicians. In

2008, the first compendium of regulations for photovoltaic systems was established. By 2013, they had already installed 30,000 systems in the country.

At the same time, between 1997 and 1998, social initiatives began introducing portable electric systems in schools, and in the productive sector, pumping and energy systems were developed for tourist lodges. The current electrification model consists of a combination of subsidy and credit, with the transfer of ownership to the user and with a limited operation and maintenance service, to increase the number of beneficiaries and achieve widespread growth.

The study presented below focuses on two projects: Decentralized Infrastructure for Rural Transformation (IDTR) and Global Partnership Output Based Aid (GPOBA). Both began in 2005 and ended with the maintenance stage in 2015. The IDTR and GPOBA projects apply what is basically a subsidy/credit (60%/40%) model with which users are aided to purchase a photovoltaic system and maintenance service for two to four years. Between 2012 and 2013, the IDTR project installed 10,334 systems, and the GPOBA project installed 7,666 systems, a total of 17,840 systems in five departments, 96 municipalities and 3,500 communities, with an average of between four and five systems per community. The size of most of the installed systems is 50 watts, and in most houses they are used for lighting, radio and charging cell phones. Three points of light are generally installed in each house, as they do not have many rooms. As for the systems' maintenance, 25,000 visits were planned as part of the project, but 28,000 were carried out, which meant that the systems were inspected on four occasions. 15% of the systems are no longer operational after four years, indicating the need for permanent technical staff in the area.

The implementation of the projects faced several challenges. Firstly, the long distances between houses limited the number of installations to only

The one-day workshop welcomed over 50 participants who were eager to share their thoughts on rural energy in Bolivia.

two systems per day. Between 10-15% additional visits were needed because the beneficiaries were not at home. The second problem involved transport, because each system was very heavy (just the battery weighs 35 kg), the participation of the community was needed to transport the equipment. There were also problems with some components: a batch of 11-watt lamps, for example, reached the site with factory defects. Finally, there were breakdowns due to the mishandling of equipment by users, such as failing to clean the equipment, or causing damage to the batteries through failing to use distilled water or using the batteries to start a car. There is generally little notion of preventative maintenance among users.

A very positive aspect has been the systematisation of 17,840 systems. There is recorded data for each system installed, including its location, the users' personal information, and the type of system installed. This enables systems to be monitored online when required.

Finally, the study shows the importance of developing a planning process for rural electrification incorporating new technologies that are tailored to meet the particular challenges of each rural community. The provision of services that includes technical assistance is also needed.

## Punto Solar project

Ivailo Peña, Servicios Integrales de Energía S.A.

One of the major problems identified in large-scale electrification initiatives, such as the IDTR and GPOBA projects, is ensuring the sustainability of the solutions. Ivailo Peña considered that the problem is that once the maintenance contract with the distribution company comes to an end (it usually lasts four years), maintenance becomes the users' responsibility, and users live in rural or remote areas where it is not always possible to access spare parts or specialised technicians.

Servicios Integrales de Energía (SIE) is a private company based in Cochabamba, with 14 years of experience working on solar energy technologies with different types of applications. Punto Solar is a project developed by SIE, with the support of GIZ, the German development agency, which aims to establish a network of suppliers of renewable energy technologies in rural areas of Bolivia. The project begins by identifying areas of interest with an analysis of variables that includes the study of the geographical location, electricity coverage, and the census. This is followed by the identification of potential distributors based on pre-feasibility criteria defined by the company. Finally, supply contracts are agreed with the distributors, and both parties agree on the budget and consignment materials.

So far there are 29 outlets distributed in every department of Bolivia, except Beni and Pando. Each outlet receives training twice a year on the basic features of the products on sale, and to reinforce promotion and advertising activities. Initially each outlet receives basic stock worth US$500. There are no subsidies or funding, and the relationship between distributors and users is purely private.

Approximately 42% of the sales have been components for pre-existing photovoltaic systems, especially batteries. One or two pico lamp systems represent 31% of sales, new photovoltaic systems 17%, and water pumping systems and solar thermal represent 10% of demand.

