Climate Investment Funds

SREP/SC.14/7/Rev.1
November 5, 2015

Meeting of the SREP Sub-Committee
Washington D.C.
Wednesday, November 11, 2015

Agenda Item 6

SREP Investment Plan for RWANDA

PROPOSED DECISION

The SREP Sub-Committee, having reviewed document SREP/SC.14/7/Rev.1, *SREP Investment Plan for Rwanda*

a) endorses the investment plan as a basis for the further development of the projects and programs foreseen in the plan and takes note of the request for USD 50 million in SREP funding.[1] The Sub-Committee requests the Government of Rwanda, in the further development of the proposed projects and programs, to take into account comments made at the meeting and any additional written comments submitted by Sub-Committee members by November 27, 2015, and to respond in writing to questions raised during the meeting and in subsequent written comments;

b) reaffirms that all allocation amounts are indicative for planning purposes and that approval of funding will be on the basis of high quality investment plans and projects;

c) approves USD 800,000 as preparation grant for the project entitled, *Renewable Energy Fund (REF)* (World Bank)

d) takes note of the estimated budget of USD 428,000 for MDB project preparation and supervision services for the project entitled, *Renewable Energy Fund (REF)* (World Bank), and approves USD 128,000 as a first tranche of funding for such services;

[1] *USD 300,000 in SREP funding has already been approved for the* development of the investment plan.

REPUBLIC OF RWANDA

MINISTRY OF INFRASTRUCTURE

SREP Investment Plan for Rwanda

October 2015

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1 Executive Summary

Rwanda is one of the countries selected to benefit from the Scaling-up Renewable Energy Program (SREP) in Low Income Countries. The SREP program aims to demonstrate the economic, social and environmental viability of low-carbon development path with a view to increase energy access, by using renewable energy and creating new economic opportunities. In September 2014, the Government of Rwanda was invited to take a leadership role in working with the Multilateral Development Banks (MDBs), namely the African Development Bank (AfDB) and the World Bank Group (WBG), including the International Finance Corporation (IFC), to develop the SREP Investment Plan (IP) for Rwanda.

The main objective of Rwanda's IP is to establish the conditions for significant growth in off-grid electricity access solutions for households, firms and institutions. The Rwanda IP is aligned with Rwanda's national and energy sector priorities. Rwanda's Economic Development and Poverty Reduction Strategy II (EDPRS-II) sets the overall economic strategic framework up to 2018. One of the thematic areas of EDPRS-II is rural development, which aims to reduce rural poverty from around 45% to 20% by 2018.

The Energy Sector Strategy Plan (ESSP) has set a target of increasing electricity access from around 22% (2014) to 70% by 2018. The plan calls for about 48% of the households to be connected to the grid, with the remaining 22% (about 550,000 households) to be served by off-grid solutions. Rwanda's Rural Electrification Strategy and the Sustainable Energy for All Action Agenda, both of which are currently at the draft stage, will provide the framework for serving rural households with renewable energy.

The Rwanda IP was developed under the leadership of the Government of Rwanda, through a technical team led by the Ministry of Infrastructure (MININFRA) with support from the MDBs. The preparation of the Rwanda IP benefited from extensive consultation with key stakeholders in Rwanda's energy sector, including renewable energy developers, renewable energy associations, financial-sector stakeholders, implementing agencies and development partners.

1.1 Energy Sector Challenges

Renewable energy (RE) plays an important role in Rwanda's energy system. In the on-grid electricity sector, hydropower and solar PV represent 61% and 5% of total installed capacity, respectively, and there is potential for further growth in both. The central electricity grid has expanded rapidly. Connection rates as a percentage of population increased from 6% in 2009, to 17% in 2013 during the EDPRS I period, and 23% in June 2015 as a result of targeted grid extension programs

The government's target is for 48% of households to be connected to the grid by 2018. This will require further scaling up of existing grid-extension programs. To maintain and / or increase the high level of renewable energy generation in the Rwandan on-grid electricity sector will also require additional support to accelerate the planned pipeline of renewable energy projects.

Reaching the overall government target of 70% (of which on-grid 48% and off-grid 22%) access will require significant investments and off-grid access is currently at a low base. Private companies are in a good position to deliver these solutions, but face a number of significant barriers. For this reason, the Rwanda IP focuses on the off-grid and mini-grid sectors. Future phases of the program could broaden in scope to support investment in other aspects of the energy sector including on-grid renewables.

1.2 Off-grid Renewable Energy Status

1.2.1 Solar Energy

The stand-alone solar PV market in Rwanda has been the target of several donor programs some of which include; the Energy for Development (EnDev) being implemented as a results-based financing (RBF) program for 'Lighting Africa' certified pico-solar lamps. There are a number of other pilot projects which have been successfully completed for a range of solar systems ranging from pico-solar products to larger solar home systems, and the market is preparing for considerable expansion.

The solar mini-grids in Rwanda is made up of about 15 solar PV 'pico-grids', systems of around 1kW which serve clusters of around 10 to 20 households. These modular systems can be scaled up in line with demand, and developers expect that per connection capital costs could come down to around US$100 for larger-scale systems.

1.2.2 Hydro Energy

There are also some mini-grids based on hydropower in Rwanda. Some legacy mini-grid projects which performed poorly in the past due to poor project design are planned to be refurbished under private development arrangements. There are a number of development partners in the development of hydro micro grid.

1.3 Constraints to Off-grid Renewable Energy Development

The development of sustainable private sector-led markets for off-grid renewable electricity has the potential to transform energy access arrangements in Rwanda. The private sector has completed a number of successful pilot programs, and is in a good position to increase investment, but faces a number of challenges and barriers to achieve the level of market scale required to meet the Government's goals and ambitions for the off-grid sector.

1. ***Financial and commercial constraints.*** Companies in the energy sector companies face cash-flow risks because the main prospective customers are low-income households. Their overall ability to pay is limited because of their low incomes. *and most them* lack access to finance from local financial institutions for off-grid projects
2. ***Market at early stages of development.*** For solar PV, financially sustainable pay-as-you-go business models are just emerging. For mini-grids, there is no experience yet with a commercially-run, private sector-based mini-grid, demonstrating a commercial business case and successful customer tariff collection, making it a high risk sector.
3. ***Inadequate technical standards.*** There are no well-defined, well-enforced technical standards for stand-alone solar PV systems. For mini-grids, there is uncertainty about the technical standards to be followed in order to ensure system compatibility when the national grid reaches a previously isolated mini-grid.
4. ***Capacity constraints.*** There is a capacity constraint in some aspects of the supply chain for all off-grid options including a shortage of qualified technicians for installation and maintenance. For mini-grids in particular, due to the lack of market experience, and limited commercial funding opportunities, there is a lack of companies able to present high quality proposals and / or develop bankable business cases.
5. ***Institutional constraints.*** The institutional structure of the energy sector has not yet responded to the increased focus in Rwanda on off-grid solutions. In particular, there is no clear specification of which geographic area or socioeconomic strata of the population shall be targeted by off-grid service approaches such as stand-alone systems or mini-grids. To date, there has been a patchwork of different off-grid support programs.
6. Legal and regulatory constraints. Standalone PV systems do not face major legal or regulatory constraints. Mini-grids, particularly those based on micro-hydro plants, face a number of

specific legal and regulatory barriers. First, RURA is developing a simplified licensing framework for rural electrification, but there remains a lack of clarity about the commercial details regarding user tariffs and arrangements regarding eventual connection to the grid.

1.4 SREP Program Description

The Rwanda IP aims to unleash the potential of the private sector to provide off-grid energy solutions using renewable energy sources. While there are good opportunities for main grid renewable energy development, a comprehensive plan has been developed for the main grid and not for off-grid electrification. There is need for a comprehensive off grid strategy to be developed. The SREP intervention will focus on off-grid renewable energy which fits well with national priorities.

The IP was developed with particular focus being put on enhancing the enabling environment and overcoming the barriers and constraints mentioned above. The primary instrument for the SREP program will be a Renewable Energy Fund (REF), which will be created by the Government. The REF is part of the wider Government strategy set out in the ESSP to support energy sector investments by the private sector. While the REF will have a broad mandate, the SREP funds will support only off-grid renewable energy electrification.

The creation of the REF is consistent with the successful on-going regional practice. The REF is similar to Uganda's Rural Electrification Agency (created in 2001, with initial and on-going support from the World Bank) and Tanzania's Rural Energy Agency (created in 2007, with initial and on-going support from the World Bank) in the sense that all of these agencies aim to promote, *inter alia*, private sector led off-grid renewable energy development by creating an enabling environment.

As a guiding principle, the REF will utilise SREP funds to catalyse private sector investments while providing a coherent and coordinated mechanism for donors to support rural electrification on a sustainable manner. The REF will be flexible to different types of renewable energy solutions, subject to the application of high quality technical standards and avoid top-down decisions or allocations to pre-determined technical solutions. Further details about the functioning and the day-to-day operational modalities of the REF will be developed during the project appraisal stage once approved.

