IOREC
International Off-Grid Renewable Energy Conference & Exhibition

IRENA
International Renewable Energy Agency

IOREC 2012

International Off-Grid Renewable Energy Conference

KEY FINDINGS AND RECOMMENDATIONS

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low carbon economic growth and prosperity.

Acknowledgement

The International Off-Grid Renewable Energy Conference (IOREC) was jointly organised by IRENA, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) and the Alliance for Rural Electrification (ARE).

This report was prepared by Hugo Lucas, Salvatore Vinci, and Divyam Nagpal from IRENA's Knowledge, Policy and Finance Centre (KPFC). Along with internal IRENA review, the report benefited from the support of Akanksha Chaurey (India) and valuable comments provided by Harish Hande (India), Henry Gichungi (Kenya) and Nico Peterschmidt (Germany).

For further information or to provide feedback, please contact Mr. Salvatore Vinci, IRENA - Knowledge, Policy and Finance Centre, C67 Office Building, Khalidiyah Street, P.O. Box 236, Abu Dhabi, United Arab Emirates; Email: SVinci@irena.org. Questions or comments can also be sent to secretariat@irena.org.

The report is available for download from www.irena.org/Publications.

International Renewable Energy Agency

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Key Findings and Recommendations

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Acronyms

AC	Alternating Current
AGECC	The UN Secretary General's Advisory Group on Energy and Climate Change
AMADER	Agence Malienne pour le Dévelopment de l'Énergie Domestique et l'Électrification Rurale (Malian agency for the Development of Household Energy and Rural Electrification)
ARE	Alliance for Rural Electrification
ASER	Agence Sénégalaise d'Électrification Rurale (Senegalese Agency for Rural Electrification)
CILSS	Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (Permanent Interstate Committee for Drought Control in the Sahel)
CRSE	Commission de Régulation du Secteur de l'Electricité (Regulatory Commission for the Electricity Sector)
DC	Direct Current
DP	Diesel Pumping
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EMS	Energy Management System
ESCo	Energy Service Company
GDP	Gross Domestic Product
GEDAP	Ghana Energy Development and Access Project
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
GSM	Global System for Mobile Communication
GSMA	GSM Association
IDCOL	Infrastructure Development Company Limited
IEA	International Energy Agency
IFC	International Finance Corporation
IOREC	International Off-Grid Renewable Energy Conference
IRENA	International Renewable Energy Agency
KP	Kenya Power
LED	Light Emitting Diode
MFI	Micro Finance Institution
NGOs	Non-Governmental Organisations
O&M	Operations and Maintenance
POs	Partner Organisations
PPP	Public Private Partnership
PQM	Power Quality Meter
PV	Photovoltaic
PVP	Photovoltaic Pumping
R&D	Research and Development
RE	Renewable Energy
RSP	Regional Solar Programme
SEEDS	Sarvodaya Economic Enterprise Development Services
SHS	Solar Home System
SMEs	Small & Medium-sized Enterprises
UN	United Nations
UAE	United Arab Emirates
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization

Foreword

Achieving universal access to modern energy services is a vital pre-requisite to advancing socio-economic development. The options available to policy makers seeking to accelerate electrification have developed significantly in recent years. Decreasing costs and improving reliability have led off-grid renewable energy technologies to become the most cost-effective option for electrification in most rural areas. In recognition of the critical role renewable energy will play in achieving the goal of universal energy access it must be integrated into national rural electrification strategies.

The International Off-grid Renewable Energy Conference (IOREC) was held in Accra, Ghana, on 1-2 November 2012, with the aim of bringing together stakeholders from the public and private sectors to identify barriers to scaling-up off-grid renewable energy deployment and to discuss possible solutions. The International Renewable Energy Agency (IRENA) co-organised this event along with valued partners: the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE) and the Alliance for Rural Electrification (ARE). This report presents the key findings and recommendations that emerged from the roundtable discussions during IOREC.

The report concludes that adopting an effective policy and regulatory framework, along with tailored business and financing models and adapting technologies to the rural context, are all crucial factors in accelerating the deployment of off-grid renewable energy. Unfettered political commitment to rural electrification, together with a clear institutional framework, are key to attracting private sector involvement. At the same time, access to affordable finance and providing smart incentives that de-risk private sector investments will promote sustainable business models. Local enterprise will be instrumental in extending electricity access in rural areas, and hence needs to be fostered and supported.

Off-grid renewable energy technologies, as this report highlights, produce striking synergies with sectors critical for human development, and play an important role in improving access to water supply while also extending healthcare and telecommunication services in rural areas.

IOREC forms an integral part of IRENA's broad support to countries looking to accelerate the adoption and sustainable use of renewable energy, while also advancing the goals of the Sustainable Energy for All initiative. I am confident that the findings and recommendations of this report will contribute to global efforts to meet the challenges of energy access.

Adnan Z. Amin
Director-General of the International Renewable Energy Agency (IRENA)

Executive summary

Nearly 1.3 billion people globally lack access to electricity. What is more, 1 billion will likely remain without electricity access in 2030 unless there is a drastic shift in approach. While grid extension has been the preferred option for increasing electricity access, global statistics indicate this will not be sufficient to meet the goal of universal electrification by 2030.

Nearly 60% of additional generation needed to achieve universal access to electricity by 2030 is estimated to come from off-grid installations, either mini-grids or stand-alone. Renewable energy (RE) technologies are the most economic option for off-grid electrification in most rural areas. This means off-grid RE has the potential to play a central role in extending electricity access and stimulating socio-economic development.

Significant investments from a broad range of sources, especially from private funding, will be required to realise this potential. To ensure investment is unlocked over the coming decades, national governments will need to create an enabling environment that facilitates the involvement of private enterprises and promotes local entrepreneurship. This is based on a range of factors, including appropriate institutional and regulatory frameworks, enabling policies, sustainable financing and business models, and technology adaptation.

The creation of this enabling environment requires cooperation and dialogue between different stakeholders, in order to identify challenges and possible mitigating measures. The International Off-Grid Renewable Energy Conference (IOREC) provided an opportunity to facilitate such dialogue, particularly between the public and private sector.

International Off-Grid Renewable Energy Conference

IOREC was jointly organised by IRENA, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) and the Alliance for Rural Electrification (ARE). It was held in Accra, Ghana on 1 and 2 November 2012 and was an official contribution to the Sustainable Energy for All initiative.

IOREC inspired and promoted dialogue among stakeholders from across the rural electrification value chain, with a focus on Africa. The conference was attended by over 350 participants from 80 countries, including representatives from rural electrification agencies and ministries in charge of RE development from around 30 countries. The event attracted speakers from 23 countries, representing the public and private sector. IOREC's eight main sessions and parallel side events covered three areas: policies supporting off-grid RE; financing and business models; and technologies and their applications. This paper draws on the IOREC discussions and presents critical considerations for scaling up rural electrification through off-grid RE.

Policies supporting off-grid RE

Three elements emerged as particularly critical to establish an enabling environment for off-grid RE: political commitment; clear rural electrification strategy with realistic targets; and dedicated policies. In particular, effective and efficient national policies can directly influence the development of a market for off-grid RE by encouraging the involvement of local enterprises and attracting investments. Power sector reforms, such as regulations allowing for independent power producers, can further facilitate private sector involvement.

The success of national rural electrification policies is closely related to the institutional frameworks that have been set up. Delegates highlighted the benefits of creating dedicated bodies, such as semi-autonomous agencies or specialised divisions within ministries, with a clear mandate to promote off-grid RE deployment for rural electrification. They also stressed the importance of **earmarked funds** for programmes and implementing bodies. These bodies should coordinate with all public stakeholders involved in rural electrification to ensure effective and efficient utilisation of resources, provide clarity to the private sector, and reduce the administrative costs incurred by developers. Participants at IOREC also drew attention to the need for coordinated efforts by national and international institutions towards a sustainable off-grid RE market, while moving away from a grant-driven project-by-project approach.

Regulatory frameworks can contribute to the development of a sustainable market for off-grid RE by breaking down existing barriers. For instance, while defining the tariff approach (fixed tariff, ceiling price, tenders, negotiated tariff, etc.) for mini-grid projects, regulators should consider the local socio-economic conditions as well as the commercial feasibility for private sector mini-grid developers.

A broad range of policy instruments has been adopted to support off-grid RE deployment. These include, among others, financial incentives (soft loans, grants, publicly backed guarantees, etc.), fiscal incentives (exemptions from import duty, value added tax, etc.) and elimination of market distortions (*e.g.* fossil fuel subsidies). The choice of the appropriate instruments depends on factors that are specific to each context. Hence, **dynamic and tailored policy frameworks** are required to effectively support the growing market at local level. Policy instruments should also address specific challenges facing the off-grid RE market. This includes, for instance, **dispelling myths** about 'unreliable' and 'expensive' RE technology using awareness campaigns targeted at stakeholders across the board, from public institutions to end users. This is particularly important, since one of the findings from IOREC was the existence of apparent misconceptions among policy makers about technology reliability and cost (Appendix 1). In addition, attention must be paid to developing **technical skills** as the market grows. Capacity building should be encouraged along all links in the rural electrification value chain - public institutions, financing agencies, the private sector, communities, etc.

Financing and business models

There is a significant market for off-grid RE in areas with non-existent or unreliable access to electricity. The fact that over USD 36 billion is spent annually on kerosene lighting (USD 10 billion in sub-Saharan Africa alone) indicates the market potential. The need to provide **technology and financing services** in rural areas presents significant business opportunities. While successful and innovative business models are currently available, there is a need to scale up and **local entrepreneurs** are expected to play a central role in this effort. Innovative business models often focus on using local capacities to reduce operational costs, thereby stimulating development at local level and improving sustainability.

Sustainable business models, which are mostly independent of public financial support, will be critical to ensure rapid enough off-grid RE deployment to meet the goal of universal electricity access. There is a strong link between sustainable business models, access to **long-term affordable finance** and provision of electricity for **productive uses.**

Access to finance is an important pillar supporting off-grid RE deployment. Off-grid finance consists of two components: the 'downstream' component focuses on end users (consumer finance), while the 'upstream' component focuses on enterprises (start-up capital, working capital, etc.).

Access to financial institutions and **affordable lending terms** for rural households are pre-requisites of successful *downstream financing* schemes. Consumer access to finance depends on the presence of an extensive network of financial institutions that provide outreach to rural areas. This challenge is accentuated in less populated areas, which often lack suitable institutions with the necessary outreach. In addition, it is important to ensure that financial institutions have the capacities to perform their role. In particular, they need to be sensitive to the characteristics of off-grid RE projects in order to better tailor their financial products.

Several different models for end user financing were presented at IOREC. The collective experience from Africa, Asia and Latin America suggests that **tailor-made financing schemes**, based on the end users' cash flow and existing energy expenditure, are most effective. In addition, temporary guarantees (provided by public or other institutions) towards off-grid RE loans contribute towards demonstrating creditworthiness of rural households, thereby facilitating borrowing also for other needs.

Upstream finance for small and medium enterprises (SMEs) at different stages of project development is vital for increasing private sector role. For private micro-utilities in particular, there is often a critical finance gap in the initial stages of project development. Private finance will be essential to bridge this gap. However, unlocking private finance requires adequate **de-risking measures.**

IOREC highlighted that development funds, and in particular instruments such as grants, can have a role in the initial stages of market development. As the off-grid RE market matures, external financial support can be gradually phased out. IOREC also revealed the need for coordinated use of domestic, multilateral and bilateral funding sources. to lay the foundations of a sustainable market, for instance by investing in capacity building, infrastructure (*e.g.* local grids or other 'non-generation' assets) and various types of financial incentives (such as soft loans, guarantees, etc.).

Providing electricity supply for productive uses in rural communities is an important feature of sustainable business models, irrespective of technology approach adopted. This facilitates the growth of income generation opportunities and helps communities pay for energy services, thereby stimulating a sustainable market for off-grid RE.

Technologies and their applications

Off-grid RE technologies are **reliable and cost-competitive** with fossil fuel-based generation systems in rural areas. Their modularity provides flexibility to adapt system size to local energy needs, while different generators can be easily integrated to meet increasing demand.

RE stand-alone systems (*e.g.* Solar Home Systems) can be deployed rapidly and are cost-competitive with kerosene lighting on a life-cycle basis. Given adequate financing schemes, they are affordable for most rural households. It is important that components are available in local markets and that systems are designed to be robust and tolerate harsh environments. **Stringent quality control and standards** reduce the risk of premature failures. Stand-alone installations require adequate technical safeguards as well as end user awareness to prevent system abuse.

Mini-grids have proven to be an attractive option for rural electricity access. They can be installed in unelectrified areas or can offer an opportunity for communities to upgrade from basic electricity access provided by stand-alone systems. Kilowatt-scale mini-grids can provide **reliable electricity for productive uses** and can, in turn, be developed into larger mini-grids integrating several sources of generation to service diverse loads.

Innovative approaches to electricity distribution, load management and metering are being adopted to efficiently and transparently manage mini-grids. Load management has a significant bearing on overall mini-grid operations and maintenance (O&M) costs, since it significantly affects performance and lifetime of system components. Automation plays an important role in mini-grid management. For instance, household supply can be automatically synchronised with surplus/deficit RE generation by controlling other loads (*e.g.* water pumps). Utilising technology platforms like Global System for Mobile Communications (GSM) for remote monitoring and fee collection can significantly reduce operational costs.

Ensuring that the mini-grid installations operate optimally with minimal breakdowns requires **clarity in designation of O&M roles** and resources throughout the system lifetime. In addition, regular O&M requires local technical capacity and availability of spare parts in the local market.

The synergies between off-grid RE technologies and sectors critical to human development are striking. Off-grid RE technologies can **effectively contribute to meeting basic needs** and stimulating socio-economic growth, by improving access to water supply and extending rural healthcare and telecommunication services.

Off-grid RE provides a unique opportunity for **water pumping and purification** in rural areas. Photovoltaic (PV) pumping systems are highly reliable and cost-competitive with diesel-powered pumps on a life-cycle basis. The importance of post-deployment maintenance of the installation came through strongly at IOREC since water distribution components (piping, valves, fixtures, etc.) are found to be more vulnerable to failure than PV systems.

IOREC discussions also emphasised the role of off-grid RE in **extending basic healthcare**. Off-grid RE systems can provide critical electricity supply for lighting and medical equipment in rural areas. Similarly, the development of solar vaccine coolers to replace kerosene and gas-based fridges contribute to the outreach of healthcare services by ensuring independence from fossil fuel supply.

The rapid growth of mobile communications is providing new opportunities for off-grid RE technologies. IOREC discussed different private sector business models to extend electricity access to rural communities by creating **synergies with mobile communication** infrastructure.

1. Context and background

1.1 THE ELECTRICITY ACCESS CHALLENGE

Electricity access is essential to reduce poverty, improve health conditions and stimulate socio-economic development. Nearly 1.3 billion people across the world do not have access to electricity. The majority of them live in rural parts of Africa and developing Asia (International Energy Agency (IEA), 2011a). The key challenge facing policy makers and other stakeholders is to extend electricity access in these areas, not only for meeting basic needs, but also for productive uses. Recognising this challenge, the United Nations (UN) General Assembly declared the decade 2014-2024 as the 'Decade of Sustainable Energy for All'.

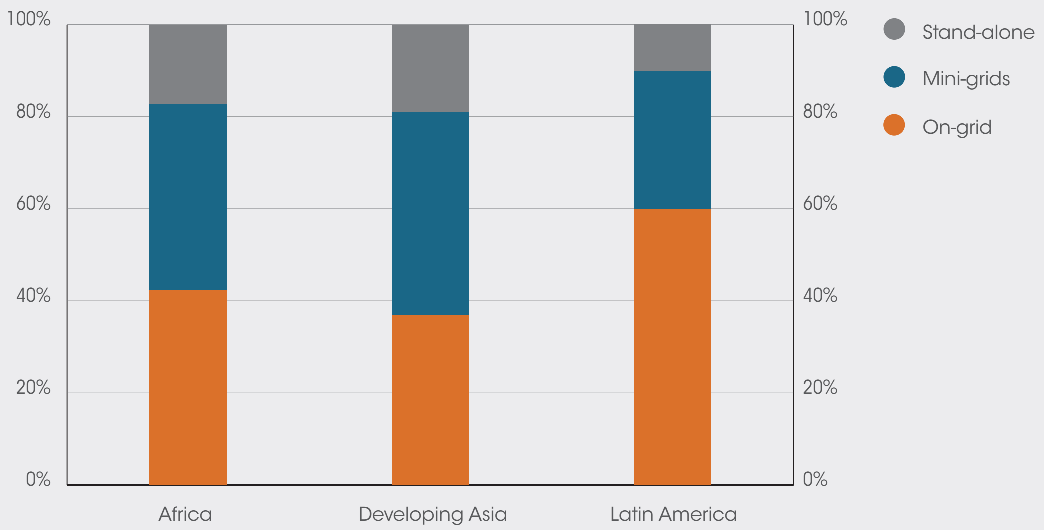
Most national electrification programmes have traditionally relied on large-scale, centralised power stations and power lines extending across the national landscape. As is evident, this reliance on grid extension has not always succeeded in reaching rural or scarcely populated areas. For instance, in Sub-Saharan Africa, the electrification rate in rural areas is 14.2% (IEA, 2011b).