Of the 29 identified outlets, 65% report frequent sales, with cumulative transactions totalling Bs. 350,000 (USD 50,500). Moreover, 300 families have been benefited from the rehabilitation of their systems.

## Contribution of solar water heaters to productive rural development

Rodolfo Astete, Sico Sol S.R.L

Rodolfo Astete explained that Sico Sol was founded in 1978 and now works mainly on the design, manufacture, and installation of solar water heat-

ers. Secondary activities include the design and manufacture of agricultural machinery and the sale of photovoltaic systems. With a presence in every department of Bolivia, Sico Sol connects different models of solar thermal systems. It also sells industrial systems that are installed in hotels and hospitals.

Several schools in rural areas of the country have had photovoltaic systems installed to provide lighting and water heaters for hot water. In northern Potosi, communal showers have been installed for four or five families who pay a minimum fee of Bs. 1 for their maintenance. Sico Sol offers a five-year warranty, and the systems generally only require replacement after 20 years. Water heaters improve their users' quality of life, preventing potential diseases, increasing family incomes and contributing to the preservation of the environment because they do not require fuel.

Responding to a question about imported products, Rodolfo Astete indicated that customers know the quality and reputation of Sico Sol, and many of them prefer to buy its products, despite the damage done to the sector by some poor-quality imported products.

Customers are trained in the use and maintenance of the systems, and preventative maintenance is performed by Sico Solar once a year. The most common problem is the lack of clean water for systems with antifreeze, so the design has been changed to include a closed circuit. The material has been changed to stainless steel to avoid problems caused by the use of poor quality water.

## Discussion session

**Moderator:** Renán Orellana, Inter-American Development Bank

In his introductory comments to the discussion session, Renán Orellana considered that several important issues had been discussed in the expositions, such as the technological leap. Photovoltaic technology has taken a major step forward in two areas: the shift from lead acid to lithium ion batteries, and the change from fluorescent tubes to LED lamps, a great technological leap that also enabled a reduction in the size of batteries.

As for the participation of the State, Renán Orellana Stated that the situation in rural areas can be improved as long as political decisions are made. Another major challenge is that the poorest people spend the most on poor quality energy resources, which is something that must be reversed. In Bolivia, communities without electricity are in widely scattered locations and rural electrification programmes involving grid extension are currently reaching locations where there are only about five houses. The costs of extending the electricity grid to rural areas, however, are increasingly higher, going from US$2,000 in some cases to US$4,000 per home connected (depending on the region). It is important to work on the development of less expensive solutions.

He reminded participants of the presentation of Edgar Terrazas, which showed the evolution of these technologies in terms of management structures, and also that it is a learning process, where each implemented project contributes more information. He also highlighted the importance of a follow-up model to facilitate planning new initiatives.

Renán Orellana indicated that the World Bank is finalising an impact assessment that will be shared in the coming months. 17,000 systems have been installed according to the 2012 census, but 35,000 families in Bolivia claim to have a photovoltaic system, and at least some of those systems are operational. He considered that Ivailo Peña had shown a very interesting business system: a private business without State involvement. The importance of energy for cooking and heating was also highlighted.

Renán Orellana posed three questions:

1. Is it enough to adopt smart technologies for universal access? We have seen that there has been progress and that is the route we are following, but does something else exist? Should we do more?

2. Is it possible to carry out integrated interventions? Can this generate some savings in the intervention? Is it possible to include topics such as those described by David Whitfield concerning stoves?

3. To what extent do subsidies help when it comes to access to energy? Are subsidies necessary? Do they help or hinder?

Contributions to the discussion made by workshop participants are summarised in the following paragraphs.

**Intervention 1**

It is not enough to adopt a smart technology: it is also necessary to invest in research. We are energy consumers, but we are not developing our own research: Bolivia has different climatic conditions and technologies should be adapted to domestic requirements. What is missing is a channel of communication between the different sectors for better planning and for offering better solutions. The quality of information is also very important. With regard to the subsidy of energy, it is necessary to provide cheap and affordable prices: if energy prices go up, food prices also increase, and therefore so does extreme poverty.