In mitigating the *financial constraints*, the REF aims to facilitate private capital, not crowd it out, without distorting the local financial markets for renewable energy lending. This involves mitigating the consumer affordability constraint, the access-to-finance constraints, and other financial constraints that may emerge. The REF would choose from a range of financing instruments, including equity and debt, grants and results-based-financing (RBF) to cover viability gap financing and improving affordability of off-grid energy services, credit enhancement instruments (e.g., guarantees, mezzanine financing), and consumer finance. In using RBF, the REF will recognise that that RBF may not be able to finance upfront capital costs, which can be a critical barrier. Total support levels to individual companies may be capped to avoid creating over-dominant players in the market. See Appendix 5 for further details.

Thus, the REF will finance a variety of renewable energy investments to be defined in the project appraisal stage, as well as provide technical assistance for enhancing the enabling environment for private investments in off-grid energy markets. The main areas of support which are envisaged include:

A. Investments

-Stand-alone solar PV systems. The objective of this sub-program is to build markets and private sector capabilities to develop stand-alone solar PV systems as a significant contribution toward the overall objectives for the off-grid electricity sector. The SREP support focuses on a short-term aim of providing electricity access to over 250,000

households and 175 social infrastructure projects (health clinics, schools, etc.). The long-term aim is to help grow a number of businesses able to service the off-grid power sector on a sustainable basis. The REF aims to raise solar PV product standards, promoting the dissemination of systems that are certified to international quality standards.

-Mini-grids. This sub-program will contribute to the financing of mini-grid projects, estimated to provide electricity access to around 250 villages (around 38,000 households, at least 250 businesses), and supporting electricity use by businesses to support job creation and productive use. The aim is to demonstrate the benefits to local communities, and the commercial and technical viability of business models in order to trigger further market growth.

B. Technical Assistance/enabling environment.

This component will address financial and non-financial barriers in the market. Examples of activities include: i) market development including awareness campaigns, ii) improving technical standards of equipment in the market, iii) addressing training and other technical capacity needs in the supply-chain, iv) increasing institutional and regulatory capacity including developing M&E systems for the off-grid sector, v) assistance to project developers in developing their projects, and vi) assistance to the local financial institutions in appraising renewable energy projects.

1.5 Transformative Outcomes and Co-benefits

The SREP program will support the development of off-grid energy markets in Rwanda, helping to establish the conditions necessary for off-grid markets to make their full contribution over the long-term to low-carbon development pathways, reductions in energy poverty, increasing energy security and increasing access to renewable energy. Benefits to communities arise through increased access to modern energy services for households and productive uses, improving quality of life, economic opportunities, as well as educational and health outcomes particularly for women. Some of the key co-benefits to communities of the program include:

- Enhanced energy security. Scaling up renewable energies helps diversify the energy mix, reducing dependence on imported fossil fuels, and enhancing the security of energy supply in the country.
- Improved access to electricity. Mini-grids and stand-alone solar PV help increase access to electricity in isolated areas where the grid is not expected to reach in the short term, helping ensure that a renewable energy delivery infrastructure is established before diesel generation becomes standard.
- Capacity building. SREP activities build and sustain management and technical skills within rural communities.
- Job creation and income generation. The program aims to maximize economic development opportunities, including new activities that create jobs and raise incomes, especially in rural towns.
- Improved quality of life in rural areas. Household and institutional access to electricity in rural communities can lead to better education, health and public security, especially for women and children
- Improved gender equality and women's socioeconomic status. SREP initiatives will help improve women's access to productive uses of electricity, and reduce women's barriers to information and training options for new energy services and technology. The project team will collaborate with the Africa Renewable Energy and Access Program AFREA Gender and Energy program to identify key gender issues, risks, constraints and opportunities associated with the proposed SREP programs in order to maximize gender benefits and other socio-economic benefits.

- Improved access to communications. Increased access to electricity helps boost use of communications through mobile phones, televisions, and the internet, improving access to information and empowering local communities.

1.6 SREP Financing Plan

The total estimated funds requirement for the Rwanda IP is US$183.2m with a SREP contribution of US$50m for off-grid renewable energy investments and technical assistance activities over a five year program starting 2017. The SREP financing leverage ratio 1:2.7 (US$1 from SREP is expected to leverage US$2.7 from other financing sources).

The financing plan presented in the table below is *indicative*, noting that the final allocation of SREP funds for Mini-grids and Stand-alone solar PV sub-programs will be subject to market demand. The amount of SREP funding allocated to Technical Assistance / Enabling Environment will not exceed US$2.8m.

Table ES1. SREP indicative financing plan (US$ million)

Project / sector	Project component	Total investment US$m	Private Sector US$m	Other dev. partners	REF budget US$m, of which:		
				US$m	MDBs (WB, AfDB)	GoR	SREP
Mini-grids	Feasibility & TA	1		1			
	Investments	64.3	34.3	3.9	14.0		12.1
	Sub-total	**65.3**	**34.3**	**4.9**	**14.0**	**0.0**	**12.1**
Stand-alone solar PV systems	Market building	2		2			
	Investments	108.4	40.0	12.0	16.0	5.3	35.1
	Sub-total	**110.4**	**40.0**	**14.0**	**16.0**	**5.3**	**35.1**
TA / Enabling Environment	TA / Enabling env't	7.2		4.7			2.5
	IP prep. Grant	0.3					0.3
	Sub-total	**7.5**	**0**	**4.7**	**0**	**0**	**2.8**
TOTAL US$m		**183.2**	**74.3**	**23.6**	**30.0**	**5.3**	**50.0**

About US$110m of potential co-financing has tentatively been identified (see Table ES2). Other co-financing is expected to be identified from the private sector and other development partners as SREP implementations progress.

Table ES2. Identified potential co-Financing (US$ million)

Funding Source	Comments	Amount (US$m)
MDBs (WB, AfDB)	Provisional co-financing	up to 30.0
SEFA / AfDB	Country program (separate approval process)	1.0
DFID/ EnDev	Village grids	1.8
DFID/ EnDev	Solar lighting	3.3
BTC	Technical assistance	6.7
Private sector	Acumen / African Renewable Energy Fund / Commercial banks / investors	65.0
GoR	Provisional allocations for social infrastructure	5.3

2 Country Context

Rwanda is a small land-locked country of 26,338 km^2 in area with a population of 11.7m people (national census, 2012). It is densely populated in comparison to other African countries. At 480 people per km^2, Rwanda's population density is the highest in Africa. Population is forecast to grow at 2.5% per year according to UN[1], making it set to expand to 17.8m people by 2030, with much of the growth expected to be in urban areas. In 2014, Rwanda's GDP was 643 US$/capita. Rwanda's economy has been growing at an annual average rate of 8.3% between 2008 and 2012[2].

Rwanda's Economic Development and Poverty Reduction Strategy II (EDPRS-II) sets overall economic objectives up to 2018. EDPRS-II identifies challenges confronting medium and long-term development aspirations. Poverty and inequality are high. Land, a basic resource for many people's rural livelihoods and for new productive activity, is pressured by increasing population density and demographic trends. The growing youth share of population requires 200,000 jobs to be created each year. Yet, the labour force is characterised by low skills and productivity; the private sector is constrained by its small scale and lack of suitable infrastructure; and delivery of development faces horizontal (across sectors) and vertical coordination (centre to district to community) challenges.

On the other hand, a number of opportunities exist to overcome these challenges. Rwanda's favourable dependency ratio can provide a demographic dividend based on its youthful labour force and the demands for goods and services arising from increasing urbanisation. Domestic political and economic stability and an attractive regulatory environment are positive for private investment and doing business. The improving literacy and numeracy of the population provides the basis for a more skilled national workforce. The existing decentralised modalities for development and service delivery, often based on traditional institutions, are platforms for increased engagement of citizens in planning and delivery. Increased regional integration can massively expand market potential and economies of scale. Rwanda's alertness and pro-activeness in environment mainstreaming can provide a natural centre for green growth and investment. In order to maximise these opportunities, the following thematic priorities have been identified in the EDPRS-II:

- **Economic transformation**. This thematic area targets accelerated economic growth (11.5% average) and restructuring of the economy towards more services and industry as Rwanda moves towards middle income country status. The main targets relate to: strategic infrastructure investment for exports, increased private sector financing for increased exports coverage of imports, urbanisation and green economy approach for sustainability.
- **Rural development**. This thematic area is focused on ensuring that poverty is reduced from 44.9% in 2010/11 to below 30% by 2018. This will be achieved through focus on increased productivity of agriculture, which engages the vast majority of the population and ensures sustainable poverty reduction. Enhanced linkages of social protection programs will also be developed with particular attention to increasing graduation from extreme poverty.
- **Productivity and youth employment**. This thematic area is focused on ensuring that growth and rural development are underpinned by appropriate skills and productive employment, especially for the growing cohort of youth, and the creation of at least 200,000 new jobs annually.
- **Accountable governance**. The objective of this thematic area is to improve the overall level of service delivery and ensure citizen satisfaction above 80%. It also focuses on increased citizen participation as a way of ensuring ownership and feedback for efficiency and sustainability.