> By 2030, electricity access to 25% of the rural population in the ECOWAS region will be through off-grid technology.
>
> **Mahama Kappiah,** Executive Director, ECREEE

Present trends indicate that a shift in approach is needed if the 2030 target of universal access is to be met. Often grid extension to rural areas is not viable from a technical or economic point of view. Off-grid systems[1] are emerging as a significant alternative to grid-based electrification. Nearly 60% of additional generation needed for universal electricity access by 2030 is estimated to come from off-grid installations, both stand-alone and mini-grids, as depicted in Figure 1. This illustrates their importance in the electricity access efforts.

From an economic point of view, renewable energy (RE) technologies are increasingly becoming the most

Figure 1 Electrification approach required to achieve universal access by 2030 by region (as % of generation)
(Based on IEA, United Nations Development Programme (UNDP), United Nations Industrial Development Organization (UNIDO), 2010)



[1] For the purpose of this paper, the term off-grid refers to both stand-alone and mini-grid systems.

cost-effective option for off-grid electrification. Virtually all off-grid electricity systems based predominantly on oil-fired generation will see system generation costs fall by integrating RE (IRENA, 2013). This indicates the potential and the important role of off-grid RE.

Significant investments into the off-grid RE sector are required for this potential to be realised. These investments are expected to come from a broad range of sources: private sector, public funds, bilateral and multilateral funding agencies and so on. In particular, the role of the private sector will be vital in bringing investment, technology and innovative business models to meet the needs of local communities. In order to facilitate this process, it is important to address the challenges that hinder off-grid RE technology deployment. This effort requires cooperation and dialogue between all stakeholders in the rural electrification value chain. The International Renewable Energy Agency (IRENA) role in co-organising the International Off-grid Renewable Energy Conference (IOREC) fulfilled this aim. IOREC provided a platform for dialogue and for discussing the main barriers and drivers of rural electrification through off-grid RE systems.

1.2 ABOUT IOREC

IOREC was co-organised by IRENA, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) and the Alliance for Rural Electrification (ARE), as an official contribution to the Sustainable Energy for All initiative. It took place in Accra, Ghana, on 1 and 2 November 2012.

IOREC inspired and promoted dialogue among stakeholders from the whole rural electrification value chain, especially between the public and private sector. The conference was attended by over 350 participants from 80 countries, including representatives from rural electrification agencies and ministries in charge of RE development from around 30 countries. The event convened speakers from 23 countries, representing the public and private sector, including successful rural electrification initiatives based on off-grid RE from different regions worldwide.

The event provided an opportunity to identify and discuss the main barriers to scaling up rural electrification through off-grid RE systems. It underlined policies and measures useful to overcome these barriers, and allowed knowledge of innovative financing models and technology solutions to be shared. IOREC was divided into eight main sessions and parallel side events in three thematic areas:

» Policy and regulatory frameworks

» Financing and business models

» Technologies and their applications

This paper presents the main outcomes and recommendations of two days of deliberations. The rest of this paper is divided into two main chapters:

Chapter 2: Synthesis of main points from speaker presentations and round table discussions

Chapter 3: Key recommendations for policy makers

A brief survey was conducted using a questionnaire during the two-day conference, attracting 118 respondents. The questionnaire was mainly concerned with two key issues: a) challenges faced in relation to off-grid RE development and b) steps that national governments should take to support off-grid RE development (Appendix 1).

2. Synthesis of conference discussions

Technical sessions, discussions and side events provided different perspectives of the off-grid RE sector. They covered the policy and regulatory landscape, financing and business models, and technology aspects. This chapter provides a synthesis of the main points discussed during the conference[2].

> The challenge of extending access through off-grid RE is not technology, because technology is cost competitive and reliable. The need is for an enabling environment that makes it accessible to all.
>
> **Frank Wouters,** Deputy Director-General, IRENA

2.1 ENABLING ENVIRONMENT FOR OFF-GRID RE DEPLOYMENT

An enabling environment needs to be put in place to accelerate rural electrification through off-grid RE. IOREC highlighted that this enabling environment mainly consists of four basic building blocks: policy and regulatory frameworks, institutional framework, financing and business models and technology (Figure 2).

Sustainability is central to the building blocks above as sustainable models will be essential to sufficiently scale up off-grid RE deployment to achieve universal electricity access by 2030. In particular, as the off-grid RE markets mature, the dependence on external financial support will reduce.

The following sections discuss the critical aspects of each building block mentioned above, as highlighted at IOREC.

2.2 POLICY AND REGULATORY FRAMEWORKS

There is no 'one size fits all' approach for enabling off-grid RE policies and regulatory frameworks. However, there is tremendous potential for cross-regional exchange of best practices and lessons learnt from different rural electrification initiatives. While national frameworks need to be tailored to the local context, some successful approaches can have the potential to be replicated between countries and regions.

Figure 2 Building blocks of an enabling environment for off-grid RE deployment (adapted from UNIDO, 2012).

[2] *All conference and side-event presentations are available for download from www.iorec.org*

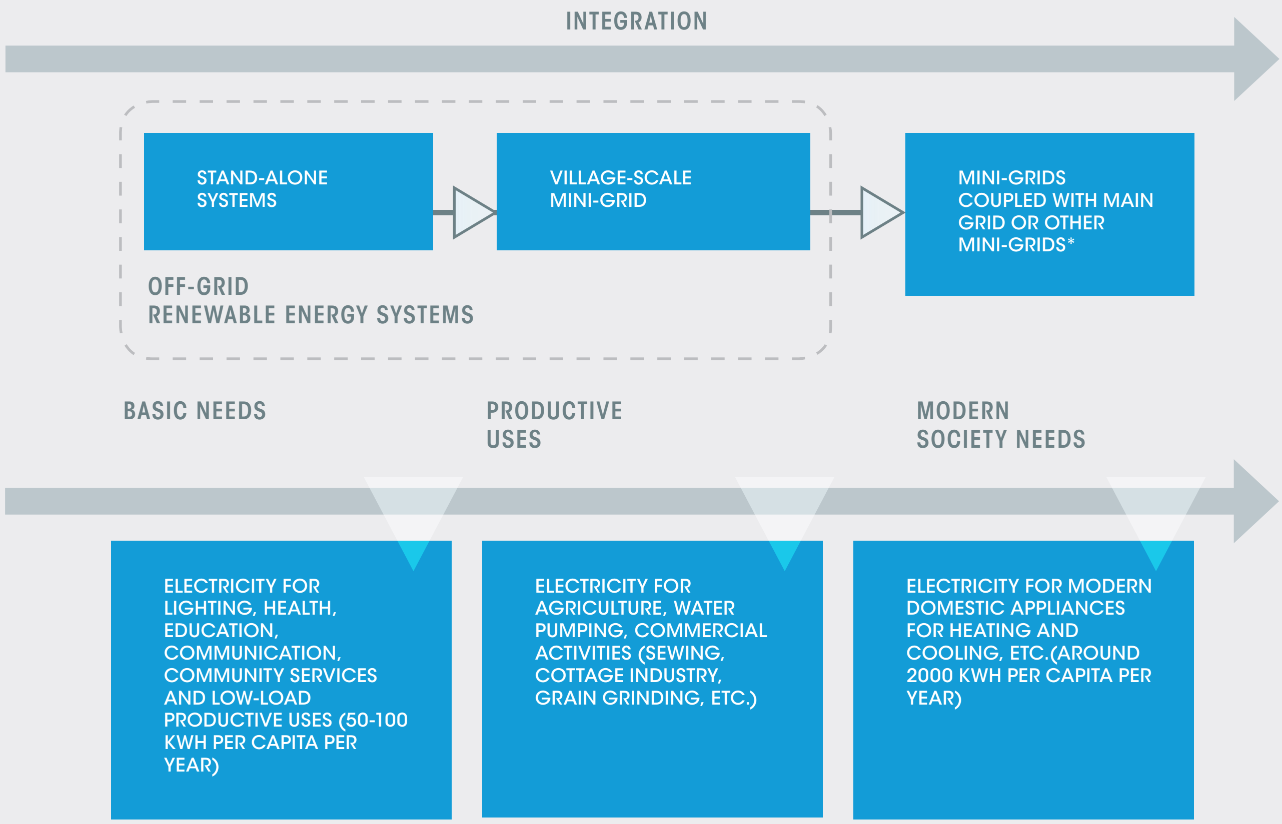
> To achieve universal access to energy, it is necessary to strengthen knowledge and technology exchange and transfer between countries.
>
> Ernesto Macias, President, Alliance for Rural Electrification

Three elements emerged at IOREC as particularly important for supporting off-grid RE deployment: political commitment, a clear rural electrification strategy including long, medium and short-term targets, and dedicated and stable policies.

Political commitment is essential at all stages of rural electrification efforts. Introducing off-grid RE into the mainstream national rural electrification strategy with dedicated policies is important for the sector's development. A clear rural electrification strategy identifies the areas to be reached by grid extension within a reasonable time frame and the areas suitable for off-grid installations. This reduces uncertainty and provides clarity to both off-grid project developers and rural communities. The interplay between stand-alone and mini-grid installations in rural areas is another important element that needs to be considered within the national electrification strategy. As illustrated in Figure 3, stand-alone systems can often stimulate demand for electricity, thereby improving the economic case for mini-grids. Similarly, mini-grids can be further integrated into regional mini-grids[3] or the main grid, where technically feasible.

> Unless off-grid RE is embedded within the national policy framework, the market cannot be developed to support private sector investment and utilise the entire potential of this opportunity.
>
> Philip Mann, Senior Project Manager, Africa-EU Renewable Energy Cooperation Programme

Figure 3 Interplay between off-grid RE deployment approaches (adapted from (AGECC, 2010) and (TERI, 2013))



* *In some instances mini-grids in villages have been known to operate in areas already connected to the national grid but receiving unreliable or intermittent supply.*

[3] *Where a number of villages need to be electrified, it was highlighted that the preferred approach is often a cluster of mini-grids with low-voltage distribution, as opposed to a large mini-grid with high voltage distribution.*

The national rural electrification strategy should set targets, which have to be pragmatic and adjusted to socio-economic conditions. Continued political support and commitment is important while the strategy is implemented. Many successful rural electrification programmes have only succeeded after years of learning and course correction. Hence, programmes should not be abandoned or resources withdrawn if short-term targets are not met. Instead, a learning-by-doing approach is recommended, accompanied by periodic reviews. This requires policies, including support schemes, to be dynamic in order to effectively support the growing market.

> Policies and regulatory frameworks created to support deployment of off-grid RE should behave like and be very receptive to the markets they are trying to support.
>
> **Ben Good,** CEO, GVEP International

Regulators play a critical role in creating an enabling environment which encourages private sector involvement, especially in the mini-grid sector. Given the importance of tariffs in sustainable mini-grid business models, regulators can adopt a tariff structure which takes into consideration both the socio-economic conditions of consumers and the commercial feasibility of projects (subsection 2.4.2). Adequate regulatory frameworks can also encourage innovation in technology design, finance and business models. This allows non-traditional players to participate. For instance, making use of the off-grid telecommunications infrastructure to provide electricity services through non-traditional business models (subsection 2.5.3) requires a suitable regulatory framework. This incentivises the participation of telecommunication infrastructure operators in a market beyond their core business.

Governments have used a broad range of policy instruments to support off-grid RE development. These include public financing (*e.g.* soft loans), fiscal incentives (*e.g.* exemptions from import duty/VAT) and the elimination of market distortions such as fossil fuel subsidies. While most policy instruments for stand-alone and mini-grid projects have a great deal in common, the needs they address may vary. In the case of stand-alone systems, it is critical to unlock the purchasing power of rural households (consumers) and support small and medium enterprises (SMEs) in supplying clean-energy products/services into the market. On the other hand, mini-grid development is better supported through reduced transaction costs for developers, appropriate tariff guidelines, access to affordable finance at various stages of project development and so on. Discussions in subsection 2.4.3 expand on the role of policy instruments within business and financing models in overcoming the specific challenges of off-grid RE projects.

2.3 INSTITUTIONAL FRAMEWORK

An appropriate institutional framework is crucial when designing and implementing a national rural electrification strategy. While some countries have created new bodies with a mandate to support rural electrification activities, others have placed responsibility for rural electrification within existing ministerial frameworks.

For instance, electricity sector reforms in Senegal in 1998 created new institutions dedicated to extending electricity access in rural areas. The main objective of the Senegalese Agency for Rural Electrification (ASER) is to promote rural electrification by implementing the national rural electrification strategy. Other new institutions included the Regulatory Commission for the Electricity Sector (CRSE) and Rural Electrification Fund. These provide regulatory and financial supervision for off-grid RE projects within the national rural electrification strategy framework (IRENA, 2012a). The shift from a rural electrification strategy based on centralised grid-extension to a more diversified approach has produced results. The rural electrification rate increased from five percent in 1998 to 24% in 2010 (ASER, 2012).

> The large-scale deployment of RE for rural electrification and its proper regulation requires the adoption of a clear institutional framework defining the role of each actor.
>
> **Alassane Agalassou**, Director, AMADER, Mali

Similarly, the Malian Agency for the Development of Household Energy and Rural Electrification (AMADER), created in 2003, has made major progress. AMADER adopts a two-pronged approach to rural electrification. This consists of a planned top-down approach to electrifying larger designated areas and a simultaneous bottom-up approach to supporting private initiatives at the community level (AMADER, 2012). This has been effective and increased access to electricity in rural Mali from one percent in 2000 to over 15% in 2010 (Climate Investment Funds, 2012).

The approaches adopted differ according to country-specific contexts. However, some common aspects that have been highlighted as important, irrespective of the approach adopted, include:

- **Clearly defined roles and responsibilities** of the respective institutions. This helps to give developers certainty about administrative procedures and institutional interlocutors;
- **Cooperation** between national and international institutions and agencies involved in rural electrification. This is to create an environment that facilitates large-scale off-grid RE deployment and moves away from a project-by-project approach;
- **Minimised and streamlined administrative procedures.** This reduces the transaction costs incurred by developers, for instance in procuring adequate licences or grants (subsection 2.4.2).

It is vital to ensure institutions have the necessary capacity to effectively design and implement the rural electrification strategy. The capacity needs range from technical skills across the rural electrification value chain, including within public and financial institutions, to the availability of stable budgetary allocations for institutions charged with implementing the rural electrification strategy. In this context, a capacity needs assessment is necessary to identity the needs and the gaps. Recognising this necessity, IRENA co-developed the Capacity Development Needs Diagnostics for RE (CaDRE) tool. This tool is used to carry out such an assessment, and its methodology was presented at an IOREC side event (Text Box 1).

Text Box 1

IRENA SIDE EVENT: CAPACITY NEEDS ASSESSMENTS FOR RURAL ELECTRIFICATION

On 2 November 2012, IRENA held a workshop as an IOREC side event. It focused on the importance of systematic capacity needs assessments for targeted capacity building to support RE-based rural electrification. Representatives from regional agencies, academia and practitioners involved in capacity needs assessments attended the workshop. They shared their experiences with the audience and explained how assessment findings had helped shape responses. This also helped individuals better understand and exercise their responsibilities, and organisations to deliver effectively on their mandate.

The workshop's key findings are as follows:

- RE deployment and access to modern energy services can be facilitated by a number of factors. These include public institutions competently delivering on their mandate, financial institutions being confident in RE technologies, and rural entrepreneurs and communities accepting the technologies. Although RE technologies are becoming increasingly competitive, presenting them as an attractive business case for the purpose of rural electrification is a complex task. This is primarily due to knowledge and capacity gaps;
- A broad range of qualifications and technical skill sets are needed to support market development. They range from basic education for end users to certification for expert installers who can operate and maintain systems, and qualifications for public sector employees who have to evaluate proposals and take informed and independent decisions;

- RE courses need to be increased and the quality of course delivery and curriculum closely monitored and improved. RE training centres should have access to the latest knowledge and update their offerings accordingly. However, finance and procurement of equipment is a problem for many existing centres;
- End-user awareness and gender issues require particular attention in the context of rural electrification.