**Intervention 2**

The state of the art in battery technology is currently lithium ion, but 10 years from now there may be something else. The availability of technology is not enough. Of all the problems a family may face—lack of water, health, education, or electricity—the easiest to solve is the lack of electricity. The country should pursue a methodology to address the easiest part of the problem, but with a universal vision. A major problem with mini-grids is their high costs.

**Intervention 3**

Over the last few years, there have been technological changes involving batteries, lamps, etc. An energy-efficient culture should also be promoted, which should in turn be accompanied by a process of education on energy use. On the other hand, subsidies are a long-term evil that should be eliminated.

**Intervention 4**

On the issue of education, it is important that access to appropriate technologies is accompanied by education, so that users understand what is the role of the equipment they have been given and so that they can maintain it and use it to their advantage. One example where this did not happen was the case of a European group that brought a mill to pump water from a well to Charaña, where temperatures can get very low. After a year, the system stopped working, and the community members disassembled it because they lacked the education or training to repair it.

**Intervention 5**

In regard to biomass technologies, the key is to involve civil society, have users with knowledge about the technology, and find enterprising people who are interested in their community and may promote a supportive culture. It is necessary to create a technical position so that someone can be alert to every need, notwithstanding the municipality's and the community's participation. The most important things are education, training, and the use of each technology.

**Intervention 6**

Despite the importance of education and the training of technicians, investors unfortunately do not always take them into account because

they increase the project's cost per beneficiary. In regard to subsidies, they are very important to people in rural areas who do not have much money, so that they can have access to energy. Although from a market viewpoint subsidies are counterproductive in the long run, they can be used initially to create a surge in demand.

**Intervention 7**

The demand for electrification in rural areas could be supplied through the market offer, but the penetration level would not be very large. Subsidies are needed to achieve high levels of electrification, but it is important to consider where they should be invested to achieve the greatest impact.

In the cases of Argentina and Peru, there is a large monetary fund that is regenerated every year. A photovoltaic system operated by a company costs US$19 per month. Users pay US$3, and US$16 is subsidised per month. The State, through any mechanism used to subsidise every family, pays US$200 over one year and US$4,000 over 20 years. An important decision is whether subsidies should be one-time or whether a permanent subsidy package is established. The problem of long-term subsidies is that in times of economic crisis they are the first to be cut, affecting the poorest people.

Why not consider a model that uses subsidies? It is possible to combine a subsidy with payment facilities or micro-credit. There is a whole electronic system to control payments that can be applied to these third-generation systems. Each system has a microprocessor that can be programmed to turn itself off in six months, reminding the user that he/she needs to pay. The question is: how to use resources in the best possible way? This will not be achieved without State participation. On the subject of training, there should be a specialist in every community.

Wendy Guerra, a World Bank consultant who helped to organise the workshop, peruses Smart Villages reports with a fellow workshop attendee.

## Workshop closing session

The workshop was concluded by thanking all the participants for taking the time to attend and participate in the workshop, and for their valuable contributions to the discussion sessions. A special vote of thanks was given to Wendy Guerra for her help in organising the workshop.

# Annexes

## Annex 1: Agenda

**Sustainable energy sources for off-grid rural communities in Bolivia: opportunities, challenges and perspectives**

### Agenda

0900 **Workshop Opening**

**Session 1**

0910 **The Smart Villages Initiative**

*Claudia Canales*

0930 **Alternative energy in Bolivia's electricity sector by 2025**

*Raúl Villarroel Barrientos, Vice Ministry of Electricity and Alternative Energies*