[1] Source: UN Department of Economic and Social Affairs World Urbanization Prospects: The 2014 Revision"
[2] NISR Statistical Yearbook 2013

3 Rwanda's Energy Sector

The energy sector is one of the key enabling sectors to achieving Rwanda's development goals. In particular, increasing access to energy for households, schools, health facilities and productive uses is seen as essential to improving quality of life, improving educational and health outcomes, and providing the basis for increasing productivity and growing prosperity in the country.

Rwanda's ESSP sets out the following high-level targets for the sector by 2018:

- Increase the electric power system equivalent installed capacity (domestic generation + imports) to 563 MW
- Increase household access to grid electricity to 48% and access to off-grid electricity to 22%
- Achieve savings from energy efficiency measures of 10% through demand-side management measures and grid-loss reductions (from a 2013 baseline)
- Reduce carbon intensity of the grid by 10% by 2018, and 25% by 2025 (from a 2013 baseline)
- Ensure 80% of all households employ clean cooking energy technologies
- Realise all EAC Regional Integration Policy priorities for the energy sector
- Ensure the necessary infrastructure is in place to meet current petroleum strategic reserve requirements

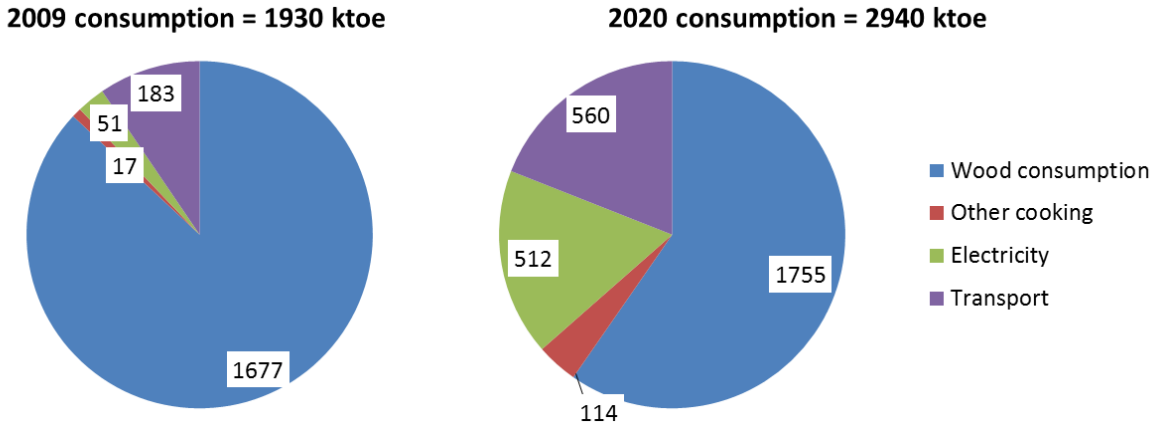
The SE4All Action Agenda which is currently being developed by Rwanda also helps set strategic direction for the energy sector over a longer time frame to 2030. This extends the goals for energy access, increasing the role of renewable energy and sustainable biomass, and improving energy efficiency.

The following sections identify some of the key issues arising in different aspects of Rwanda's energy sector.

3.1 Primary Energy Supply and Demand

Total primary energy consumption is shown in Figure 1 for 2009, the latest year for which data are available across all fuels. Rwanda's development needs imply a considerable pressure to increase the supply of energy in the country; population and economic growth is leading to rapidly increasing demand for energy by households and productive uses.

Figure 1 Primary Energy Consumption by Use (2009 and projected for 2020, source: SE4All Action Agenda)



Biomass consumption, mainly wood and charcoal for cooking, currently dominates primary energy supply. Biomass is heavily relied on for cooking and related uses by both urban and rural households. The sustainability of biomass in Rwanda is potentially better than in many other Sub-Saharan African countries, because in Rwanda the biomass comes predominantly from either

planted trees (mostly eucalyptus) or agricultural residues. However, currently demand is higher than annual production, leading to a sustainability gap. This gap is growing as the population grows, as household incomes rise, and as urbanisation increases (leading to greater share of charcoal use).

A number of actions are identified in the ESSP to address these issues. Institutional responsibility for the biomass sector transferred in January 2015 from Ministry of Infrastructure (MININFRA) to the Ministry of Local Government (MINALOC) with the aim of decentralising control of the sector. Under this arrangement, MININFRA's role will remain to give technical support to the local government in policy, strategies and guidelines, planning and fund mobilisation, research and development of technologies, training and promotion, as well as monitoring and evaluation. MINALOC's role will be the implementation of biogas and improved cookstoves programs and projects. It will be involved in training, awareness and promotion, planning and fund mobilisation at district level. Current biomass programs include a biogas program and an improved cookstoves (ICS) program[3]. The biogas program has an annual target of 3,500 units for households and 15 units for institutions (e.g. schools, prisons etc.) to meet the EDPRS-II target by 2017/18. For the year to 2014, this target was exceeded, with 4,441 domestic units installed. The ICS program aims to reach 100% of households having ICS by 2017, with current usage estimated at 70%.

Hydropower has traditionally provided the majority of Rwanda's electricity supply. Since the mid-2000s, hydropower has been supplemented with expensive centralised diesel generators. As a result, since then, the focus of energy policy has been to develop cheaper local alternatives to the diesel, as well as to rapidly scale-up supply to meet growing demand. Options include power from peat, methane extracted from Lake Kivu, hydropower, solar, geothermal, and to a lesser extent wind. Electricity imports from neighbouring East African countries, resulting from efforts at regional integration of the electricity systems, are also a key potential source of electricity for the country.

Many of the energy resources at Rwanda's disposal such as hydro and methane are shared with its neighbours, requiring international agreements to be forged on how these resources should be exploited.

Rwanda faces a range of important cross-cutting policy issues relating to the energy sector:

- Urbanisation trends will have important implications for the energy system, in particular increasing the demand for charcoal which tends to be the primary cooking fuel in urban areas, as well as increasing demand for transport fuel as incomes grow and demand increases
- Minimising the environmental impacts of energy provision which can arise from all aspects of the energy system including biomass, peat, hydro, methane and fossil fuels. Rwanda is committed to taking a green growth approach to development, and energy goals need to be aligned with maintaining a sustainable environment.
- Gender-based effects of policy need to be considered. The choice of energy source can have particular effects on women since they are often responsible for collecting biomass as well as cooking, which has a disproportionately high impact on their time and health.
- Security of supply issues need to be addressed across all energy types. For example, security regarding petroleum products needs regional coordination, as well as country-specific actions regarding strategic oil storage reserves in order to reduce supply shortage risks.
- Some energy supply options, particularly hydro, are vulnerable to climate change, and the likely increase in variability that this will bring to rainfall patterns and water availability. The country needs to take a risk-based approach to assessing its dependence on different energy sources taking these vulnerabilities into account.

[3] Source data for progress on these programs is taken from: Biomass Handover Report, January 2015

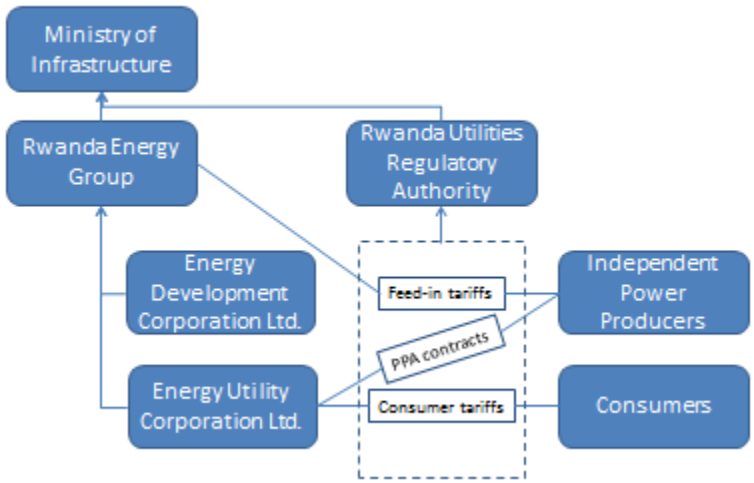
3.2 Legal, Regulatory and Institutional Structure

A clear legal and regulatory framework for the energy sector plays a fundamental role in boosting confidence in Rwanda as an investment destination and attracting more private sector operators. The Ministry of Infrastructure (MININFRA) has political responsibility for the electricity sector in Rwanda, and is responsible for setting and delivering strategic goals for the sector. Day-to-day responsibility for managing the electricity system is devolved to the Rwanda Energy Group, a state-owned company, which has two subsidiary companies: the Energy Development Corporation Ltd (EDCL) and the Energy Utility Corporation Ltd (EUCL).

EDCL has primary responsibility for developing new energy generation assets, both government and privately owned. Their mandate includes preparing comprehensive energy development plans, increasing investment in generation and transmission capacity, and planning and executing energy access projects to meet national targets. EUCL on the other hand has the mandate for operation and maintenance of existing generation plants together with the transmission and distribution network. They act as counterparty to independent power producers once projects are up and running. They are also responsible for network growth and increased connections within the foot print of electrified areas. EUCL has the mandate for retail of electricity.