Participants confirmed that capacity needs assessments would help determine whether the conditions to deploy RE in rural areas are available and in place. If not in place, it would define what is required to put them in place. It was acknowledged that systematic and coordinated approaches like these provide critical inputs for decision makers. They allow them to identify key actions that can help to achieve electrification targets. It also allows them to integrate capacity building into the planning process from the beginning.

ROLE OF CHAMPIONS

Several successful rural electrification programmes based on off-grid RE can be found across the world. These are led by institutions that have accumulated tremendous experience in different regions. These sector champions mostly begin as entrepreneurial initiatives and work their way up the learning curve. They continuously develop their businesses to suit the needs and capacity of rural communities. These champions can play a critical role in communicating best practices and lessons learnt from their diverse experience in different regions. This provides rural electrification programmes and local enterprises with the opportunity to leapfrog the learning curve associated with the off-grid RE market. That in turn accelerates rural electrification.

> We do not need a top-down centralised approach to electrify the poor households, but rather a decentralised bottom-up approach.
>
> Dipal Chandra Barua, Co-founder, Grameen Bank

Massive deployment of off-grid RE systems will only be possible through involvement of local enterprises that draw on local capacities. Hence, there is a need to achieve a critical mass of local enterprises in rural areas. Sector champions have an important role to play in addressing this need by empowering local entrepreneurs through cross-mentoring (Text Box 2). National and local governments will need to play a fundamental role

> The critical challenge facing the scale-up of off-grid RE deployment in Africa is not technology or finance but the need to foster local entrepreneurs.
>
> Harish Hande, Managing Director, SELCO India

in facilitating the sharing of experience and lessons and in creating the ecosystem for incubating and fostering local enterprises at sufficient scale to massively deploy off-grid RE in remote areas.

2.4 FINANCING AND BUSINESS MODELS

There is a sizeable market for off-grid RE in rural areas with no electricity access or with unreliable supply. Households and small businesses across the world spend over USD 36 billion annually on fossil fuel-based lighting, mainly kerosene (International Finance Corporation (IFC),2012) – an indicator of the potential market. Indeed, USD 10 billion per year is spent in Africa alone (Lighting Africa, 2011). This demonstrates the tremendous business opportunity for the private sector to provide a broad range of services relating to rural electrification.

Accelerated rural electrification by scaling up off-grid RE deployment can only take place through adoption of sustainable business models. IOREC highlighted two factors that contribute to the sustainability of business models. These are: **access to affordable finance** and **electricity supply for productive uses**.

Text Box 2

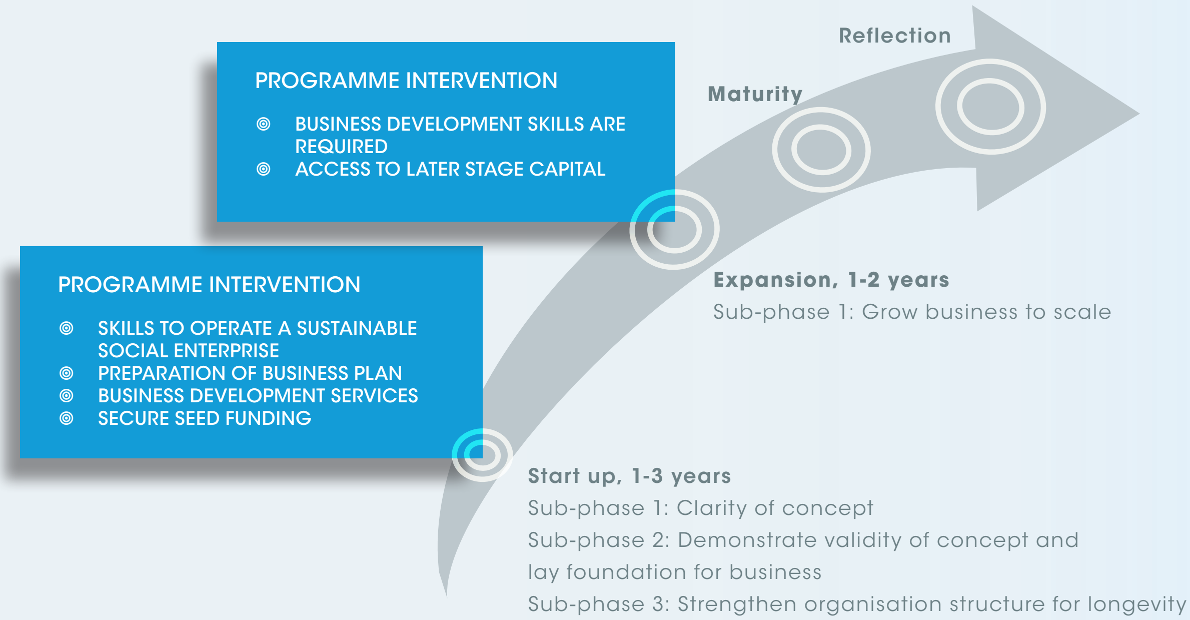
SECTOR CHAMPIONS EMPOWERING LOCAL ENTERPRISES: SELCO INCUBATION CENTRE

SELCO Incubation Centre is a non-profit organisation hosted by the Small Scale Sustainable Infrastructure Development Fund, supported by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The programme draws on SELCO's shared resources, management expertise, intellectual capital and learnings from the past 17 years. This improves the potential for local energy enterprises to deliver off-grid RE-based lighting to low-income communities as follows:

- By replicating decentralised business models and processes;
- By mentoring on social enterprise management and business planning support;
- By helping develop the enabling conditions for delivering energy services;
- By facilitating access to seed and later stage capital (mix of debt, equity and grants);
- By establishing a network hub among the entrepreneurs engaged in the programme and facilitating access to multiple stakeholders who can provide trusted advice;
- By introducing entrepreneurs to other partnerships that can benefit the enterprise.

The programme intervenes mainly at the critical start-up phase of enterprises with business development services provided at later stages, as highlighted in Figure 4. Training for selected entrepreneurs, including their operational staff, is a mix of classroom and field experience for a period of one year.

Figure 4 Enterprise development phases and the role of SELCO Incubation Centre (SELCO, 2013)



Key elements of the training programme include critical aspects of a sustainable business model based on off-grid RE: the sales and after-sales service component, customisation of technology based on consumer needs, building banking relationships, designing end-user financing schemes, rural marketing and its dynamics, enterprise finance, making use of local human resources and capacities, policy impacts on business dynamics, building management capacity to carry through business plans, etc.

IOREC participants emphasised that access to affordable finance is one of the most important challenges for off-grid RE development (see also Appendix 1). Access to long-term, affordable finance allows developers to deliver products and services at lower costs. It is important for all stages of project development, including scale-up. At the same time, access to consumer finance means end users can afford the energy services and products offered. Hence, off-grid finance mainly consists of two components: a) downstream (end users) who require consumer finance and b) upstream (enterprises) that require start-up capital, working capital, project finance, etc.

> Every successful model we are seeing (at IOREC) today has an element of affordable financing.
>
> John Wasielewski, Development Finance Advisor, U.S. Department of State

The lessons and best practices from different approaches to financing and business models will be discussed further for stand-alone (subsection 2.4.1) and mini-grid (subsection 2.4.2) projects. Following the discussions, a summary of key measures to overcome common challenges is provided (subsection 2.5.3).

LINKING PRODUCTIVE USES AND SUSTAINABLE BUSINESS MODELS

Off-grid RE can provide services beyond basic lighting, and utilising these for income generation activities positively impacts the sustainability aspect of business models. An example highlighted from UNIDO's experience in deploying mini-grids included the use of off-grid RE systems not for household lighting but for charging lanterns that enable fishermen to fish at night, leading to higher income generation which in-turn also enables them to pay for the services being offered. Hence, focusing provision of electricity supply for productive uses in the communities serves a dual purpose: facilitating growth in income-generation opportunities, thereby driving socio-economic development, as well as increasing the ability of the communities to pay for energy services being provided.

2.4.1 Financing and business models for stand-alone systems

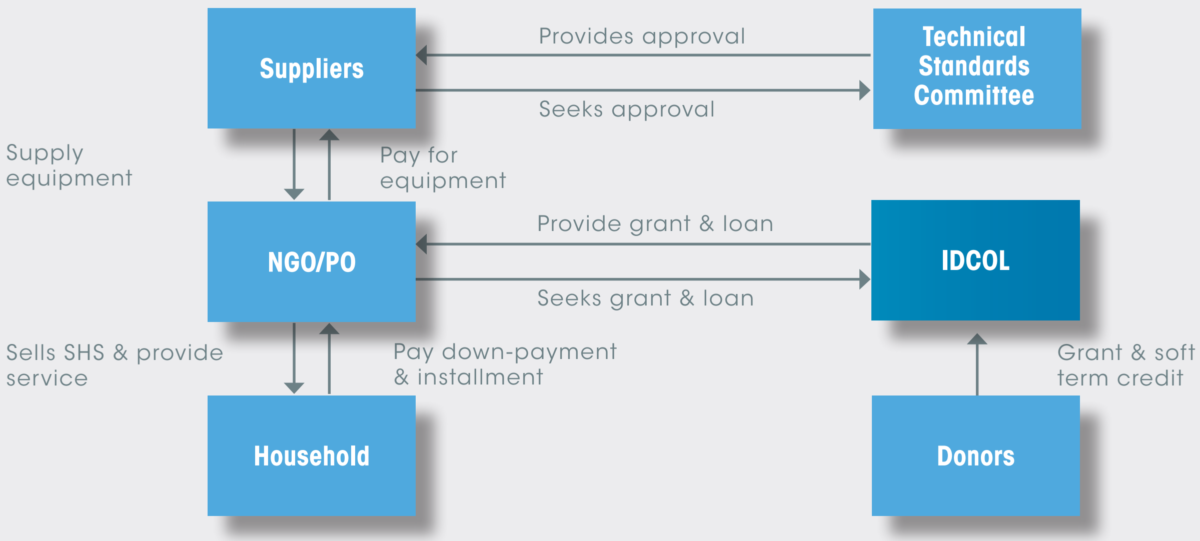
Stand-alone systems, replacing fossil fuel-based lighting (such as kerosene lamps) and providing basic electricity access to rural households, have the potential for rapid and widespread deployment. IOREC participants emphasised that stand-alone RE systems are cost-competitive with conventional kerosene lamps on a life cycle basis. The payback period is usually between one and five years for a solar home system (SHS) depending on the system size[4]. The major obstacle to large scale diffusion of stand-alone RE systems is the higher initial cost compared to kerosene lamps. Innovative financing schemes have allowed rural electrification programmes and businesses to break down this barrier by offering debt financing or a mixture of debt financing and grants to rural households. There are several successful programmes and business models and they share common success factors which emerged at IOREC. These include outreach to rural areas, capacities within implementing agencies, customised financing schemes, role of development funds and sustainability of financial support, stringent quality control and after-sales service and leveraging technology platforms. These factors are discussed below.

OUTREACH TO RURAL AREAS

A network of institutions and enterprises with the necessary outreach to provide technology or services like financing or operations and maintenance (O&M) is required to ensure that rural households can access off-grid RE electricity. In the case of Bangladesh's Infrastructure Development Company Limited (IDCOL), the successful SHS programme is implemented through a large network of intermediary Partner Organisations (POs). These supply microfinance and technology to rural households. The IDCOL SHS programme has targeted the 'downstream' end users as well as the 'upstream' enterprises. It does so by acting as an intermediary between the funding agencies (World Bank, Asian Development Bank, etc.) and the local POs (SMEs, Non-Governmental Organisations (NGOs), etc.). The POs act as focal points for all dealings with the households. This includes selling the system, liaising with system suppliers, providing the finance through cash or credit, recovering the debt and providing O&M services. The programme's operational model is illustrated in Figure 5.

[4] *See also (ARE, 2011a)*

Figure 5 Operational model for the IDCOL SHS programme in Bangladesh (adapted from IDCOL, 2012)



The IDCOL SHS programme is the largest off-grid electrification programme in the world. It has deployed over 2.1 million SHS across Bangladesh and aims to finance four million SHS by 2016. The programme has gone through a significant learning curve; from about 280,000 installations between 2002 and 2008 to 2.1 million as of March 2013 (IDCOL, 2013).

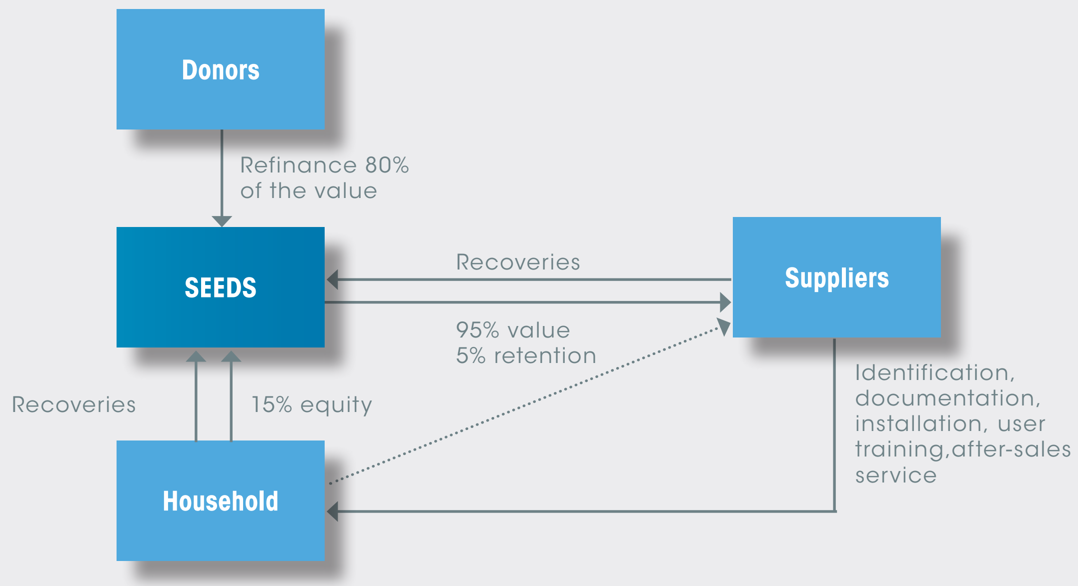
> The IDCOL model can be replicated in many African countries, which have similar economic environments as Bangladesh.
>
> Nazmul Haque, Director & Head of Investment, IDCOL

Sarvodaya Economic Enterprise Development Services (SEEDS), a microfinance institution in Sri Lanka, also featured at IOREC. While both IDCOL and SEEDS provide microfinance to rural households, there are intrinsic differences to the approach they take. IDCOL works through intermediaries by enlisting POs which extend finance to consumers and hence take the risk of collections. SEEDS, on the other hand, gets directly involved in financing and recovery through its 2,500 registered societies, as shown in Figure 6. Local field officers employed by SEEDS collect monthly repayments and also carry out checks and minor repairs to the systems.

The challenge of finding suitable partner organisations with the required outreach is accentuated in areas with lower population density. IOREC revealed the experience of Emprenda, a microfinance company in Argentina, which has extremely low population densities in rural areas compared to Bangladesh, India or Sri Lanka. The enterprise targets last-mile electrification to over 300,000 rural households where the low presence of financial institutions presents an additional challenge. To overcome this challenge, Emprenda has adopted an integrated approach. It has trained loan officers not only to provide financial solutions but also to promote, evaluate, install and repair systems, train the consumers and collect microcredit. Over 1,500 households now have access to electricity through this approach.

> Off-grid RE projects benefit from public support during the scale-up phase.
>
> Juan José Ochoa, Vice President, Emprenda

Figure 6 Operational model for the SEEDS programme in Sri Lanka (adapted from SEEDS, 2012)



CAPACITIES WITHIN IMPLEMENTING AGENCIES

While it is important that institutions exist with the required outreach to remote rural areas, ensuring they have the capacity to provide the services to rural households is just as vital. For instance, among the challenges that IDCOL faced with its POs was the limited availability of working capital for offering debt financing to rural households. This is because most sales are based on credit. IDCOL addressed this challenge by providing concessional finance to those POs which provide microfinance to rural households. This allows the POs to borrow the required capital from IDCOL to maintain a steady flow of working capital which can then be lent to rural households. The same facility can be used for investments that contribute to creating a sustainable market for off-grid RE products. This includes investing in building local capacity, consumer awareness, training and promotional activities and so on.