0950 **EnDev experiences**

*Iván Fernández*

1010 **Electricity for Living with Dignity Programme (PEVD)**

*Isela Bermúdez Gutiérrez, PEVD*

1040 **Perspectives of photovoltaic electrification**

*Miguel Fernández, Energética*

1100 **Break**

1130 **Soluciones Prácticas experiences**

*Mónica Cuba, Practical Action*

1150 **Cedesol experiences**

*David Whitfield*

1210 **Satellite classrooms**

*Enrique Rodríguez, Lucas Nuevas*

1230 **Discussion Session**

*Moderator: Mónica Cuba, Practical Action*

1300 **Lunch**

**Session 2**

1400 **Experiences with lithium systems**

*Ronald Cavera, Phocos Latin America*

1420 **Experiences with photovoltaic projects: Operational statistics**

*Edgar Terrazas, Energética*

1440 **Punto Solar project**

*Ivailo Peña, Servicios Integrales de Energía S.A.*

1500 **Break**

1530 **Contribution of Solar Water Heaters to Productive Rural Development**

*Rodolfo Astete, Sicosol*

1550 **Discussion Session**

*Moderator: Renán Orellana, Inter-American Development Bank*

1650 **Closing Remarks**

## Annex 2: List of participants

| | |
|---|---|
| Alvaro Herbas | Luces Nuevas |
| Alvaro Montaño Saavedra | Coordinador a.i. PEVD |
| Analía Gonzáles | Universidad Católica Bolivia “San Pablo” |
| Arturo Loayza Ordóñez | Endev |
| Bernardo Fernandez | Universidad Católica Bolivia “San Pablo” |
| Carolina Garvizu | Universidad Católica Bolivia “San Pablo” |
| Cecilia Lazarte | Universidad Católica Bolivia “San Pablo” |
| Cinthia Schmiedl | Traduccion |
| Claudia Canales | Smart Villages |
| David Whitfield | Cedesol |
| Desiderio Guzman | Soluciones Practicas |
| Diego Bacarreza | Consultant |
| Diego Bacarreza Machicado | Universidad Católica Bolivia “San Pablo” |
| Edgar Terrazas | Energetica |
| Enrique Rodriguez | Luces Nuevas |
| Erica Quispe | Universidad Católica Bolivia “San Pablo” |
| Fernanda San Martin | Diputada |
| Gabriela Mariaca | Universidad Católica Bolivia “San Pablo” |
| Hernan Coarite Mamani | Especialista en Energias Renovables I |
| Isela Bermudez | Coordinadora PERER |
| Ivan Fernandez | Endev |
| Iver Carlos Rodríguez Aguilar | Universidad Católica Bolivia “San Pablo” |
| Jaime Guerra | Solar Eagle |
| Javier Moeller | Cooperación Alemana |
| Jhovana Jordan | Diputada |
| Jimena Zenteno | Consultora |
| Joaquin Loayza Aliaga | Universidad Católica Bolivia “San Pablo” |
| John Holmes | Smart Villages |
| Karina Salguero Lopez | Notas |
| María Alejandra Espinoza | Universidad Católica Bolivia “San Pablo” |
| Marcelo Lorberg | Consultor |
| Mariana Butron Oporto | Endev |
| Mariana Daza | Secretaría Municipal de Gestión Ambiental |

| | |
|---|---|
| Mariana Rojas | Universidad Católica Bolivia “San Pablo” |
| Marlene Arispe Alban | Universidad Católica Bolivia “San Pablo” |
| Mauricio Acha | APLITEC La Paz |
| Michelle Echenique | Ecoenergia Falk |
| Miguel Fernandez | Energetica |
| Molly Hurley-Depret | Smart Villages |
| Rodrigo Vargas Ramos | Consultor |
| Rocio Maldonado | Asociacion Inti Illimani |
| Reinhard Mayer | Ecoenergia |
| Ramiro Trujillo | Universidad Católica Bolivia “San Pablo” |
| Raul Villaroel | Resp. de Energias Alternativas |
| Reinhard Mayer Falk | Ecoenergia Falk |
| Renan Orellana | Consultor de PERER y PER |
| Rodolfo Astete | Sicosol |
| Rodrigo Vargas Ramos | Universidad Católica Bolivia “San Pablo” |
| Ronald Cavero | Phocos Latin America |
| Ronanth Zavaleta Mercado | Academia Cientifica de Bolivia |
| Sergio Ballon | Coordinador de Proyecto |
| Sergio Alejandro Elío | Universidad Católica Bolivia “San Pablo” |
| Tesoro Michel | Ministry of Rural Development and Lands |
| Verónica López | Secretaría Municipal de Gestión Ambiental |
| Vesna Marinkovic | Energia Bolivia |
| Walter Ita | Soluciones Practicas |
| Wendy Guerra | Banco Mundial |

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SMART VILLAGES
New thinking for off-grid communities worldwide

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