The independent Rwanda Utilities Regulatory Authority (RURA) determines the tariffs in consultation with REG and MININFRA. RURA has a central role to play in setting tariffs. These include both feed-in tariffs (the rate at which EUCL enters into long-term contracts with IPPs for the supply of electricity) and consumer tariffs (the rates paid by consumers). Consumer tariffs are divided by size, with one tariff for households and small businesses being supplied by the low-voltage distribution system, and another (lower) tariff for large users supplied by the medium voltage distribution system. These relationships are shown in Figure 2.

Figure 2 Institutional structure of the electricity sector



While political responsibility for the energy sector lies primarily with the Ministry of Infrastructure, there are important inter-ministerial aspects of policy. For example, the Ministry of Natural Resources leads on exploitation of natural resources and environmental impacts, The Rwanda Development Board acts as a gateway for private developers, the Ministry of Trade and Industry is responsible for improving overall business environment, Ministry of Finance leads on resource mobilisation to support energy sector development, RURA is the sector regulator, National Fund for Environment and Climate Change (FONERWA) leads on the implementation for green growth and

climate change, Rwanda Standards Bureau develops national technical standards, and Ministry of Local Government leads on promoting decentralised delivery of basic services including delivery of some of the modern energy resources

In March 2015, the Government of Rwanda formulated the Rwanda Energy Policy (REP) and the Energy Sector Strategic Plan (ESSP). The REP sets out the overall vision and policy framework, whilst the ESSP translates the policy directives and principles into concrete measures necessary to reach medium-term targets. The ESSP has five strategic pillars:

- Energy Access (on-grid and off-grid electricity),
- Electricity generation,
- Biomass,
- Energy Efficiency, and
- Petroleum.

In the short-term, adoption of the energy policy and the Energy Sector Strategic Plan gives a clear political basis for the quick adoption of appropriate laws and regulations by the end of the EPDRS II period. However, the ESSP does not discuss the off-grid electricity sector in detail. Since the ESSP contains only the high-level off-grid access targets, further work is required to flesh out the Government's policy for the off-grid sector. Further discussion is provided in Section 4.

The principal laws and related regulations connected to the exploitation and use of Rwanda's energy resources comprise the Investment Code (2014), Electricity Act (2011), the Law Establishing EWSA (2010) and the Law Repealing EWSA (2013), the Law Establishing and Determining the Mandate of the Rwanda Utilities Regulatory Authority (2001) and as revised (2013), Law on Mining and Quarry Exploitation (2008), and the Petroleum Law (2013). The ESSP sets out a timetable for development of specific legislation governing supply of renewable energy in Rwanda, and these are currently being developed. This includes the provision of a simplified licensing framework for rural electrification currently being finalized by RURA for the purpose of expediting licensing the supply of electricity for small isolated grids.

A detailed review of the institutional framework for energy in Rwanda is provided in Appendix 2.

3.3 Electricity Demand

In order to strike the right balance between increasing access to grid connectivity, ensuring the long term financial sustainability of the utility, maintaining a reliable supply of electricity, and making electricity more affordable, investments in new power generation and transmission infrastructure need to be tightly aligned to projected power demand. Ensuring an efficient balance between demand and supply in the power system is one of the core functions of the REG. Its Planning Units are responsible for projecting electricity demand over a 20-year horizon, and update the figures annually. Particular considerations are made for peak demand including:

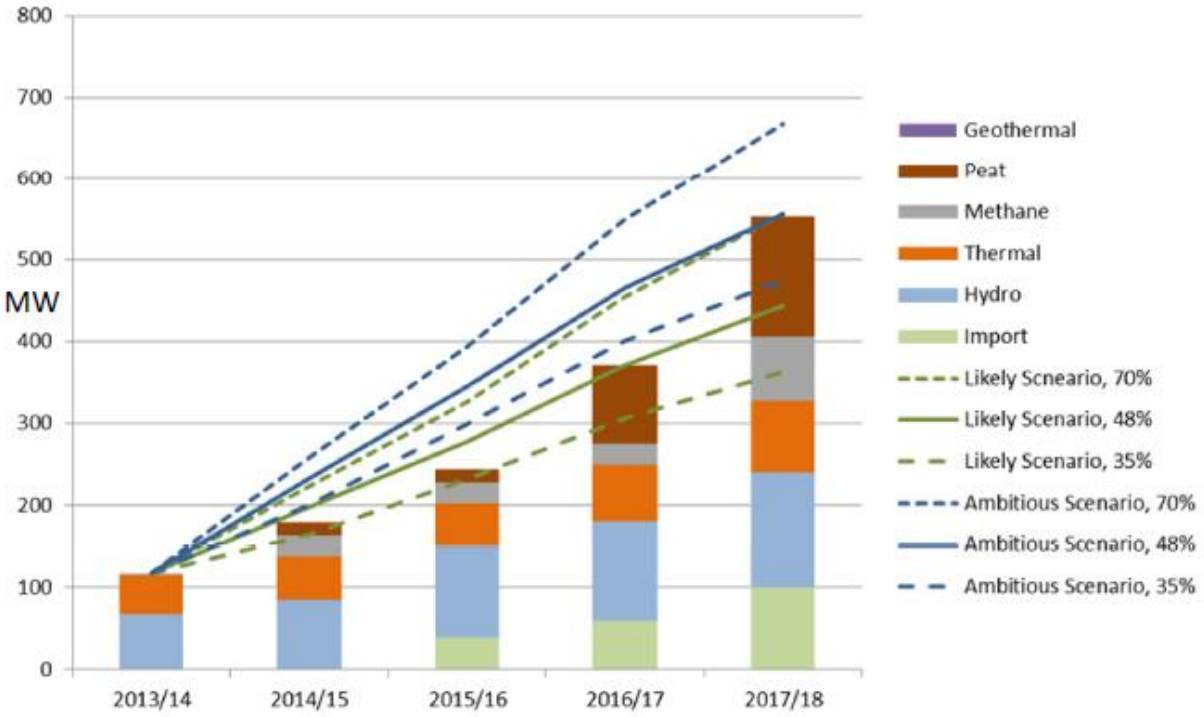
Residential demand: This is a function of the number of households connected to the grid and their typical level of consumption. As households tend to consume most of their energy at peak times (18:00 – 19:00), residential demand is a key driver of peak demand.

Industrial and commercial demand: This covers all non-residential demand. Significant contributors are in the mining, manufacturing and agricultural sectors, along with commercial premises.

The demand forecasts also take into consideration potential improvements to energy efficiency including projects to reduce power losses in the electricity grid from their current levels of 23% Since there is uncertainty over the level of future demand, plans need to be adaptable. The chart in Figure

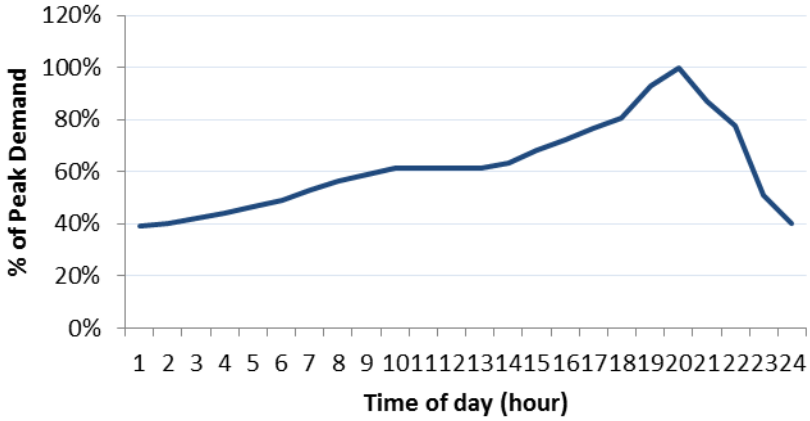
3 illustrates scenarios developed in the ESSP for meeting different peak demand forecasts. The lines indicate generation requirements under various scenarios, inclusive of reserve margin requirements. The green lines represent the most likely peak demand forecasts made in the ESSP taking account of population growth, increased levels of connections to households and demand from commercial users based on likely economic growth. The different scenarios relate to different assumptions about the level of access to on-grid electricity (i.e. 70%, 48% and 35% scenarios). The ESSP sets a target of 48% on-grid access. This means that on-grid electricity demand is forecast to be 444 MW under the likely growth scenario.

Figure 3 Electricity demand scenarios (Source: ESSP)



The Rwandan electricity system has quite a pronounced peak during after-dark hours because of the predominance of household demand on the system, and the need for lighting (see Figure 4).). This currently outweighs electricity demand during the day for industrial and commercial uses, although the balance could change over time depending on the relative growth of different sectors of the economy. There is currently a focus on baseload generation under PPA arrangements with independent power producers, and this will need to be balanced with additional peak power generation technology. This could include flexible thermal plant, or renewable sources such as hydro with storage reservoirs.