The case of ARB Apex Bank, the implementing agency of the Ghana Energy Development and Access Project (GEDAP), illustrated the need for technical capacities within financing institutions. The bank acts as a mini-central bank by lending capital to a vast network of rural and community banks across Ghana. These in turn finance SHS to rural households lacking electricity access. In order to design financing schemes for off-grid RE systems, the bank developed in-house technical expertise with insight into the nuances of the technology. It is now working towards its target of financing 15,000 systems by 2013 benefiting over 90,000 people. A summary of the key lessons learnt from the programme has been summarised in Text Box 3.

CUSTOMISED FINANCING SCHEMES

Different models for providing finance to end users were discussed at IOREC. The collective experience from Africa, Asia and Latin America suggests there is a need to approach the end user financing challenge by designing tailor-made schemes. These should be based on the cash flow and existing energy expenditure of end users, for instance on kerosene-based lighting. SELCO India drew attention to the importance of adopting a flexible and tailor-made approach while designing financial products. SELCO's experience of selling, servicing and financing over 135,000 SHS has shown that access to customised long-term affordable financing has made off-grid RE products available to rural households with limited income, mostly without grant support. However, this means extending financial infrastructure to remote areas, as discussed earlier. It also means ensuring lending conditions are compatible with the household's ability to pay instalments and place collaterals or guarantees. This also emerged in the case of ARB Apex Bank Ghana. The recent growth in systems installed (137 until mid-2010 to 9,038 as of

Text Box 3

FINANCING OF SHS: LESSONS LEARNT BY ARB APEX BANK IN GHANA

Some of the key lessons highlighted by ARB Apex Bank can be summarised as follows:

- Demonstration projects are important to showcase the benefits of the system. These projects provide the initial push to convince the households of the added value;
- Technical capacities should be developed within financing institutions with dedicated officers who have an understanding of off-grid RE projects;
- There is a need for community awareness about off-grid RE benefits. It is important to dispel the myth that accepting off-grid systems means end users are being supplied with unreliable electricity and deprived of grid electricity;
- The repayment plans (instalments, maturity period, down payment, etc.) should be designed with an understanding of the monthly cash flow of the consumer;
- Solar companies (or suppliers) should be provided with support in accessing affordable finance in order ensure that they play their part in scaling up off-grid RE deployment. Both access to finance and technology should work in tandem for the success of an electrification programme;
- To ensure quality installations, on-site independent inspectors should be engaged. They inspect each retrofitted household prior to paying the solar company;
- With increasing installation rates, the need for skilled installers will rise significantly. In order to build technical capacity, the Solar Training Centre has been integrated into the national Ghana Energy Development and Access Project to train more solar installers.

November 2012) can also be attributed to the bank's ability to adapt its services to the needs of rural households. It does this through initiatives like flexible loan repayment models (six months to three years) based on customer cash flow.

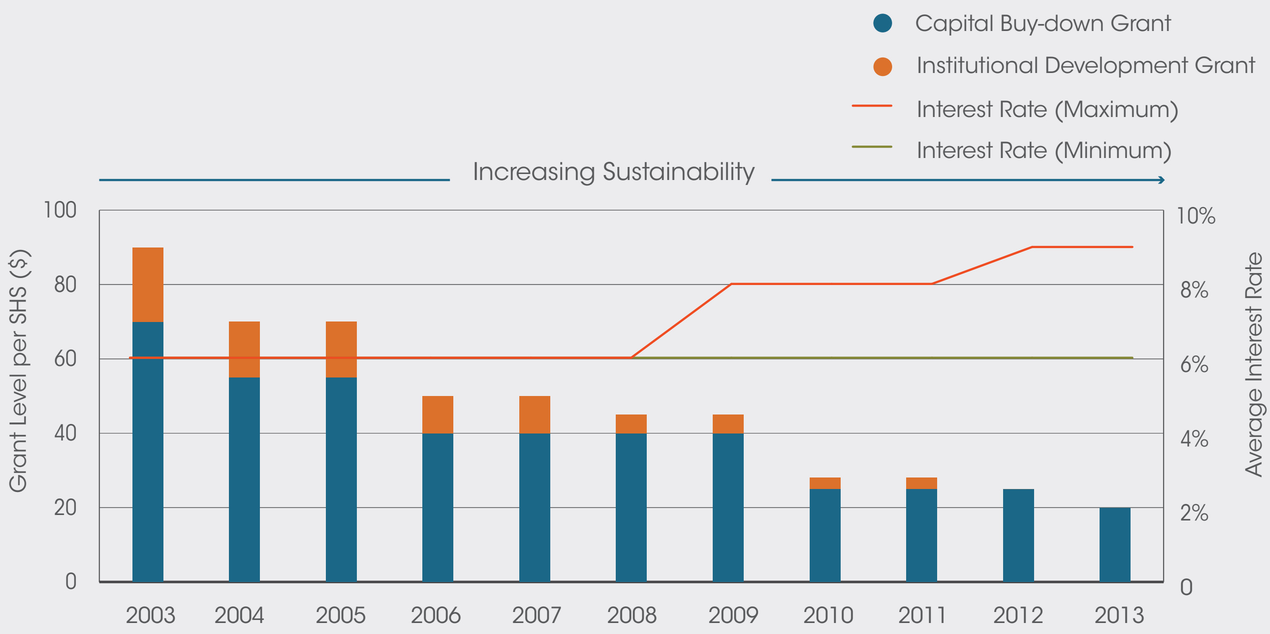
ROLE OF DEVELOPMENT FUNDS AND SUSTAINABILITY OF FINANCIAL SUPPORT

There is a perceptible shift in the use of donor funding sourced, for instance, from public financing or development agencies. It is moving away from partly or wholly subsidising off-grid RE systems towards supporting the creation of a sustainable market for them. In this context, donor funding can play an important role in supporting rural electrification programmes, especially in the early stages. Experience shows that the role of donor funding can be reduced as the programme reaches scale and the local off-grid market matures - as seen in the case of Bangladesh. The major financial components of the IDCOL SHS programme - grants and concessional finance - are designed in such a way that dependence on external finance gradually recedes (Figure 7). For instance, the capital buy-down grant per system is being gradually reduced from USD 70 per system in 2003 to USD 20 in 2013, and is expected to reach zero by 2014. The institutional development grant component has been completely eliminated. In addition, lending rates offered are gradually approaching commercial finance rates. This will allow commercial banks to enter the market in the future.

> Providing financial support to address the capital costs at consumer level for off-grid RE systems like SHS increases affordability for households while capping the subsidy provider's exposure.
>
> Joseph Nganga, CEO, Renewable Energy Ventures

Several factors have contributed to the maturing of the off-grid RE market in Bangladesh. The programme lays tremendous emphasis on local capacity building, customer education and training,

Figure 7 Change in grant level provided per installation and average interest rate for loans (based on IDCOL, 2012)



promotional activities, quality control, monitoring mechanisms and after-sales service. All of these contribute to sustainability within the sector. Other factors, such as the global fall in PV technology costs, policy support in the form of tax exemptions, and rising cost of kerosene have also played a contributing role.

STRINGENT QUALITY CONTROL AND AFTER-SALES SERVICE

One of the critical success factors which came through during IOREC was the importance of a strong quality control mechanism complemented by an efficient after-sales service supply chain. This finding was based on experiences from several programmes and initiatives targeting stand-alone systems. Strict quality control facilitates the uptake of the technology among rural communities and helps dispel any negative perceptions of its reliability. Several measures contribute to a stringent quality-control regime. One example is field inspections to monitor system installation and performance before funds are disbursed to the installer (*e.g.* GEDAP, Ghana). Other examples are dedicated call centre lines for registering complaints (*e.g.* IDCOL, Bangladesh) and mandatory quality standards for systems and components (*e.g.* Remote Village Electrification Programme, India).

> Quality after-sales service is key to the success of any off-grid RE project.
>
> Frank Dadzie, Project Manager (Solar), ARB Apex Bank, Ghana

LEVERAGING TECHNOLOGY PLATFORMS

Innovative technology platforms integrated into business models can decrease operational costs, optimise system performance and improve reliability. One example of a model adopted in several countries is where the consumer pays a down payment to partly cover the cost of the system. The remaining cost is paid through smaller instalments until system ownership transfers to the consumer. This model is often more efficient when integrated with mobile payment platforms and makes the bottom of the pyramid a more attractive market for entrepreneurs given the high penetration of mobile communication services. In addition, GSM-based metering and service devices are being increasingly used. They can combine mobile payment (such as M-Pesa) with a database that monitors the technical performance of each SHS installed. During IOREC discussions it was highlighted that remote monitoring has the potential to reduce maintenance cost by up to 90% and has a promising impact on the expected lifetime of the systems.

2.4.2 Financing and business models for mini-grids

Mini-grids will play a crucial role in extending electricity access and stimulating socio-economic development in rural areas by catering to diverse loads, including for productive uses[5]. They have the potential to profitably serve at least 30 million households, representing a market of up to USD 4 billion (IFC, 2012). Falling costs and increasing technology maturity make RE the most appropriate option for mini-grids in most rural areas. This is true for both new mini-grids and for existing diesel-based mini-grids that can be replaced by hybrid or RE generation. Utilising the immense potential and ensuring accelerated deployment of RE mini-grids requires appropriate business and financing models. These should take into account the different stakeholder interactions occurring at various stages of the mini-grid deployment and operational value chain, as depicted in Figure 8.

Generally there are three different approaches to mini-grid implementation:

1. Large utility-driven approaches;
2. Private sector micro-utility initiatives;
3. Community driven approaches at a local level.

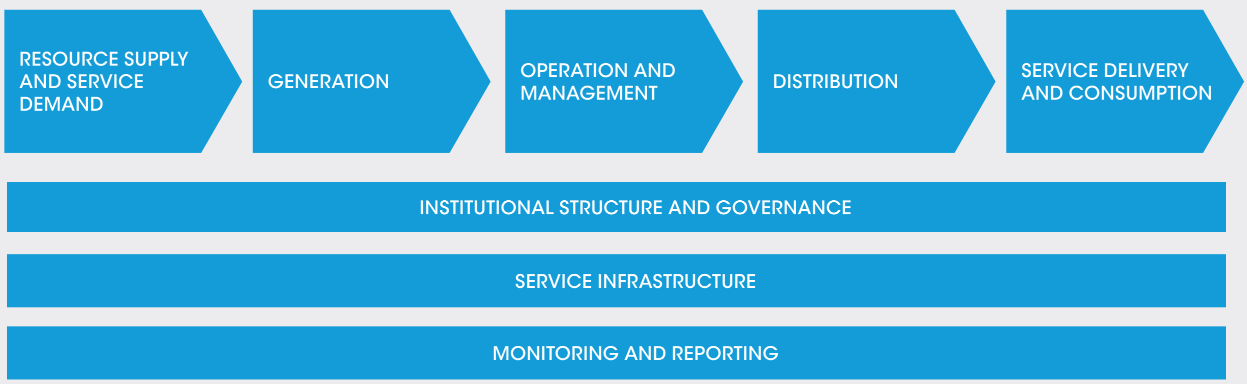
The experience of Kenya Power (KP), a public company that transmits, distributes and retails electricity throughout Kenya, is an example of a large utility-driven approach. KP has played a catalytic role in supporting mini-grids as an effective approach to rural electrification. There are currently 18 operational mini-grids with a total installed capacity of 19 MW in areas not connected to the national grid due to distance and low demand. Most are based on diesel and some have been running for over 30 years. The major challenge for these installations is the high operation cost

> The major challenge faced today by fossil-fuel based mini-grids is the high operation cost primarily due to fuel, thus leading to higher tariffs.
>
> **Henry Gichungi**, Off-grid Business Manager, Kenya Power

– mainly for fuel. This creates a case for integrating RE into existing mini-grids, which have minimal operational costs when compared to diesel generators. This has prompted KP to diversify the generation mix by making increased use of either hybrid or RE configuration for mini-grids (KP, 2013). The increasing use of RE is expected to reduce the fuel cost component of the consumer tariff while decreasing the exposure to volatile diesel prices.

In addition to the large utility approach, the role of micro-utilities for accelerating the development of RE mini-grids in remote areas was highlighted at IOREC. Private sector micro-utilities are SMEs with limited

FIGURE 8 MINI-GRID DEPLOYMENT AND OPERATIONAL VALUE CHAIN (ADAPTED FROM GIZ, 2012)



[5] *Market assessment in the ECOWAS region shows that over 60,000 mini-grids (3,600 MW) will need to be installed by 2020 and 128,000 mini-grids (7,680 MW) by 2030 to achieve universal access to electricity in the region (ECREEE, 2012).*

financial resources operating in the rural electrification sector. Conference discussions identified specific considerations critical to the **involvement of the private sector in mini-grid deployment**. Some of these are discussed below. They include project transaction costs, finance for mini-grid projects, and tariff considerations.

> The gestation period of off-grid RE projects is very long and financial incentives play a crucial role in providing the seed finance during the preparation and the validation phase.
>
> Godfrey Mwindaare, Regional Director, West Africa, Acumen Fund

PROJECT TRANSACTION COSTS

Transaction costs are an indication of the cost of doing business in a certain region. They arise primarily from private micro-utility interactions with entities at three different levels. These are the national framework (regulatory body, ministries, etc.), the international support structure (foreign investment guarantors, donor agencies, etc.) and project implementation (equity investors, banks, MFIs, etc.).

Conference discussions underlined that transaction costs can be as high as 36% of the generation cost (in dollars per kilowatt-hour) for private sector micro-utilities (INENSUS, 2012). Furthermore, these high generation costs are sometimes incompatible with guidelines set by regulatory authorities on tariffs (*e.g.* fixed or ceiling tariffs) or with consumer ability to pay.

Policy makers can take two approaches, separately or in combination, to overcome transaction cost problems:

- **Address the source of transaction costs (top-down approach)**: Transaction costs can be reduced by streamlining institutional, regulatory and legal frameworks for acquiring licences, receiving fiscal support, negotiating tariffs, etc. This also provides clarity to private sector developers;

- **Strengthening micro-utility capacity (bottom-up approach)**: Ensuring that projects have access to financial instruments (*e.g.* mixture of grants, long term loans[6], equity investments, etc.) particularly during the initial and scale-up phases when most transaction costs occur.

FINANCE FOR MINI-GRID PROJECTS

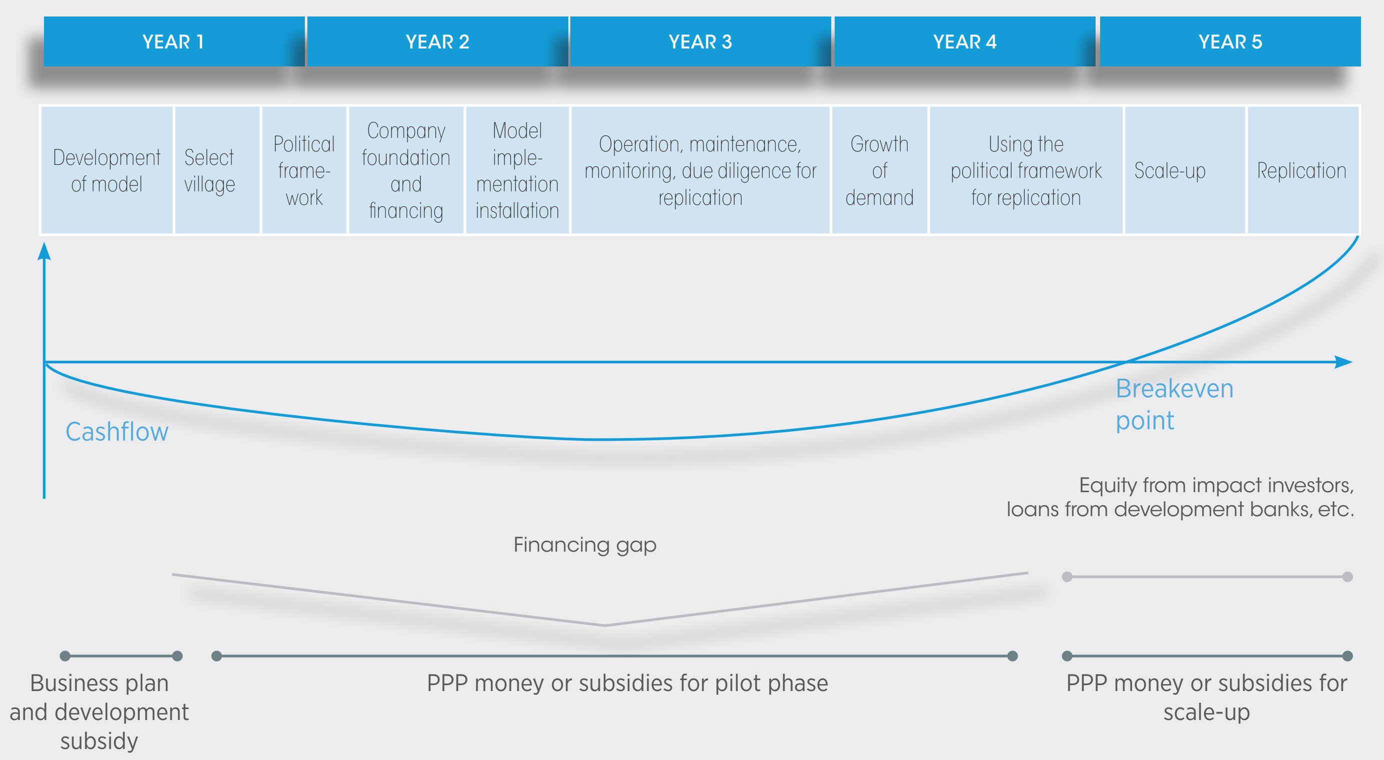
Increasing private sector participation partly depends on availability of affordable finance for private micro-utilities (*e.g.* start-up, working capital, etc.). In this context, public finance needs to be complemented by private finance. For private micro-utilities in particular, there is a critical finance gap in the early stages of operation. It is necessary to bridge this gap in order to ensure projects are commercially viable and can scale up (Figure 9). Some impact investors are entering the mini-grid sector and partly covering this financing gap. However, IOREC revealed that funding availability, as well as financial institutions active in this sector (including commercial banks), are still limited.

> The financing gap for micro-utilities cannot be covered by public funds alone; private finance is required.
>
> Nico Peterschmidt, Managing Director, INENSUS GmbH

An environment that minimises investment risks and attracts private sector participation into the RE mini-grid sector features the use of funds from different sources (*e.g.* domestic and multilateral organisations) to invest in public infrastructure (*e.g.* local distribution grids and non-generating assets, in general) or for various incentive mechanisms (*e.g.* publicly backed guarantees, long-term affordable financing, grant/debt facilities for end users to cover connection costs, etc.). Both the private sector and public utilities can benefit from such an environment, and it can effectively facilitate large-scale mini-grid deployment while shifting away from a project-by-project approach.

[6] *It was also highlighted that long term loans in the local currency should be available to reduce foreign exchange risk for micro-utilities.*

Figure 9 Financing along the micro-utility development timeline (Adapted from INENSUS, 2012)



MINI-GRID TARIFF CONSIDERATIONS

Appropriate tariff design underpins sustainable private mini-grid business models. Tariff setting/design for private mini-grid developers is particularly linked to two specific aspects - consumer ability to pay and regulator tariff guidelines. Consumer willingness or ability to pay signals the maximum price the operator can realistically charge. Any gap between this price and a commercially viable tariff will need to be bridged through adequate policy or financing instruments. Thus, while defining the tariff design approach (fixed tariff, ceiling price, tenders, etc.) regulators should pay plenty of attention to both the diverse socio-economic conditions of rural communities and the conditions allowing commercial viability of private sector mini-grid projects (see Text box 4).

> Policies should carefully address the issue of tariffs which forms an important aspect of every mini-grid business model.
>
> Pradeep Monga, Director, Energy and Climate Change, UNIDO

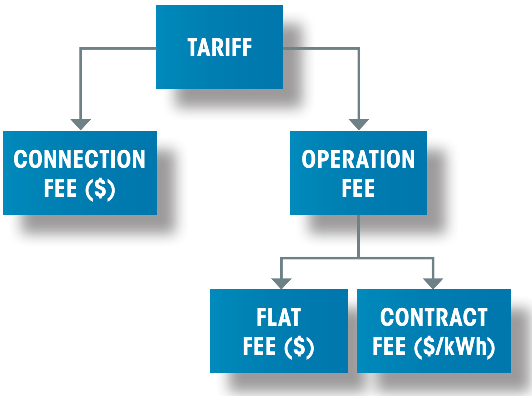
Typical tariff components around which a mini-grid business model can be based are outlined in Figure 10. The connection fee refers to a one-off payment made by the rural household to connect to the mini-grid distribution network. Once connected, it pays an operational fee for the electricity consumed, usually on a monthly basis. This requires monthly meter readings from individual households. Where consumption can be predicted with sufficient accuracy, operators can charge a flat fee. However, this comes with the risk of over-consumption leading to less reliability of supply across the entire network. Often a combination of a flat fee and contract fee is adopted with tariffs closely linked to monthly consumption levels.

Two major tariff design challenges for mini-grid operators, along with the implications for business models and relevant countermeasures, are summarised as follows:

» **High connection costs** can significantly restrict the uptake of mini-grids[7]. Downstream financing for end users, for instance through a mix of grants and

[7] *The cost of connecting to a mini-grid can vary significantly. For instance, in the case of Mali this cost can range from USD 45-USD 378 (IFC, 2012).*

FIGURE 10 TARIFF COMPONENTS FOR MINI-GRID INSTALLATIONS (BASED ON ARE, 2011B)



debt financing, is often introduced to help households overcome this obstacle. This aspect has to be incorporated into mini-grid business models, since household inability to afford connection fees affect the market penetration of the service;

» **High operational costs** are often incurred by mini-grid operators during metering and fee collection activities. This means lower revenues for developers and/or higher tariffs for consumers. To address these issues, information technology tools are being integrated into business models for remote fee collection and for metering, monitoring and regulating consumption. Smart meters, prepaid systems and mobile commerce are new efficient tools which can influence tariff design and collection methods.

2.4.3 Challenges to off-grid RE scaling up

A broad range of policy instruments, targeting both SMEs and end users, can be used to accelerate off-grid RE deployment for rural electrification. As mentioned in Section 2.2, some of these instruments include access to public finance, fiscal incentives and levelling the playing field. Specific cases highlighted at IOREC are summarised in Table 1. They illustrate the role of policy instruments in addressing specific challenges faced by off-grid RE projects.

Text Box 4

IRENA-GIZ SIDE EVENT: MAKING THE CASE FOR RE-BASED REMOTE ENERGY SUPPLY: COST TRENDS AND TECHNICAL, ECONOMIC AND POLICY CHALLENGES FOR THE REALISATION OF RE-BASED MINI-GRIDS

A noticeable decline in the price of RE technologies and significant fluctuation of fossil fuel prices has substantially improved the competitiveness of RE for the electrification of off-grid areas. Although the economic viability and technical reliability of the technology has improved significantly, a number of problems are obstructing the sustainable deployment and operation of off-grid RE projects.

The side event, jointly organised by IRENA and GIZ, focused on:

» Insights into the improved cost competitiveness of RE decentralised electricity systems; existing challenges and barriers to their promotion and deployment;

» Recent cost developments and future price trends for RE technologies in Africa;

» Lessons from implementing technical assistance programmes for rural electrification; experiences in promotion, development, management and operation of mini-grids;

» Experiences of innovative business models for off-grid electricity supply in Senegal;

» Challenges and opportunities for sustainable widespread deployment of mini-grids.

Main conclusions

» RE is now the economic solution for mini-grids, significantly cheaper than diesel generators;

» Mini-grid developers have to engage with a constellation of stakeholders such as public, private, financial and donor institutions. These institutions need to foster growth through concerted goals and action;

» Accelerating deployment of mini-grids requires an enabling environment to address a broad range of challenges that cover policy and regulation, financing, installation management, generation system design and operation, and service delivery.

Table 1 Summary of challenges, their implications and mitigation measures outlined at IOREC

CHALLENGE	IMPLICATIONS	MITIGATION MEASURES
Lack of capacity in institutions	» Lack of financial resources and technical skills prevents institutions from fulfilling their role in rural electrification programmes.	» Identify capacity needs through preliminary assessments. » Provide adequate financial and human resources, staff training courses, etc. » Place dedicated human resources, with the necessary technical skills to understand RE nuances, within implementing agencies.
Lack of affordable financing for SMEs	» High cost of capital for SMEs directly translates into high cost of products and services in the off-grid RE market. » Lack of financing at different stages of project development inhibits private sector participation. » Financing gap exists particularly in the initial stages of RE mini-grid project development.	» Provide access to long-term and affordable finance to project developers at different stages of project development. » Reduce the risk in specific elements of the mini-grid business model, for instance through reduced transaction costs, appropriate tariff setting, publicly backed guarantees, etc. This can unlock private sector financing to fill the existing financing gap.
Lack of affordable finance for consumers	» Limited access to finance reduces the purchasing power of rural households. » Down payment and repayment terms are often not affordable for rural households.	» Design financing schemes customised to cash flows of rural households and restrict monthly instalments to existing energy expenditure (*e.g.* kerosene). » Introduce economic incentives (*e.g.* grants, soft loans, etc.) and fiscal incentives (*e.g.* tax exemptions and/or duty free imports of RE systems and components) to improve affordability and payback period on off-grid RE investments.
Unsustainable business models	» Lack of sustainability, for instance due to continued reliance on public/ external support (*e.g.* financial, human, etc.), inhibits the scale-up of rural electrification.	» Provision of electricity for local productive uses leads to income generation within the communities and makes electricity services more affordable. » Coordinate financial resources (domestic, multilateral funds, etc.) to create an enabling environment. For instance, one can invest in public infrastructure (*e.g.* local distribution grids or other non-generating assets) or local initiatives (*e.g.* capacity building, public awareness). This reduces costs for developers and encourages private sector involvement. » Integrate technology platforms like GSM into business models for remote monitoring and fee collection, thereby reducing operating costs and promoting sustainability.
Lack of community awareness about benefits of off-grid RE and system handling	» Slow off-grid RE uptake although technology is reliable and less expensive than fossil fuel-based systems on a life-cycle basis. » Tampering with systems and lack of maintenance leading to suboptimal performance or premature breakdown.	» Run promotional campaigns and training programmes to raise awareness on the benefits of off-grid RE systems and to banish myths about them being unreliable or expensive. » Run demonstration projects to show how the systems perform. » Train the consumers on how to efficiently use and maintain the systems.
Limited availability of local technical expertise	» Higher installation, operation and maintenance costs. » Lack of technical skills in the market to support scale up of off-grid RE projects.	» Build technical capacity, for instance by including standard modules on RE technologies in training programmes carried out by local institutions. » Adopt an integrated approach to enhancing existing skills by providing training on all aspects of off-grid RE deployment, including financing, servicing, installation, etc.
Lack of quality control and assurance	» Presence of substandard components in the market leads to premature system failures and negative perceptions of the technology in rural communities.	» Introduce stringent technical standards and quality control for off-grid RE systems and components. » Link support schemes (*e.g.* grants) with compliance checks (*e.g.* technical inspections) to ensure quality standards of installations are met.

2.5 TECHNOLOGIES AND THEIR APPLICATIONS

RE technologies will be at the core of electricity access efforts as they use locally available energy resources and can be deployed close to the load centres in various sizes and configurations. They have a wide range of possible applications and represent the most suitable option for off-grid installations in most areas.

The additional off-grid generation required for universal electricity access will need to use all RE sources including solar, wind, small hydro and bioenergy (see Text Box 5). This section will present the key points that emerged at IOREC on technical challenges as well as on design considerations for mini-grids and on technology applications for meeting basic needs.

2.5.1 Technical challenges

Technical challenges faced by specific RE technologies were discussed at IOREC round tables and side events. Some of these have been summarised in Table 2.

2.5.2 Rural mini-grid design

Mini-grids have proved to be an attractive option for rural electrification. They provide a major opportunity for communities since they can service diverse loads, including for productive applications. Whether hybrid or entirely based on RE, mini-grids can integrate several sources (wind, biomass/biogas, hydro, solar, diesel, etc.). They can be designed in a way that is compatible with the main grid distribution infrastructure.

Table 2 Summary of technical challenges highlighted at IOREC

TECHNOLOGY	TECHNICAL CHALLENGES AND ISSUES
SHS	» For rural areas it is important that the system and individual components are robust, tamper-proof and user-friendly. Thin and fragile cable connections are known causes of system failures. » System abuse, as users experiment with heavy loads can limit the lifetime of components, requiring more frequent replacements. » Compromise on quality of less expensive components like charge controllers (two to four percent of system lifetime costs) may negatively impact the overall cost of the system over its lifetime. This is because they play a crucial role in the effective operation of relatively expensive components like batteries (as much as 50% of system lifetime costs). » The choice between direct current (DC) and alternating current (AC) SHS should take into account the distances through which power has to be distributed since efficiency of DC systems declines significantly more with increasing distance.
Small and Medium Wind Turbine	» Lack of wind resource data for rural areas prevents preliminary assessments of suitable sites for small and medium-sized wind power plants. » There is a general lack of awareness of the technology and its potential role in an integrated rural electrification network that benefits from synergies between different technologies. » Product certification of wind turbines using international standards has been highlighted to be important to ensure that installations in rural areas operate optimally.
Biomass Gasifier	» Developing sustainable biomass supply chains in the long term is critical to project success. » During the initial stages of project operation, the electricity demand may be limited, leading to lower plant load factors (PLF). » Need for a comprehensive model for regular installation O&M. In some cases, a cluster approach could be adopted to cater for multiple installations through a single O&M infrastructure.

Text Box 5

IRENA SIDE EVENT: EMPOWERING COMMUNITIES USING BIOGAS

IRENA organised a side event at IOREC on the role of biogas in extending access to energy. The side event acted as a platform to share experience on biogas technology deployment, different business models and policies required to further stimulate its scale-up in ECOWAS countries.

The event was attended by around 50 participants, including representatives of ministries of energy from most ECOWAS countries as well as from the private sector, academia, civil society and sub-regional/international organisations. The participants shared lessons learnt about past and present regional biogas initiatives and key drivers to success in several countries, such as Vietnam and Rwanda. They also discussed about private sector perspectives.

Presentations covered regional initiatives (ECOWAS Regional Biogas Initiative, West African Economic and Monetary Unit and the New Partnership for Africa's Development), national experiences (Vietnam National Biogas Programme, Rwanda National Biogas Programme and African Biogas Partnership Programme) and enterprise experience (Biogas Technologies Africa Ltd). The presentations were followed by an engaging discussion on critical issues inhibiting the large-scale uptake of biogas, despite different initiatives and programmes being launched in the region. Key outcomes from the presentations and discussions include:

- There are many ongoing initiatives on bioenergy and in particular on biogas in the region, but there is no clear coordination between the stakeholders. There is a need to harmonise action taken by different institutions to avoid duplication and better support market development of the biogas sector;
- There is a need for capacity building for all stakeholders involved in the deployment value chain along with awareness initiatives targeting end users;
- Strong government ownership and support (*e.g.* through long-term affordable finance) are instrumental to the success of national biogas programmes;
- There is a clear business case for biogas. Scaling up the use of biogas technologies in a sustainable and cost effective way will require an enabling framework that attracts the private sector;
- Local entrepreneurs will play a crucial role in catalysing the sector. They need to be encouraged through adequate incentives and support schemes (*e.g.* mentoring, training initiatives, etc.).

IOREC discussions emphasised that RE is increasingly becoming the default option for off-grid electrification as far as the economics is concerned. As also highlighted in IRENA's report on "Renweable Power Generation Costs in 2012: An Overview", RE can be significantly cheaper than diesel-fired generation, particularly in remote areas with poor, and even non-existent, infrastructure where transport costs can increase the cost of diesel by 10% to 100% (IRENA, 2013). This presents a unique opportunity for existing diesel-based mini-grids to be replaced by hybrid or entirely renewable generation. Integrating multiple RE generators in a hybrid mini-grid configuration can ensure the reliable supply of electricity and reduce the impact of resource intermittency. For

WHY MINI-GRIDS?

- The technology is present in the market and available at the scale required for off-grid areas.
- The modularity of the system provides flexibility in system sizing to adapt to different local energy demands.
- The potential for integrating different energy generators, along with storage devices, improves the reliability of electricity supply.
- Reliable supply can catalyse productive enterprises, contribute to development of local economy and create jobs .

instance, there are several rural electrification projects based on small and medium-sized wind turbines operating in hybrid configurations with solar PV and/or diesel generators. In a typical small hybrid system using RE power plant, diesel generator and battery bank, the diesel generators can provide the top-up necessary to the battery bank when wind generation is not sufficient. In larger hybrid systems, direct AC coupling allows diesel generators to operate continuously (Figure 11).

Demand analysis, design of metering concept and energy management are among the key mini grid aspects outlined at IOREC. They directly impact mini-grid business models by dictating the required capacity of power generation, size of components and eventually capital and operating costs.