Figure 4 Electricity demand profile in Rwanda (Source: ESSP)



Demand for off-grid electricity is determined by the gap between total percentage of the population requiring access to electricity and the level of on-grid provision. The ESSP sets a target for growing provision of off-grid access to 22% of the population, amounting to around 550,000 households.

3.4 Electricity Generation

In the electricity sector, Rwanda plans to rapidly scale up its energy infrastructure to increase levels of energy access, to develop clean low-carbon energy sources and improve energy efficiency. At an implementation level, the country has seen some remarkable successes, notably in electricity access roll-out program (EARP), which has seen the number of households connected to the grid grow from around 11% of the population in 2010 to 21% of the population in Jan 2015.

The ESSP target is for the level of on-grid access to grow to 48% of the population by 2018. Planning scenarios in ESSP anticipate peak demand growing to between 377-473 MW, requiring supply to increase to between 444-563 MW by 2018.

The current generation mix is dominated by hydro plant, with diesel and HFO providing most of the remainder of the capacity, as illustrated in Table 1. By 2025, the technical potential is significantly larger than required to meet demand, meaning that choices will need to be made about which of these potential projects go ahead. The share of renewables for the committed pipeline of projects in 2018 is expected to be 35%. However, the share of renewables is expected to increase to 46% after 2020 as a result of the regional hydro Ruzizi III project coming online.

Table 1: Power generation: installed capacity and technical potential[4]

	Current Capacity (MW)	Project pipeline to 2018 (MW)	Technical Potential to 2025 (MW)	Current %	2018 potential %	2025 potential %
Solar PV	8	18	160[5]	5%	3%	1%
Domestic hydro	78	122	178	50%	22%	13%
of which <10MW	*(28)*	*(70)*	*(126)*	*(18%)*	*(13%)*	*(9%)*
Regional hydro	16	16	186	10%	3%	13%
Geothermal	0	0	47			
Import	4	94	494	2%	17%	35%
Gas (methane)	4	79	304	2%	14%	22%
Peat	0	145	145	0%	26%	10%
Diesel	28	8	8[6]	18%	1%	1%
HFO	20	80	80	13%	14%	6%
Total	157	560	1602	100%	100%	100%

As seen from these tables, Rwanda has the potential to import significant amounts of electricity from its neighbours, particularly Ethiopia, Kenya and Uganda; these imports would mostly be from renewable sources, particularly hydro and geothermal.

Rwanda is actively participating in a range of regional energy development initiatives, where it has a share of resources which lie on or across national boundaries. The Eastern Africa Power Pool (EAPP) which was formally established in February 2005 and the Nile Basin Initiative (NBI) will facilitate the on-going initiatives of power exchange with the 10 member countries which include Egypt, Libya, Rwanda, Ethiopia, Sudan, Kenya, Uganda, Tanzania, Burundi and the DRC[7].

If these imports are included in the fraction of Rwanda's supply that is considered to be renewable, then the share of renewables increases significantly to around 44% of capacity in 2018 and up to 62% in 2025.

The electricity demand profile noted in the previous section has important consequences for the design of the electricity system, and the choice of electricity generation technology. In particular:

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[4] Source: REG see http://www.reg.rw/index.php/our-business/generation. Future potential from draft LCPDP, except for solar and geothermal which are based on ESSP limits and JICA geothermal study respectively.

[5] Technical potential for 2025 for on-grid utility-scale solar limited to 10% of total for strategic & grid-stability reasons.

[6] Figures for diesel and HFO are planned capacity figures – technical potential is fairly unrestricted.

[7] Some of the power line projects that Rwanda can potentially benefit from are:

- Gilgel Gibe III (Ethiopia) - Suswa (Kenya), High Voltage Direct Current: expected completion Dec 2017.
- Lessos (Kenya) – Tororo (Uganda), 400 kV: under construction, expected completion in Dec 2015.
- Masaka – Mbarara (Uganda) designed for 400 kV but to be initially operated at 220 kV: fund mobilisation is ongoing and the target date for completion is Mar 2017.
- Mbarara – Mirama, 220 kV double circuit: under construction, expected completion in Sep 2015.
- Mirama – Shango, 220 kV double circuits: under construction, expected completion in Sep 2015.

- New plants being built by IPPs currently tend to have take-or-pay PPAs based on provision of baseload capacity.
- Most of Rwanda's current and proposed hydro plant are run-of-the-river hydro providing baseload capacity, with considerable seasonal variation in output. Exceptions include the recently completed Nyabarongo I plant (28MW), which has intra-day storage capacity allowing the plant to respond to daily fluctuations in demand.
- Utility-scale on-grid solar PV plant in Rwanda do not to come equipped with storage, so they provide day-time power, but do not contribute to peak.
- Peaking power is currently provided by diesel and HFO plant. As the system grows in response to rising electricity demand, the need for peaking plant is also expected to increase.

3.5 Electricity Access

3.5.1 On-grid Access

In order to provide access to on-grid electricity for households, businesses and social infrastructure, the electricity system needs capital-intensive investment in the transmission and distribution (T&D) grid. Rwanda's flagship Electricity Access Roll-out Program is a nationwide initiative to extend access to electricity for households, productive uses and social infrastructure with the following headline aims:

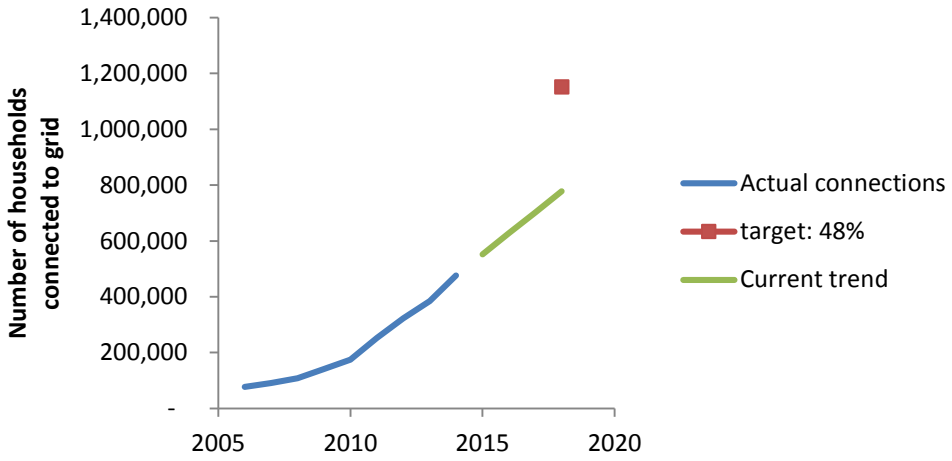
- Phase 1 (2009-2012): Extend the network across the country and provide direct connections, with a target of 350,000 connections by the end of 2012, or 16%. Roughly US$350 million in funding was mobilized for Phase 1 allowing for targets to be exceeded. Total connections were 379,851 as of August 2013.
- Phase 2 (2013-2018): Additional connections onto the network, which combined with off-grid solutions, results in 70% of the population with access to electricity, of which 48% is proposed to be on-grid. Provision of electricity to industrial parks and other productive activities are also planned to be scaled up significantly over this period.

It has been found that where electricity connections have been made, living conditions improve;[8] education improves due to access to modern lighting and computers, service delivery improves, e.g. health facilities are able to stay open longer, and associated risks with energy security are reduced.

The number of household connections is shown in Figure 5. Over the past four years from 2011-2014, an average of over 75,000 households per year have been newly connected to the grid, requiring an annual investment in the region of US$50-60m per year. To meet the target of 48% by 2018, this would need to increase to 170,000 new household connections per year, with a budget of around US$130m per year. As the figure shows, under currently identified funding for the program, there would be a gap between achieved number of connections and the 48% target in 2018 unless additional sources of funding for the program are provided.

[8] See e.g. EARP mid-term review report, and survey evidence collected by Colorado State University 'Smart Village Micro-grid Project.

Figure 5: Number of household connections to the grid[9]



The additional cost of providing transmission and distribution for households has been estimated in the SE4All analysis at US¢10/kWh, as an average for rural and urban households. However, as noted in the EARP mid-term review, consumption levels for newly connected households remain at a low level for a considerable duration. Low income levels, particularly in rural areas, mean that energy consumption is restricted to a few low-energy consumption appliances such as lighting and mobile phone charging. This means that for such consumers, the fixed costs of T&D are spread out over a smaller number of units used. T&D in these circumstances adds a much larger amount (up to US¢40-50/kWh) to the cost per unit of electricity.

There is also a need to develop a smart T&D grid that is able to facilitate greater penetration of renewable energy. As noted in the previous section, some renewable energy sources are intermittent, and place increased demands on the electricity network in terms of system balancing. As well as requiring flexibility to dispatch the required generation, this can also require additional investment in the T&D network. Likewise, a requirement to allow small-scale embedded renewable energy systems, such as solar-PV systems in households, schools, clinics etc. to be able to export electricity to the grid during times of surplus places a requirement on the grid to be able to intelligently manage such 2-way flows of electricity and potential mismatches of supply and demand.