Mini-grids can serve multiple users in a rural community and can be designed to provide electricity for a broad range of uses. These may include household uses, street lighting, water pumping, and productive uses in general. The challenge for mini-grids is to meet diverse needs reliably without user conflict, taking into consideration that a limited resource has to be shared among different users. Innovative approaches to electricity distribution, metering and energy management therefore have a critical role in distributing electricity transparently and ensuring optimum system performance. In this context, promoting user awareness on demand-side management, and particularly on managing consumption (*i.e.* encouraging consumption during surplus generation) while allowing individual user independence and flexibility of use, have emerged as particularly important aspects.

Integrating automation into systems plays an important role in the transparent management of generation, consumption and metering in mini-grids. An innovative concept called Energy Daily Allowance, deployed as part of a hybrid PV-diesel installation in Akkan, Morocco, was described at IOREC. It is based on the principle of providing each user a fixed amount of electricity per day, depending on the expected generation. This is managed by a device which is a variant of a smart meter. The consumer pays a flat rate every month based on a catalogue of tariffs. The meter can automatically supply the contracted electricity amounts, synchronise with surplus/deficit RE generation by controlling loads like water pumps and allows energy exchange between neighbours (valuable interactions in a rural neighbourhood). It was also highlighted that households had accustomed their energy needs to suit the availability of RE supply.

Integrating innovative technology into RE mini-grid business models can significantly improve sustainability. For instance, the costs incurred by operators in the monitoring and fee collection stages can be reduced by exploiting remote technology platforms like GSM. This taps into the existing deep penetration of mobile infrastructure (see also subsection 2.5.3).

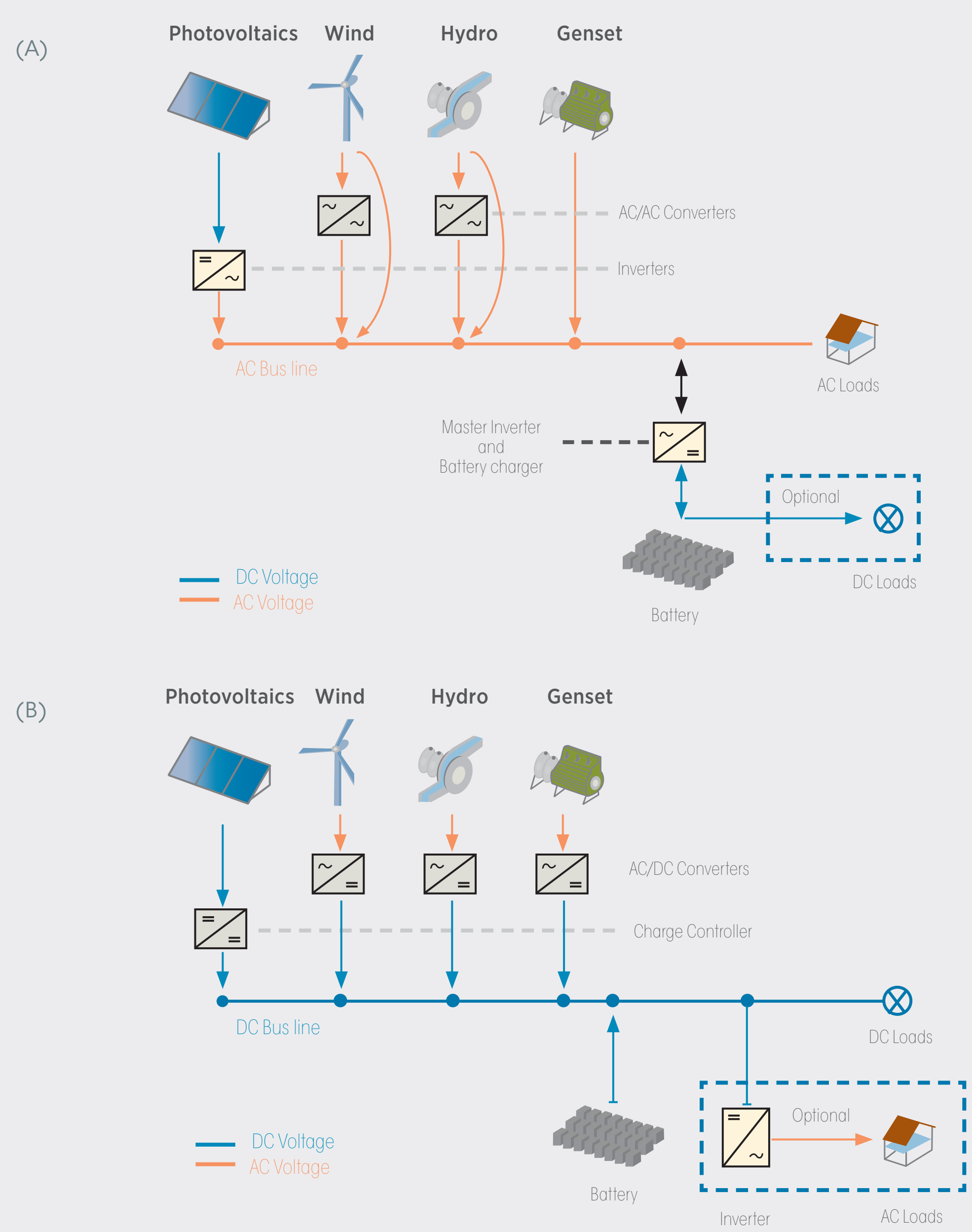
Research and development (R&D) is moving towards automation for improving efficiency, increasing reliability and reducing lifetime O&M costs. Energy storage was highlighted as a critical aspect for RE mini-grids. IOREC discussions drew attention to on-going work on development of hybrid battery installations and integrated battery management systems. Such systems aim at ensuring optimal performance and extended lifetime of batteries.

One of the key initiatives that focus on research, development and deployment of smart micro-grids is being led by Masdar Institute and Global Green Growth Institute in the United Arab Emirates. It aims to develop a 100% RE micro-grid using state-of-the art design philosophy which includes smart control systems, energy storage and high efficiency DC distribution systems that can accommodate energy produced from a broad

TECHNICAL CHALLENGES FOR MINI-GRID DEVELOPMENT

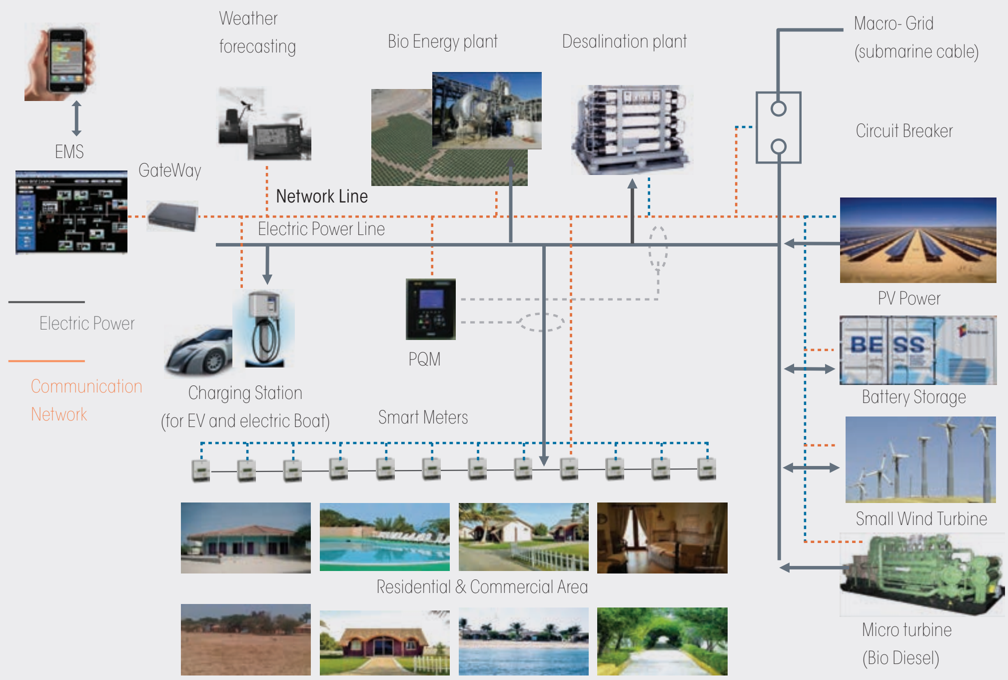
- Mini-grid technical challenges are mainly due to system stability complications and lack of redundancy.
- Transparent and efficient energy distribution, consumption and metering are needed since a limited resource has to be shared among many users without conflict.
- There needs to be clarity in designating O&M roles and resources throughout the system lifetime to ensure efficient and optimum installation performance.
- Different components sometimes cannot be integrated optimally, due to differences in technology standards. Standardisation is required.

Figure 11 Topology of hybrid mini-grids (a) AC and (b) DC coupling (adapted from ARE, 2011b)



range of RE sources such as solar PV, small wind power and biofuel production from waste and algae. The micro-grid can also link up to desalination plants, provide energy for transportation and cater to other diverse needs (Figure 12). The roadmap for the project includes demonstrating the robustness and cost-effectiveness of the technology followed by designing suitable public private partnership schemes to support large-scale deployment in developing countries.

Figure 12 Configuration of micro-grid pilot project in the UAE
(Adapted from Masdar Institute; Global Green Growth Institute; Research Institute of Industrial Science & Technology, 2012)



2.5.3 Applications: water supply, healthcare and telecommunications

OFF-GRID RE FOR WATER PUMPS AND SUPPLY

Of the 2.8 billion people who suffer from water scarcity, half live in off-grid areas (IEA PVPS, 2012). The water-energy nexus forms an important component of energy access efforts. RE, in particular, can play a fundamental role in providing reliable access to water supply in rural areas, therefore promoting sustainable development and improving livelihood.

IOREC underlined the unique opportunity for RE to power pumping and irrigation systems in rural areas as a result of the increasing cost-competitiveness of off-grid RE technologies. A typical solar-powered water pumping system consists of a submersible pump, PV array, electronics (inverters) and overhead storage tanks. Declining costs of PV modules and rising diesel costs mean photovoltaic pumping (PVP) systems are cost-competitive with diesel pumping on a life-cycle basis (Figure 13). This presents a tremendous opportunity to reduce dependence of water pumping systems on volatile fossil fuel prices and fuel transportation.

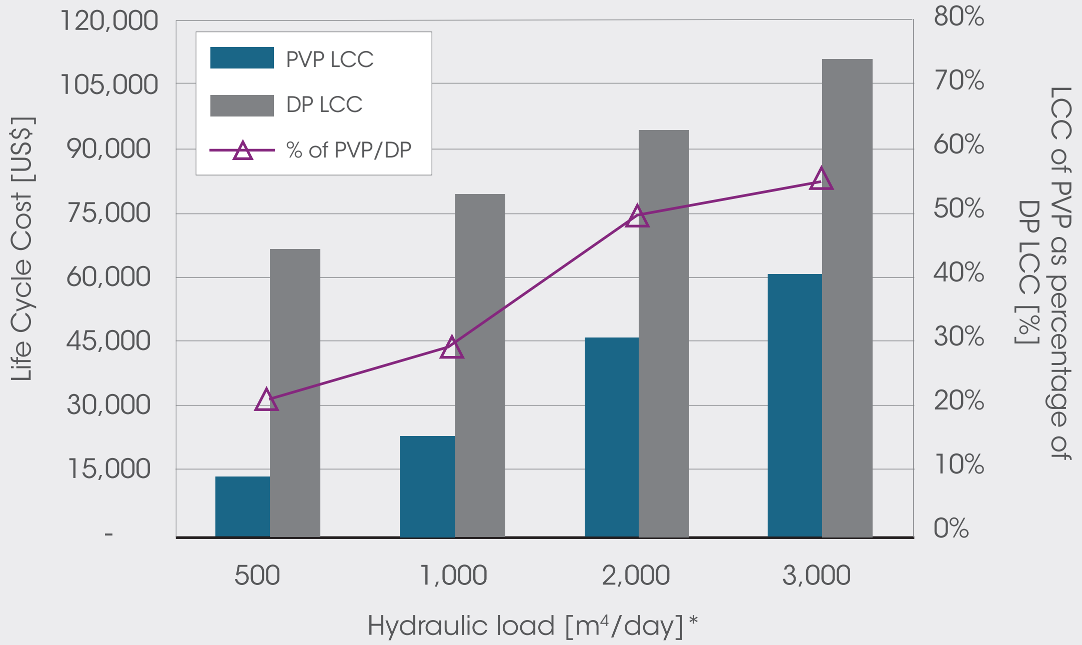
The main barrier to PVP system deployment is the capital cost. As illustrated in the Namibia case (Figure 14), this forms a big proportion of the life-cycle cost (72%) compared to diesel systems where the capital cost is significantly lower (seven percent).

PVP systems in varying configurations have been deployed across the developing world. In Mali, mobile PV arrays and pumps are used for farm

OFF-GRID RE FOR AGRICULTURAL PUMPING

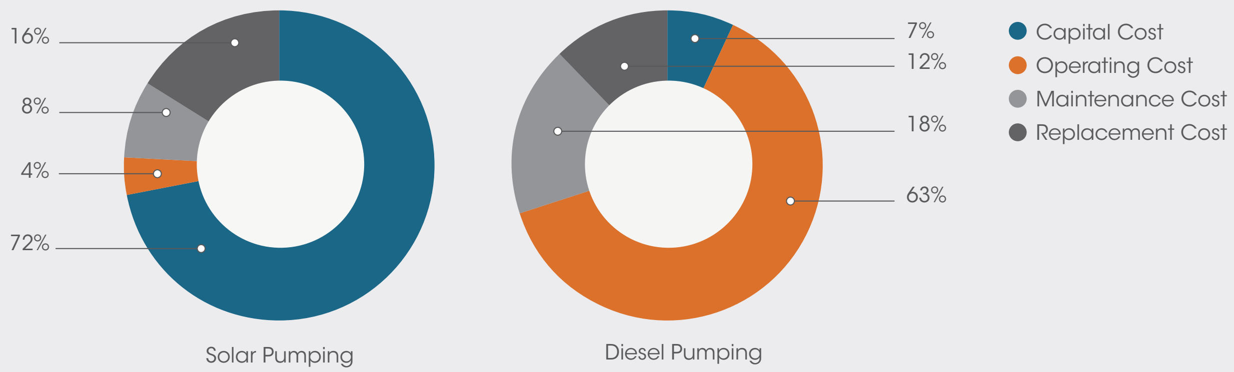
- PV-based pumping is a mature technology with very low failure rates.
- PV pumping systems are cost-competitive with diesel pumping systems on a life-cycle basis.
- The initial capital cost is a major proportion of the PVP life-cycle cost (72%) compared to diesel systems where the initial capital cost is very low (7%).
- The water distribution components (piping, valves, fixtures, etc.) are more vulnerable than PV components, requiring adequate support after installation.

Figure 13 Comparison of life cycle cost (LCC) (USD) between PV pumping (PVP) and diesel pumping (DP) in Namibia (IEA PVPS, 2012)



* Hydraulic load (m^4/day) is representative of the pumping head (m) and the daily flow rate (m^3/day).

Figure 14 Breakdown of life cycle cost components for solar- and diesel-based pumping in Namibia (Adapted from IEA PVPS, 2012)



irrigation. When not used for pumping, the modules can be used for other purposes such as lighting, charging, etc.

Following installation, post-deployment support plays an important role in long term project sustainability. IOREC discussions emphasised that while PVP has very low failure rates, water distribution components are more vulnerable to failure. This creates a strong case for large-scale deployment of solar water pumping systems involving private investment and supported by adequate post-deployment support. The Regional Solar Programme (RSP) is emblematic of the success and competitiveness of the solar pumping technology for ensuring sustainable water supply and quality drinking water. It was launched by the Permanent Interstate

POLICY RECOMMENDATIONS TO SUPPORT PV DEPLOYMENT FOR RURAL WATER SUPPLY (RWS)

» Embedding RWS project development in government policies to ensure access in rural areas.

» Create an enabling environment for private sector involvement in deploying water infrastructure through access to standardised technology, incentives and capacity building.

» Ensure scalability of RWS project development to create a market which can support sustainable business models that service the infrastructure.

» Investment decisions to be taken on life-cycle cost basis for RWS infrastructure development.

» Consider entire water chain to guarantee system reliability as PVP technology has low failure rates but system breakdown can occur at other stages (leaking tanks, pipes, etc.).