Another issue facing Rwanda is that projects greater than around 5MW typically require high-voltage connection to the grid. Such high-voltage lines may be required to pass quite long distances over parts of the country that do not have access to grid-based electricity. This can cause difficulties with respect to perceptions of fairness amongst local populations.

Provision of electricity access to social infrastructure is also a GoR priority. According to ESSP, as of June 2014, roughly 63% of health facilities, 41% of primary schools, 66% of secondary schools and 64% of administration centres had access to electricity. This was met through a mixture of on-grid connections and off-grid distributions. REG is tasked with reaching 100% access by 2018, and will need a mixture of on-grid and off-grid solutions to meet this target.

3.5.2 Off-grid Access

Off-grid electricity access is also an important part of the ESSP strategy, targeting 22% of the population, or about 550,000 households, by 2018. As noted in Section 4.7, there are several initiatives in place which contribute to this target, and promotion of solar lanterns is reaching large

[9] Current trend based on finances identified for EARP program to date (Source: REG)

numbers of households. However, provision of more substantial electricity access through off-grid systems is still relatively low. Further work is ongoing to develop the Government's off-grid access strategy as part of its Rural Electrification Strategy being supported by the EU. This off-grid strategy will need to define more accurately what is meant by electricity access in the off-grid context in terms of installed capacity and / or energy consumption levels of households.

Since 2000, there has been fairly rapid growth of the off-grid industry but it remains an early-stage market of small players that is loosely integrated with the global and regional solar energy industry. Today more than 40 companies[3] compete in the market - few sell over 15 kW per year[10]. Many commercial hardware and electronics shops have added solar modules as over-the-counter product. This market sector is discussed in more detail in section 4.2.2.

Apart from solar PV, the EDPRS-II also encourages the development of off-grid micro hydro generation. "*Micro hydropower projects will generate electricity for communities located in isolated areas away from the national grid, but with hydro potential. These provide higher levels of power than solar systems but at a high investment and maintenance and operation cost. Local and international investors will be encouraged to invest in micro-hydro power projects through improved incentives to exploit local energy resources.*"

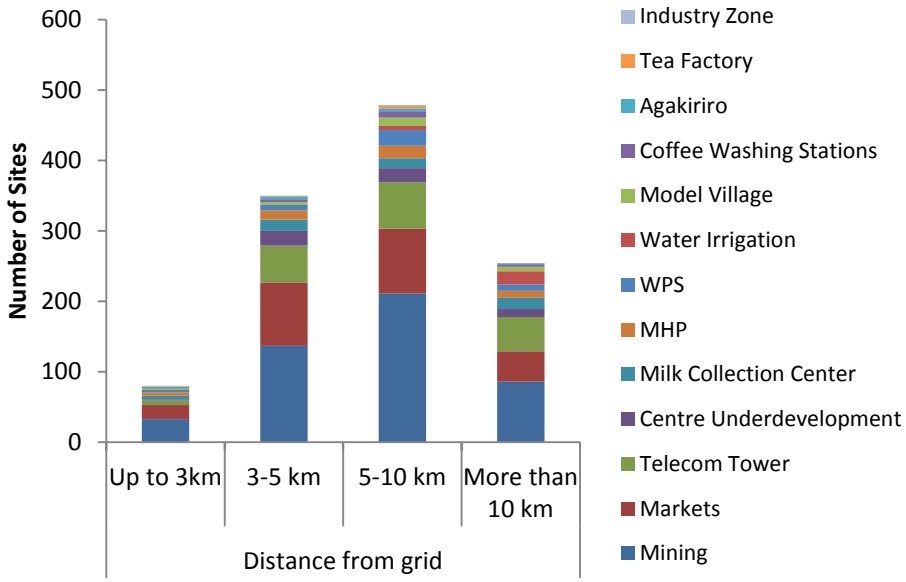
As well as serving remote communities, mini-grids have the advantage of being able to serve productive loads in remote areas, which can help improve the economic viability of the project by acting as an anchor load. The cost of the technologies is influenced to different degrees by various local conditions: the proximity of primary sources of energy, the size of the community, the density of the population, the distance to the existing national grid, the topography and general socio-economic factors such as energy demand and economic growth potential.

To date, some off-grid pico-hydro schemes in Rwanda have faced poor performance and reliability problems, partly because community ownership led to a lack of incentives to scheme operators to invest sufficiently in maintenance of the systems. The government is currently arranging to tender out a package of work to the private sector to rehabilitate and contract to run a group of these micro-hydro projects. This will help to demonstrate the technical viability of the schemes.

There is a variety of productive loads in Rwanda, many of which are more than 5 – 10km from the grid, which could be the basis for an anchor load for a mini-grid scheme (see Figure 6). Although there is a plan to eventually connect these to the central grid through EARP, the rate of grid roll-out is dependent on available financing, and the timing of these connections is therefore uncertain.. Since these sites are the furthest from the current grid, they would be considered lowest priority for EARP, and would therefore present good candidates for mini-grid as an alternative. However, further work is required to fully address the issue of coordination between grid expansion and mini-grid projects.

[10] Marge: "Technical Assistance and Advisory Services for Solar PV Market Development" page 17

Figure 6 Off-Grid productive loads (Source: REG)



Mini-grids based on solar PV are also a potential solution for providing electricity access in Rwanda. These can vary in scale from whole-village schemes similar in scale to the micro-hydro schemes down to pico-grid schemes which supply power to clusters of around 10-20 homes within a village.

Pico-grids are much lighter and lower cost in terms of infrastructure needs; since they only carry low power volumes they requiring much less cabling and can be quite expandable and portable if systems need to be removed. An example in Rwanda is the Mesh Power company, which has developed 15 solar-powered mini-grids serving around 300 customers, and has secured financing for a further 70 grids to reach 2,000 households by mid-2016.

More substantial AC power mini-grids, with higher specification equipment compatible with the main grid would be considerably more expensive to install. But, they would have the advantage of allowing for eventual integration with the main grid if and when this expands to absorb mini-grids. Several companies are considering such systems based on either solar PV or micro-hydropower as the energy source.

Regulations are currently being adopted to encourage mini-grid development. As required by the Electricity Law of 2011, RURA is developing a regulation on the simplified licensing framework for rural electrification. The draft regulation stipulates separate licensing requirements for isolated grids between 50-100 kW and between 100-1000 kW. While isolated grids beyond 1 MW are covered by the existing electricity licencing regulation of 2013, very small isolated grids below 50 kW are only required to provide a notification letter. The regulation also establishes a small power distribution (SPD) licence, introducing a new private business case of purchasing wholesale electricity from REG and selling it via a self-established distribution network to rural customers.

4 Renewable Energy Sector Context

As noted in Appendix 3, Rwanda has considerable potential to develop various renewable energy resources. These are at different stages of development, and although renewable energy can be a cost-effective source of electricity in Rwanda, development of renewable energy projects face a number of barriers, notably relating to the risks associated with capital intensity of upfront investment. These barriers depend on the types of project, and are discussed in the following sections split down by technology type.

4.1 Hydropower

Hydropower has been a mainstay of Rwanda's electricity supply since the 1980's, and still forms an important part of the country's technical potential for future scale-up of the electricity supply. The current status of hydropower is shown in Table 2. Current installed capacity is 93.6 MW.

Table 2 Current hydropower plant operating in Rwanda

Category	Name	Installed Capacity (MW)
On-grid Hydro Power	Nyaborongo	28.0
	Ntaruka	11.3
	Mukungwa	12.0
	Gihira	1.8
	Gisenyi	1.2
	Rukarara	9.0
	Rugezi	2.2
	Nkora, Keya, Cymbili	3.2
	Murunda (REPRO)	0.1
	Mukungwa II	2.5
	Rukarara II	2.2
	Giciye	4.0
Imported/Shared Hydro Power	Rusizi I (SNEL)	3.5
	Rusizi II (SINELAC)	12.0
Off-grid Micro Hydro Power	Nyamyotsi	0.1
	Mutobo	0.2
	Agatobwe	0.2
	Nyamyotsi	0.1
	Rushaki	0.04
TOTAL		**93.6**

There is still a considerable remaining hydropower resource, with potential projects falling into two categories: i) relatively large regional hydropower projects shared with neighbouring countries, and ii) smaller (below 10 MW) domestic micro-hydro projects. Including regional and domestic projects, the available resource for further hydropower projects is estimated at an additional 230 MW.

The former category includes Rwanda's share of three regional hydropower projects. Rusumo Falls on the border with Tanzania is 81 MW (Rwanda's share is 27 MW), expected online in 2019.The project is funded by WB (power plant & reservoir) and AfDB (transmission lines) and EU at a total cost of US$ 468.6 million, and is being developed by Tanzania, Rwanda & Burundi jointly, with NELSAP acting as technical secretariat overseeing the implementation of the project. Ruzizi III on the border with the DRC is 147 MW (Rwanda share 48 MW), to be developed by Communauté

Economique des Pays des Grands Lacs (CEPGL), expected online in 2021. The total cost Ruzizi IIIHPP is US$ 641 million and financing is expected from AfDB, WB, EIB, EU, KFW & AFD. Ruzizi IV is a potential project downstream of Ruzizi III, with up to 285 MW technical potential (Rwanda share 95 MW), but project development has not yet commenced. The development of the regional power projects also require interconnection between Ruzizi sites and Karongi with an estimated cost of US$28m[11]. Sharing of contractual liabilities between multiple countries in these projects increases project risks, and creates additional complexity that can make these project slower to develop than national projects.