Source: (IEA PVPS, 2012) and (IEA PVPS, 2011)

Committee for Drought Control in the Sahel (CILSS) in 1986. The two phases of the programme have deployed 995 solar pumping stations and 649 community systems. This has given two million people improved access to water and electricity. These systems have been operating successfully and reliably for over ten years with operational costs within the reach of the users. By the end of the second phase (RSP 2) in 2009, a 16% reduction in population without access to safe drinking water was observed in the Sahel countries of West Africa.

OFF-GRID RE FOR RURAL HEALTHCARE

The role of off-grid RE in extending basic healthcare services in rural areas that lack, or receive unreliable, electricity supply emerged at IOREC. An estimated 1 billion people are served by health facilities with no electricity access (Practical Action, 2013). This deficiency means medical equipment, such as ultrasound and autoclaves, cannot be utilised. Surgery is dependent on ambient light from windows or, at night-time, kerosene lamps. We Care Solar pointed out that annually 358,000 women die during pregnancy and childbirth across the world and that provision of minimal lighting and operational equipment would cut maternal mortality by 70%. To meet

Figure 15 Components of the Solar Suitcase for medical use (We Care Solar, 2012)

this need, We Care Solar developed an easy to use and maintain solar powered system (Figure 15). It provides a means to power critical lighting, mobile communication devices and medical equipment in off-grid areas for the purpose of delivering timely and critical medical care. The Solar Suitcase has brought highly efficient medical lighting and portable power to 150 health centres in 20 countries. It was also highlighted that the operating theatres became functional with only 15 watts of power (four 2.5 watt LED bulbs for ambient light and a five watt surgical LED light).

> Recognising that technology alone is not enough, building local capacity and partnerships has been central to the We Care Solar initiative
>
> **Irene Abagi,** We Care Solar

Solar vaccine coolers are another important off-grid RE application in extending healthcare services. At present there are approximately 100,000 kerosene vaccine coolers and over two million domestic kerosene and gas fridges worldwide. These lead to local air pollution from kerosene as well as dependence on fuel supply. SolarChill is a solar cooling technology which eliminates these drawbacks by substituting the refrigerant and insulation gas (HFC) with hydrocarbons and electric lead battery with a thermal ice "battery" and thick (or vacuum) insulation. The upfront cost for SolarChill is still higher than for kerosene-based vaccine coolers. However, the system was highlighted to be less expensive on a life-cycle basis. One of the challenges that was underlined regarding SolarChill is that companies are required to work with hydrocarbons, which needs adequate supply, safety, training and service infrastructure.

As the above examples demonstrate, off-grid RE applications provide a major opportunity for improving healthcare services in rural areas. To help increase the use of RE systems in remote healthcare facilities, a broad range of measures should be put in place. These include dedicated resources for research, development and deployment; support schemes for assembling or importing these systems; policy instruments underpinning local capacity building and increased coordination between public agencies responsible for healthcare and RE.

TELECOMMUNICATION SERVICES FOR OFF-GRID AREAS

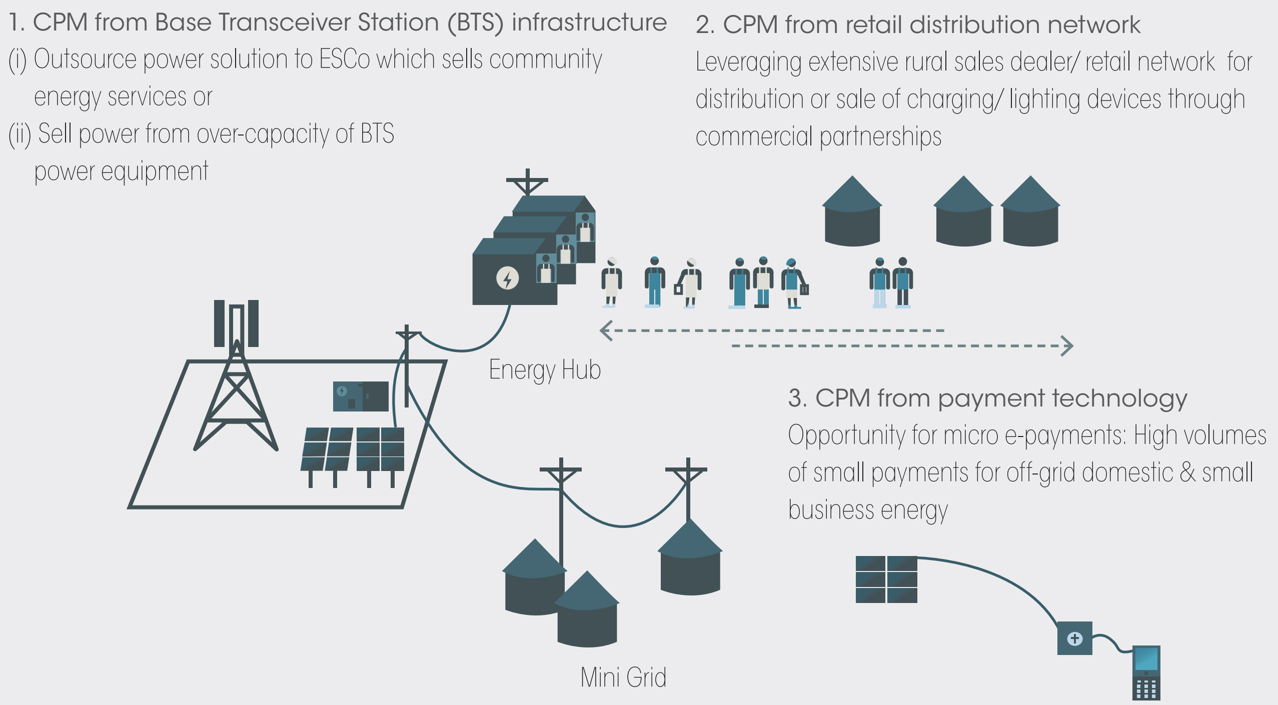
- Six billion mobile connections worldwide as of 2012.
- Four out of five new connections are being made in the developing world.
- Over 3 million mobile towers are available globally, of which 640,000 are off-grid, facing electricity access challenges.

OFF-GRID RE FOR TELECOMMUNICATIONS

The rapid growth of mobile communications is providing new opportunities for rural communities. There is a case for off-grid RE within the telecommunications sector from both the developer and end user perspective. Discussions at IOREC revealed that over 640,000 off-grid mobile telecommunication towers face a number of challenges, including high costs for power supply from diesel generators (up to 40% of operating cost), diesel theft and dependence on O&M personnel in remote areas. Furthermore, there are 548 million mobile connections that don't have access to the electricity grid and therefore subscribers spend around two to three dollars on phone charging per month (GSMA, 2012). All this adds up to a significant market for off-grid RE. In addition, the off-grid market develops further when communication infrastructure is well developed, as energy entrepreneurs can utilise the telecommunications network to run their businesses operations more efficiently. In East Africa, for instance, the M-Pesa system for money transfer using mobile phones is transforming rural markets by extending access to financial services.

During IOREC discussions, three Community Power from Mobile (CPM) channels were presented through which electricity access can be extended by utilising mobile communication technology and infrastructure, while improving the business case for network and tower operators (Figure 16). The first channel exploits the mobile infrastructure and uses existing power equipment and overcapacity to provide services to the community. It also lets third party energy service companies use mobile towers as an anchor load and sell remaining power to the community (*e.g.* OMC Power in India). The second exploits sales and distribution channels to promote community power by providing phone recharging services and partnering with other energy companies to sell their products (*e.g.* MTN Uganda). The third exploits mobile money and e-payments to support energy access initiatives. For instance, it provides consumer financing to customers (*e.g.* M-Kopa and Safaricom in East Africa). Identifying the most suitable business model for the local community requires innovation and test models through large-scale trials.

Figure 16 Extending access to electricity through mobile infrastructure (adapted from GSMA, 2012)



3. Key recommendations for policy makers

This chapter summarises the key recommendations for policy makers that emerged from IOREC discussions.

Long-term commitment and enabling policy frameworks

The discussions indicated that sustainability and scalability of rural electrification programmes largely depend on appropriate institutional and policy frameworks. Long-term political commitment needs to be translated into clear, targeted measures that can stimulate the off-grid RE market and involve local enterprises. Off-grid RE should be integrated into the national rural electrification strategy, taking into consideration the following key elements:

» A clear vision for the development of the off-grid RE sector as well as political commitment throughout the rural electrification strategy implementation are necessary;

» Targets should be realistic and adapted to the local conditions;

» Unrealistic announcements of grid extension in rural areas should be avoided as these often encourage people to 'wait for the grid' thereby inhibiting social acceptance of off-grid electrification solutions;

» Power sector reforms may be necessary to facilitate private sector involvement in off-grid RE rural electrification efforts;

» The policy-making process should involve all stakeholders in the rural electrification value chain. It is also important to encourage cooperation between public and private sector to overcome main barriers and deliver off-grid RE services effectively and efficiently;

» Levelling the playing field, for instance by phasing out market distortions like kerosene subsidies, can support the off-grid RE technology deployment;

» Fiscal incentives such as import duty or VAT exemptions for systems and components are often effective measures to reduce equipment costs.

Specific policy and regulatory support for deploying and scaling up RE mini-grids

Mini-grids based on RE can utilise the full range of local RE resources (solar, wind, hydro, bioenergy, etc.) to contribute substantially to rural development. They can provide electricity not only for basic needs but also for productive uses. In order to tap the immense potential of RE mini-grids, the following key elements should be taken into consideration:

» A clear electrification plan should identify areas to be reached by the grid in a realistic time frame, as well as areas suitable for mini-grid development;

» Institutional, regulatory and legal frameworks should be streamlined to reduce transaction costs incurred by private sector developers, which are particularly high for mini-grid projects;

» Appropriate benchmarks should be used to design suitable *upstream* and *downstream* financial incentives that take life-cycle costs into consideration;

» Regulators should adopt tariff designs which consider local socio-economic conditions as well as the commercial viability for private mini-grid developers;

» To reduce the risk associated with private investment in mini-grid projects, regulatory frameworks should take into account the impact on the projects if and when the main grid arrives. They should create the conditions for integrating mini-grids, where possible, with the national grid or other mini-grids;

» Regulatory frameworks should be flexible to allow non-traditional and innovative business models and also to integrate innovative technology platforms (such as GSM for remote monitoring and fee collection).

Customised funding mechanisms for off-grid RE sector development

The existing financial mechanisms available for the RE sector in general are mostly unsuitable for off-grid RE projects. This is due to a mismatch between lending terms set by the lender (or funder) and enterprise (or end user) profile. This means the off-grid RE sector often faces challenges in accessing finance. A dedicated, customised fund for off-grid RE, compatible with the typical profiles of end users, project developers, equipment suppliers and other key players, would be a useful instrument and would help fuel the growth of this sector. It could work within existing rural electrification funds or as an independent fund that pools public funds with development and multilateral agency finance.

Key considerations that emerged at IOREC for creating a funding mechanism include:

» Use of public resources to leverage private sector investment;

» Coordination of different financial resources (from domestic sources, multilateral organisations, etc.) to lay the foundations for a sustainable off-grid RE market;

» Investments in public infrastructure and other non-generating assets as well as in education and training initiatives targeting all stakeholders in the off-grid RE value chain to contribute to creating a sustainable market;

» Adequate institutional mechanisms and efficient administrative procedures to ensure that the dedicated fund is administered effectively and efficiently;

» Coordination between rural electrification programmes and initiatives to maximise the impact of available resources and avoid duplication of efforts;

» Provision of customised long-term affordable finance to support off-grid RE enterprises at various stages;

» Design of financing schemes targeted at rural households, which take into consideration consumers' income, cash flow and current expenditures on accessing energy (*e.g.* kerosene or candles for lighting).

Promoting capacity building

An enabling environment for the development of an off-grid RE market requires adequate capacity across the rural electrification value chain. Specific capacity needs should be identified by using tools like *Capacity Development Needs Diagnostics for RE* (CaDRE) which has been co-developed by IRENA. Adequate steps should be taken through national initiatives to address these needs.

Some of the key requirements in this respect are:

» Capacity building should be encouraged along all links in the rural electrification value chain: public institutions, financing agencies, communities, private sector, etc. National policies should support technical capacity building and training to meet the skills demand from a growing market;

» Technical capacities within financial institutions are of critical importance to off-grid RE markets. In particular, these institutions have to become sensitive to off-grid RE characteristics in order to create suitable financial products for both local entrepreneurs and end users;

» RE courses need to become commonplace. The quality of course delivery and curricula should be closely monitored and continuously improved. In addition, adequate financing and equipments should be available for existing training institutions.

Raising awareness among stakeholders

Raising awareness and educating end users, service providers and practitioners on the technical, business and economic aspects of off-grid RE enables them to effectively contribute to the growth of the off-grid RE market. Existing misconceptions about cost and reliability of off-grid RE technologies, also within the public sector, as well as on their capability to provide electricity for productive uses, needs to be addressed. In addition, improved awareness among end users of the availability, reliability and affordability of off-grid RE technologies is important to facilitate their deployment in rural communities. Information campaigns on incentives available for consumers as well as on the correct use and maintenance of off-grid RE systems are useful measures to increase community awareness and improve sustainability. They can contain case studies and demonstrations showing the technical and economic viability. These efforts support the development of an off-grid RE market, and therefore should be an integral part of rural electrification strategies.

Incubating local entrepreneurship

Business models focusing on local capacities and creating decentralised product distribution channels were highlighted to be more sustainable in the long term due to lower operating costs. This presents a unique opportunity for job creation in rural areas[8]. Local entrepreneurs will play a fundamental role in extending electricity access through off-grid RE. To identify and incubate local entrepreneurs, an incubation platform for early stage enterprises could be a useful tool.

As shown at IOREC, local entrepreneurship can benefit considerably from the following:

- » Off-grid RE sector 'champions' who have developed successful rural electrification programmes and initiatives can encourage and mentor local entrepreneurs;
- » Access to accurate information on markets, products, funds and programmes is fundamental to support local entrepreneurs. It can be facilitated through web portals, dissemination of market pre-feasibility studies, etc.;
- » Access to basic and advanced training that provide adequate technical and business skills, through relevant programmes and institutes, significantly helps local entrepreneurs to participate in the off-grid RE market;
- » Facilitation of technology cooperation and transfer is important to ensure that local enterprises have access to RE technology.

[8] *In its Renewable Energy Jobs & Access report, IRENA concludes that reaching the objective of sustainable energy for all could create 4 million direct jobs by 2030 in the off-grid electricity sector alone (IRENA, 2012b).*

Appendix 1: Analysis of survey results

Appendix 2: IOREC agenda

Appendix 1: Analysis of survey results

A questionnaire was distributed during IOREC to gather responses from the participants on two specific questions- (a) What are the three most critical challenges for the uptake of off-grid RE? (b) What steps should the government take to facilitate the uptake of off-grid RE? 118 respondents from across the rural electrification value chain participated in the survey.

Q.1 WHAT ARE THE THREE MOST CRITICAL CHALLENGES FOR THE UPTAKE OF OFF-GRID RE?