Under the latter category of domestic hydropower, Rwanda's hydropower atlas study in 2008 identified 333 potential sites with a total capacity of 96 MW. A subset of the projects identified in the atlas, together with other projects identified by private developers have since been taken forward with pre-feasibility studies into an active project pipeline of 38 projects totalling 57 MW. The Energising Development (EnDev) initiative has also been supporting a private sector promotion program for micro hydro power development (PSP Hydro) since 2005. For eligible companies, viability gap financing has been provided that allows the companies to make an IRR of 20%. Intentionally, the plants were supposed to be run as mini-grids, but on completion plants became grid-connected. In its results-based financing project, EnDev provides €1.8m towards financing 35 village mini-grids (5-100 kW).

Figure 7 shows the estimated cost of electricity generation for Rwanda's micro-hydro projects. It can be seen that there are significant economies of scale, with the smallest projects being up to three times more costly per unit of electricity generated than the larger projects.

Figure 7 Cost of Electricity generation from micro-hydro (Source: ECA consultant report)

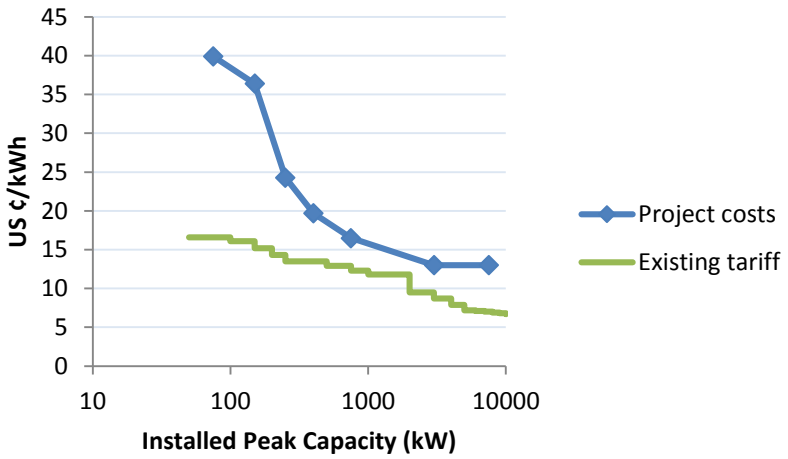


Figure 7 above shows that there is a considerable gap between estimated project costs and the existing tariff, leading to a 'viability gap', one of the barriers facing the micro-hydro power sector. The total estimated funding gap for the whole of the current project pipeline between estimated these project costs and the existing tariff amounts to around US$70m.

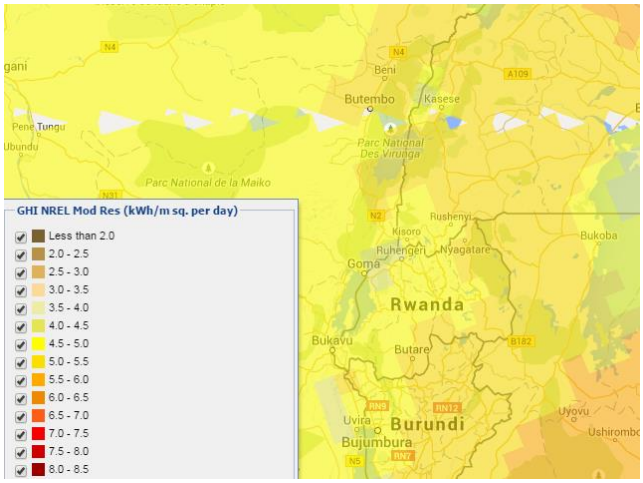
[11] AfDB 2013 "Rwanda Energy Sector Review and Action Plan"

4.2 Solar PV

Rwanda has an equatorial climate, with two rainy seasons and two dry seasons. Compared to some of its neighbours to the East and North, cloud cover can be relatively high. Solar maps for the region show that Rwanda has an average irradiation level of around 4.5-5.0 kWh/m^2/day, approximately 30% lower than some parts of Kenya at 6.5-7.0 kWh/m^2/day (Figure 8). Transport costs for importing equipment into Rwanda also tend to be higher than for its neighbours. These two factors taken together mean that solar power costs per unit of electricity generated are higher in Rwanda than in other countries in the region.

Nevertheless, solar power can be a cost-effective option for Rwanda. A full resource mapping exercise has not yet been carried out for Rwanda. The technical potential to develop solar resources for on-grid and off-grid applications is described in the following section.

Figure 8 Solar Irradiation Levels in East Africa (Source: SWERA[12]



4.2.1 Utility-scale (on-grid) Solar

There have not as yet been any comprehensive reviews of the technical potential for utility-scale solar in Rwanda, however there are constraints which need to be taken into account:

i. Generation levels are variable depending on weather conditions, leading to system integration and stability issues.

ii. In Rwanda, peak loads occur during the evening due to demand for lighting. Without storage, solar plant cannot reduce the amount of peak generation plant needed on the system. However, solar power can help to reduce dependence on use of fossil-fired plant for baseload generation, and can also contribute towards conserving water in hydropower schemes which have reservoirs.

iii. Pressures on land-use are intense in Rwanda because of the high population density in rural areas. 87% of total land area is used for arable farming, with about 10% for protected National Forests[13]. It is therefore difficult to find land for solar projects that does not compete with agricultural production.

[12] Solar and Wind Energy Resource Assessment (http://en.openei.org/apps/SWERA/). Values refer to 'global horizontal irradiance', which includes direct and diffuse sunlight, a figure of most relevance to solar PV installations.

[13] NISR Statistical Yearbook 2013 Tables 6.4.1 and 7.1.1

Taking these constraints into account has led to expectations in government planning that on-grid solar power should not exceed 20MW for now, at least until the system grows bigger. Based on a total system capacity projected for 2018 of 560 MW, the technical potential is assumed here to be capped at 20% of total installed capacity (112 MW).

Analysis of project costs in Appendix 3 indicate that solar power is currently more expensive than hydro-power. However, the costs of solar power internationally are still falling due to technological improvements, and it is likely that as Rwanda's energy system grows, solar PV will continue to play an important role.

4.2.2 Off-grid Solar

The potential for providing basic energy services through stand-alone solar systems has been proven at a technical level in many countries worldwide. Here we look at the current market conditions, and future expansion plans of companies in Rwanda.

4.2.2.1 Current Market Status

A detailed market survey completed in January 2014[14] highlighted four main segments in the current solar PV market in Rwanda:

a) **Tendered projects for social infrastructure**. These are typically larger projects driven by Government and NGO grant programs, for supplying rural health facilities, schools and administrative buildings. Solar projects are typically in the 500W-2kW range. Recent projects include: ACP-EU Energy Facility, which is installing solar PV systems in 300 schools; Solar Electric Light Fund/Partners in Health (Clinton Foundation-supported) project installed over US$200k worth of hybrid PV-diesel systems in Kirehe District; Partners in Health and the Solar Electric Light Fund installed at least 24 kWp of donated solar equipment worth US$800k in rural health centres in 2006/07; a solar installation project of larger than US$1M was tendered by the Global Foundation for rural clinics in 2007/08. When local companies are involved in such bids, it is often in partnership with larger international firms.

b) **Solar home systems and over-the-counter PV supplies**. Market typically categorized as systems that a) are larger than 10 Wp, b) are sold over the counter as components and c) are designed and installed by the end-user or small contractors. There has been a recent growth in this sector due to an increasing (but still small) middle-income community, demand from NGO's, sales to rural technicians and sales for export to neighbouring countries. However, systems from this market sector have higher failure rates because of poor design, bad advice, poor installation and system mismanagement by consumers.

c) '**Professional' PV market suppliers**. The professional market tends to supply equipment from reputable PV suppliers (Far East, Germany, USA, etc.) to customers that are looking for engineered solar solutions, such as NGOs, donors and high-income groups. Professional PV market suppliers include regional company representatives and "social entrepreneurs" (that also tend to be involved in the pico-solar business). Because "professional" suppliers are focused on all aspects of the business (design, supply, installation, after-service), they tend to gain repeat business and are able to build up clientele who demand specialized services.