- Access to affordable finance at various stages of project development has emerged as the most cited critical challenge for uptake of off-grid RE;
- The importance of enabling policy and regulatory frameworks has been highlighted, also as vital de-risking measures for attracting private sector investment in the sector;
- Capacity building, specifically in regards to education and technical training on RE, was identified as a major need;
- Lack of awareness among communities as well as within public institutions on the benefits and costs of off-grid RE from a life-cycle perspective was pointed out;
- Concerns about quality and reliability are hindering the uptake of off-grid RE in communities;

Figure 17 Composition of survey respondents

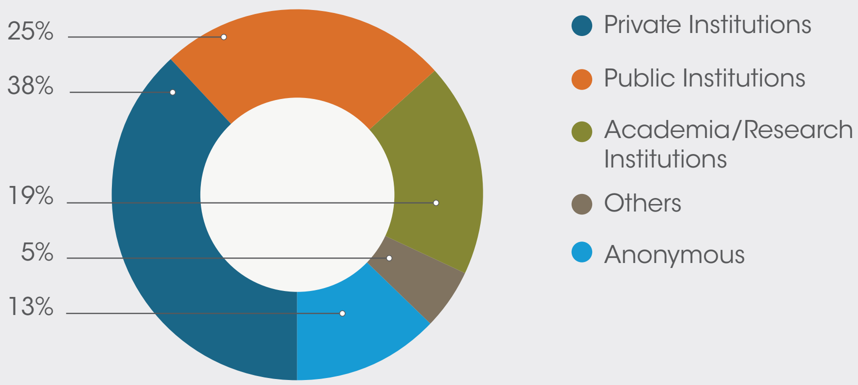
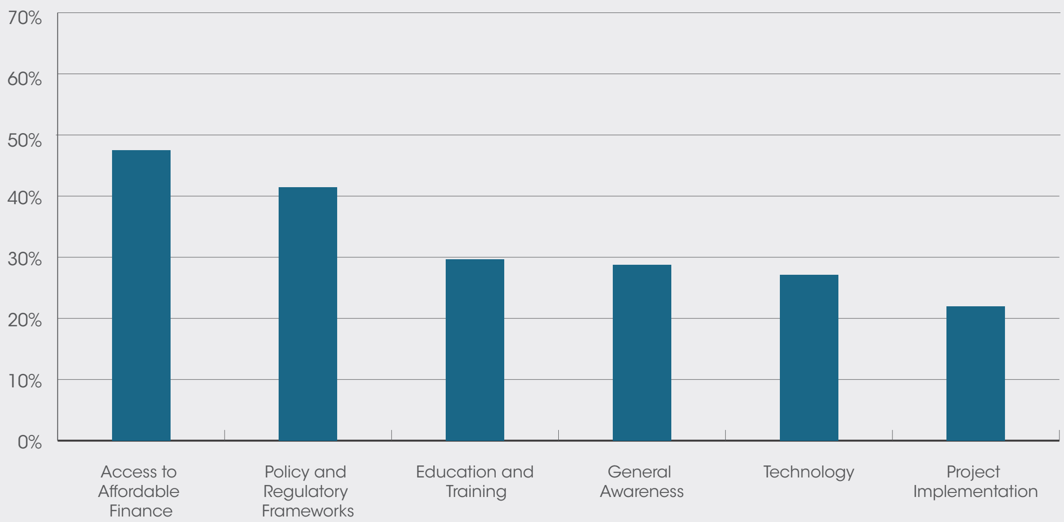


Figure 18 Critical challenges for uptake of off-grid renewables (% of total respondents*)



* *Multiple responses (three in most cases) were received from each participant.*

- Challenges faced during the project implementation stage, in terms of high cost of fee-collection in rural areas, delivering after-sales services, theft/vandalism, etc., were also highlighted to impact the long-term sustainability of projects.

CHALLENGE PERCEPTIONS FROM THE PUBLIC AND PRIVATE SECTOR PERSPECTIVE

The responses from public and private sector representatives were separately analysed to assess the relative perception of challenges facing the uptake the off-grid RE. Some of the key findings from this analysis include:

- The perception of technology as a challenge, in terms of costs, reliability and design, varies significantly between private and public sector;
- The need for access to affordable finance and enabling policy frameworks were highlighted to be critical by both the private and public sector representatives;
- Both groups have highlighted the importance of local capacity building and training for private sector and communities.

Figure 19 Critical challenges for uptake of off-grid renewables (% of total respondents)- Public sector perspective

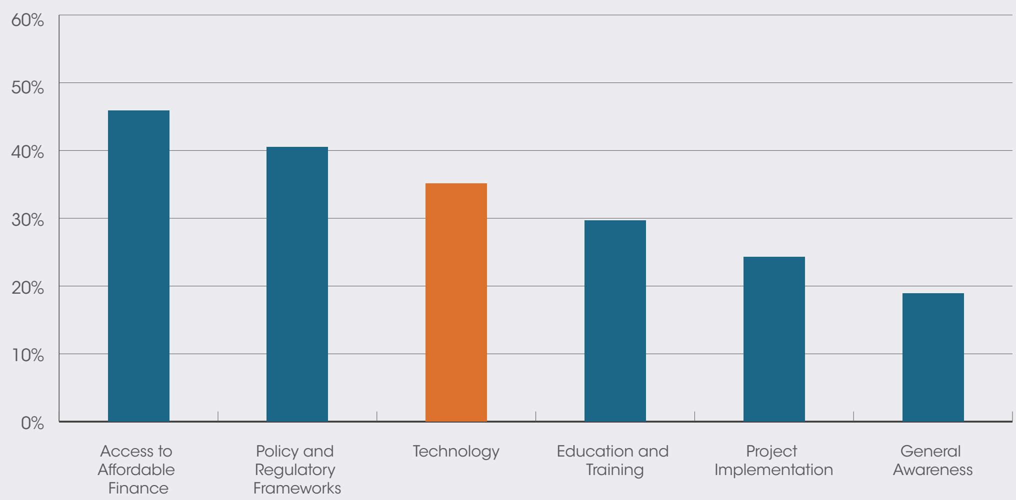
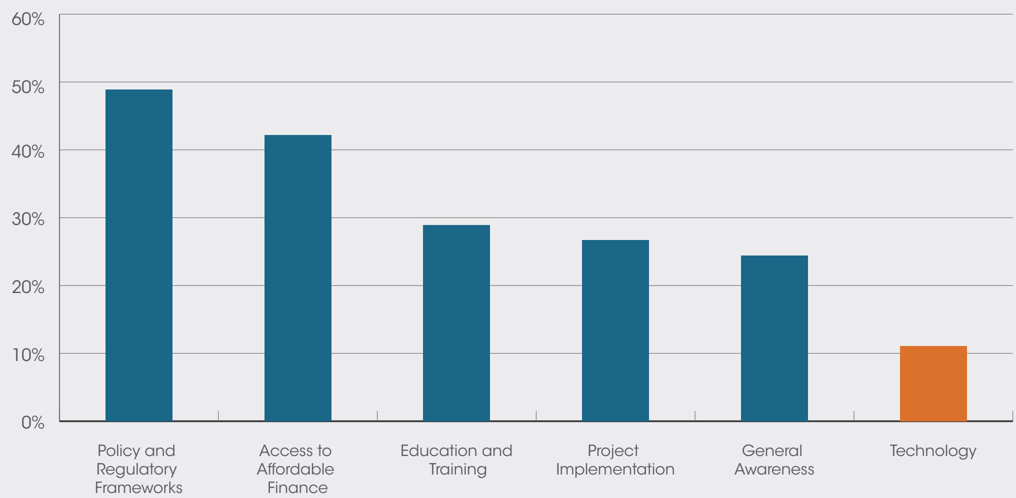


Figure 20 Critical challenges for uptake of off-grid renewables (% of total respondents)- Private sector perspective



Q.2 WHAT STEPS SHOULD THE GOVERNMENT TAKE TO FACILITATE UPTAKE OF OFF-GRID RE?

» The creation of an enabling policy, regulatory and institutional framework was particularly highlighted as being important to support the uptake of off-grid RE technology. The respondents further emphasised upon the need for clear roles and responsibilities of different institutions involved in the rural electrification value chain as well as for streamlining and simplifying administrative procedures;

» Appropriate regulatory frameworks, in terms of tariff design, extent of regulation, etc., were underlined by participants as being vital to encouraging the deployment of off-grid renewables and the involvement of the private sector;

» The critical role of governments in providing adequate financial incentives (*e.g.* grants, soft loans, etc.) and in facilitating access to finance, targeting both end users and local entrepreneurs, was highlighted;

» Undertaking initiatives that support education and training and spread awareness on off-grid RE, was cited as a step that governments should take to support the uptake of off-grid renewables;

» The need for governments to engage with stakeholders from across the rural electrification value chain was also highlighted by participants.

FIGURE 21 ACTIONS EXPECTED FROM GOVERNMENTS (% OF TOTAL RESPONDENTS*)

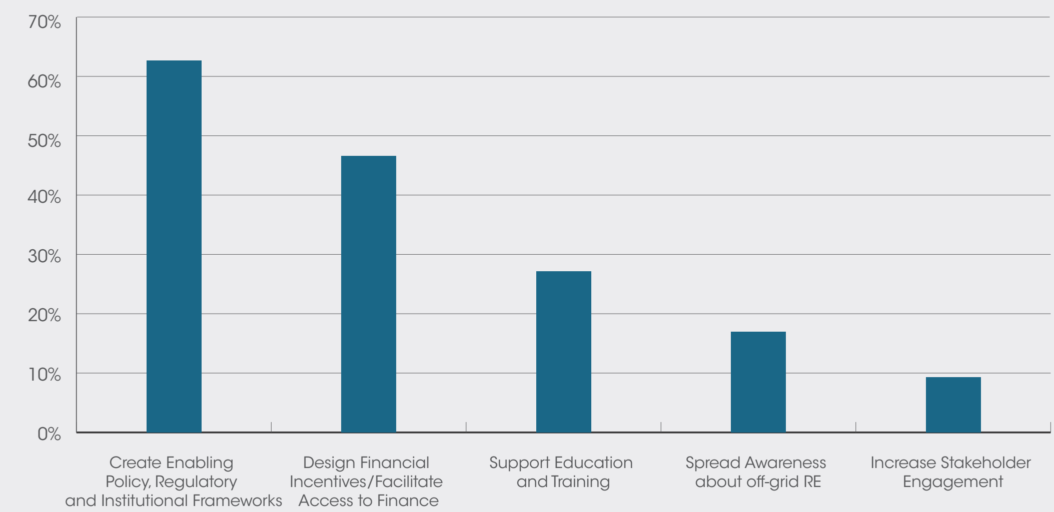
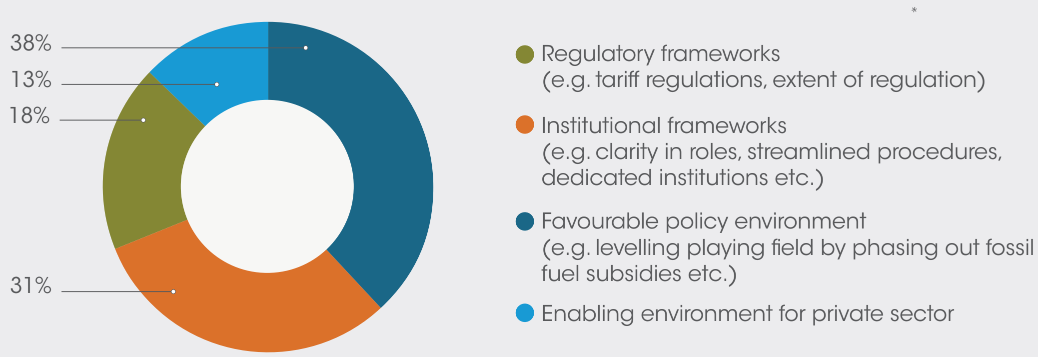


FIGURE 22 BREAKDOWN OF RESPONSES RECEIVED TOWARDS 'CREATING ENABLING POLICY, REGULATORY AND INSTITUTIONAL FRAMEWORKS'



* *Multiple responses were received from each participant.*

Appendix 2: IOREC agenda

INTERNATIONAL OFF-GRID RENEWABLE ENERGY CONFERENCE

November 1-2 2012

International Conference Centre, Accra, Ghana

THURSDAY, NOVEMBER 1ST 2012	
Theme:	Off-grid Renewable Energy System Deployment: Regulations, Policies and Financing
08:00-09:00	Registration
09:00-09:15	Welcome Address
09:15-09:35	Key note Speaker: **Dipal Chandra Barua**, Co-founder, Grameen Bank; Founding Managing Director, Grameen Shakti; Founder and Chairman, Bright Green Energy Foundation
	Scaling-up off-grid renewable energy technology deployment - Regulations and Market development
Session 1 09:35-11:00	Moderator:**Frank Wouters**, Deputy Director-General, IRENA Panelists: **Mahama Kappiah**, Director, ECREEE **Alassane Agalassou**, Director of Rural Electrification, AMADER, Mali **Harish Hande**, Managing Director, SELCO India **Henry Gichungi**, Off-grid Business Manager, Kenya Power and Lighting Company **Philip Mann**,Senior Project Manager, Africa- EU Renewable Energy Cooperation Programme
	Coffee Break and Exhibition
	Need for Targeted Support. What policies? What incentives?
Session 2 11:30-12:45	Moderator: **Ben Good,** CEO, GVEP International Panelists: **Daniel Guie,** President, Club ER **Lisa S. Go,** Chief, Investment Promotions Office, Department of Energy, Philippines **Nico Peterschmidt,** Managing Director, INENSUS GmbH **Pradeep Monga,** Director, Energy and Climate Change, UNIDO **Pablo Carvajal,** Energy Advisor, Ministry of Electricity and Renewable Energy, Ecuador
	Lunch/Exhibition
12:50-14:10	IRENA-GIZ Side Event: *Making the case for RE-based remote energy supply- Cost trends and technical, economic and policy challenges for the realization of RE-based mini-grids*
	Effective and innovative business models. What viability for privately led initiatives?
Session 3 14:10-15:35	Moderator: **Denis Rambaud Méasson,** Chair, Innovation Energie Développement (IED) Panelists: **John Afari Idan,** Chief Executive Officer, Biogas Technologies Africa Ltd. **Nazmul Haque,** Director and Head of Investment , IDCOL Bangladesh **Nganga Joseph,** Chief Executive Officer, Renewable Energy Venture, Kenya **Gurbuz Gonul,** Senior Energy Economist, Islamic Development Bank **Gamini Swarnapala,** Deputy General Manager, Sarvodaya Economic Enterprises Development Services, Sri Lanka
	Coffee Break and Exhibition
	Financing off-grid renewable energy systems: lessons learned
Session 4 16:05-17:45	Moderator: **John Wasielewski,** Development Finance Advisor to U.S. Department of State Panelists: **Zakou Amadou,** Energy Division Manager, African Development Bank **Godfrey Mwindaare,** Regional Director, West Africa, Acumen Fund **Juan José Ochoa,** Vice President, EMPRENDA Argentina **Frank Yeboah Dadzie,** Project Manager (Solar), ARB Apex Bank, Ghana
	Exhibition
18:00-20:00	ARE Side Event: *Accelerating the penetration of Small and Medium Wind Technologies in Africa's market*

FRIDAY, NOVEMBER 2ND 2012	
Theme:	Off-grid Renewable Energy Systems: Technology, Design and Innovation
09:00-09:20	Key note Speaker: **Ernesto Macias,** ARE President
	Off-grid renewable energy technologies to meet basic needs
Session 5 09:20-10:45	Moderator: **Abeeku Brew-Hammond,** Director, The Energy Centre, Kwame Nkrumah University of Science of Technology, Ghana Panelists: **Thomas Meier,** Rural water supply system expert **Clement Ouedraogo,** Comité permanent Inter-Etats de Lutte contre la Sécheresse au Sahel,CILSS **Jürgen Rheinländer,** RE Desalination system expert **Tobias März,** SolarChill **Irene Abagi,** We Care Solar
	Coffee Break and Exhibition
	Off-grid renewable energy systems: technologies, advantages, challenges and costs
Session 6 11:15-12:45	Moderator: **Michael Wollny,** ARE, Vice President; Director, Business Development Off-Grid Solutions, SMA Solar Technology AG Panelists: **Brisa Ortiz,** Head of Team, Autonomous Systems and Mini-Grids, Fraunhofer ISE **Balthasar Klimbie,** ARE Vice President; Wind Energy Solutions **Ashok Chaudhuri,** General Manager, Ankur Scientific Energy Technologies **Pol Arranz-Piera,** Polytechnical University of Catalonia **Cui Zhenhua,** Science Research Center, Hangzhou Regional Center (Asia & Pacific) for SHP
	Lunch/Exhibition
12:50-14:10	**IRENA Side Event:** Capacity Needs Assessments for Rural Electrification
14:15-14:35	Keynote Speaker: D**olf Gielen,** Director, IRENA Innovation and Technology Centre
	Innovative off-grid renewable energy system design
Session 7 14:35-16:05	Moderator: **Hugo Lucas,** Director, Policy Advisory Services and Capacity Building, IRENA Panelists: **Michael Muller,** Director, Steca **Claude Ruchet,** Deputy Director, Studer Innotec **Thomas Gottschalk,** General Manager, Mobisol **Xavier Vallvé, Director,** Trama Tecno Ambiental **Benoît Connes,** R&D Manager, Phaesun
	Coffee Break and Exhibition
	Innovation and findings in the field of off-grid renewable energy
Session 8 16:35-17:45	Moderator: **Ogunlade Davidson,** Professor, Fourah Bay College, University of Sierra Leone Panelists: **Andy Walker,** Principal Engineer, National Renewable Energy Laboratory **Sandor Szabo,** Manager, Scientific and technical projects, EU Joint Research Center D**ohyun Goh,** Global Green Growth Institute **Mary Roach,** Business Development Manager, Community Power from Mobile, GSMA Mobile for Development
17:45-18:10	Closing Ceremony
18:10-20:00	**IRENA Side Event:** *Empowering Communities through Biogas*

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IRENA

International Renewable Energy Agency

IRENA Headquarters
C67 Office Building, Khalidiyah (32nd) Street
P.O. Box 236, Abu Dhabi
United Arab Emirates
www.irena.org