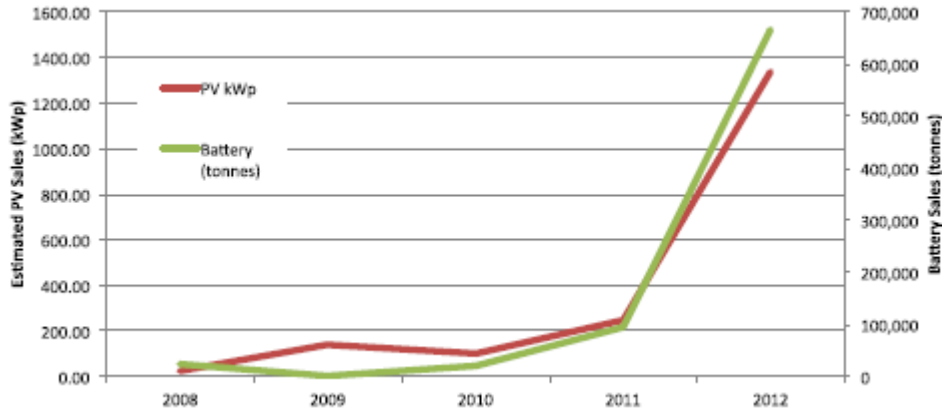
d) **Pico-solar products**. These are "off-the-shelf" plug and play products less than 15 Wp which require no design and very little installation support. They typically have one to four lighting

[14] "Technical Assistance and Advisory Services for Solar PV Market Development" Final report Jan 2014, Marge Consulting for EWSA.

points, a charging outlet for mobile phones, and, often, a radio plug or outlet for a small TV. Pico-solar products represent the largest PV product demand in terms of absolute volume, with sales at over 12,000 per units per year in 2011. Product revenue is likely to be well over US$1.5M per year in 2012.Still, pico-solar represents a relatively small portion of the overall PV market in terms of cash or kWp volume. Demand for Pico products among rural households is growing rapidly and at least 20 different products are available on the market and this number is growing. Many of these types have been approved by Lighting Africa, but there are also numerous other types on the market of dubious quality that are unlikely to be durable. Much market growth is supported by donor activity and project support will continue as the Government and donors continue to recognize the role of pico in meeting the energy needs of the base of the pyramid, and Tier 1 access systems can be accounted for in the Global Tracking Framework for SE4All.

Combined growth across all sectors of the market is shown in Figure 9; sales exceeded 1MW per year in 2012, though the capacity figures are strongly influenced by grant-driven activities in the social infrastructure sub-sector, which are not necessarily reflective of the wider market.

Figure 9 Growth of PV sales (Source: Marge 2014)



4.2.2.2 Market Expansion Plans

Several companies are planning a major scale-up in the supply of solar home systems in Rwanda in response to the Government's target of achieving 22% off-grid access[15]. Their business models vary, but typically involve variations on a pay-as-you-go (PAYG) model. This model has two main advantages. First, it allows households to spread out payment for the equipment over a period of months or years to help make the systems affordable. Second, the systems installed tend to be more technically reliable and sustainable because the equipment suppliers enter into an energy services agreement with the households and remain responsible for the maintenance and servicing over a relatively long time period. Systems typically allow remote sensing to diagnose faults, and to terminate service if payments are not made, which helps to provide security to service providers and help manage non-payment risks. These technical innovations therefore help support financially viable business models.

The types of equipment vary, with some companies offering lower power systems (10-50W), and others higher power systems (75-150W or more). There are advantages and disadvantages with each approach. Smaller systems are more affordable, whereas larger systems provide higher levels of

[15] Examples include Mobisol, Ignite Power, Azuri, BBox.

electricity access, more comparable to the level of service available through grid connections and could be considered a longer-term solution to Rwanda's energy access ambitions.

Solar PV can also be used as the power source for mini-grids. Experience to date in Rwanda has focussed on 'pico-grids', systems of around 1kW, which serve clusters of around 10 to 20 households. Around 15 such grids have been trialled in Rwanda, with plans to scale up to 70 grids serving 2,000 households by mid-2016. These systems are modular, and can be scaled up in line with demand. They are relatively low-cost; developers expect that total system costs could come down as low as US$100 per household if the systems could be installed at scale.

These positive developments by the private sector nevertheless need support to help build the market to meet the 22% target. The financing needs vary by company according to details of technology and business model, but communication with potential equity investors in the Rwanda market suggests that debt financing of US$100-120m is being sought in aggregate by these companies to support their investments. Debt needs would amount to typically 65-80% of total financing, with some companies needing additional grant finance.

Evidence from stakeholder consultations suggests that this level of finance is not readily available from commercial sources either within Rwanda's domestic financial sector[16], or from international commercial finance[17], at least without providing additional risk management finance.

However, some sources of equity finance are already actively involved in exploring expansion plans in Rwanda, including the African Renewable Energy Fund, managed by Berkeley Capital, and impact investors such as Acumen.

4.3 Geothermal

Geothermal exploration is a capital intensive and technically complex process. Despite the cost of exploration, such information is essential in order to attract investors. Exploration to date in Rwanda has been performed by private companies and the government with a range of different sources of funding, including from development partners and from government. The viability and technical approach used for exploitation of geothermal resources depends on the temperature of the water, the ideal situation being reserves of steam trapped in the rocks which can be used directly for electricity production. Lower temperature (hot water) reserves are not as valuable, but in principle may be used in a co-firing steam cycle to improve efficiency of fossil fuel plant. The base case in Rwanda is that geothermal sources would be used in binary cycles rather than co-firing.

There are currently four main prospects in Rwanda which have surface manifestations such as hot springs etc. At one of these, Karisimbi, two 26" test wells were drilled, but they did not prove a viable reserve. Work is ongoing to try to correlate data obtained from the wells with surface observations. Other prospects have not been drilled. As a result of the negative results of the Karisimbi test wells, other studies are proceeding more cautiously.

Recent analysis of these test results for a study funded by JICA indicates that total resource potential is now estimated at 47MWe at 80% confidence; with a lower 50% confidence that potential could be

[16] A mapping of Rwanda's financial services sector carried out for the study into the REF highlighted the lack of capital available for energy sector investments.

[17] These volumes are available in principle, but in practice the Rwanda off-grid sector is too embryonic and risks are not sufficiently well understood. Projects would need to be backed with subordinated debt and / or first-loss guarantees before commercial debt could be attracted at scale.

as high as 90MWe as shown in Table 3. Given these lower estimates of potential and the high cost of exploration, SREP will not pursue geothermal resources until further positive evidence arises.

Table 3: Geothermal potential in Rwanda

Field Name	Resource Potential at 80% confidence (MWe)	Resource potential at 50% confidence (MWe)
Kinigi	32.6	58.6
Bugarama	6.6	15.1
Gisenyi	1.9	3.7
Karago	2.5	4.9
Iriba	3.7	7.2
Total	47.3	89.5

4.4 Wind

One academic study using modelling analyses based on recorded wind measurements at selected Rwandan meteorological stations noted that electricity production in the area of the Gisenyi station could be possible with a good mean value of both wind speed and power density whereas in areas such as Kigali, Butare and Kamembe wind energy potential is sufficient for windmills or water pumping for agricultural and intuitional needs.[18]

However, a wind energy resource assessment[19] carried out in Rwanda in five locations in 2011 came to a less optimistic conclusion. Measurements were made using a combination of dedicated masts as well as installing monitoring equipment on mobile phone antenna. Field measurements of wind speeds and climate data over the course of one year were analysed and the preliminary indications were that most of Rwanda is not suitable for wind energy.

The data collected during the study indicates that the predicted capacity factors (i.e. percentage of the time wind turbines would be generating electricity) were typically below 10%, a level which would not be economically viable (Table 4). This is particularly true for the smaller turbines, which show markedly smaller capacity factors. Typically, capacity factors above 20% would be needed to make a commercially attractive proposition.

Table 4: Predicted capacity factors based on wind speed monitoring (Source: 3E wind resource study)

Hub Height:	55m (275kW)	70m (1MW)	100m (2MW)
Mast 1	5.4%	6.8%	9.6%
Mast 2	8.0%	9.7%	12.9%
Antenna 1	3.8%	4.8%	6.7%
Antenna 2	1.9%	2.3%	3.1%
Antenna 3	3.6%	4.2%	5.5%
Mast DW	1.8%	2.3%	3.4%

[18] Bonfils Safari. "Modelling wind speed and wind power distributions in Rwanda." Renewable and Sustainable Energy Reviews 15 (2011) 925–935.

[19] Wind Resource Assessment in Rwanda: Report by 3E for Ministry of Infrastructure

4.5 Biomass

Biomass is the largest primary energy source in Rwanda. It is the predominant source of energy for household cooking, and also has important industrial energy uses, for example in tea factories. According to the latest available survey[20], annual consumption is about 4.3Mt dry wood equivalent, whilst the annual amount of new growth of firewood each year is 3.3 Mt dry wood equivalent. The higher consumption level means that standing stocks of wood plantations are being depleted. A number of actions are identified in the Masterplan to address this imbalance through a combination of supply-side increases in production and demand-side improvements in efficiency, which would make biomass a renewable and sustainable resource. It is likely that for the foreseeable future biomass will remain a resource primarily for thermal applications (i.e. household cooking and industrial heat), rather than for the production of electricity.

Headline targets identified in the SE4All Action Agenda for biomass are:

1. To close the gap (currently about 20%) between production and consumption of biomass energy
2. To supply a growing and urbanising population with clean secure supplies of biomass for cooking, 3 main pillars of the sector will need to be addressed:
    a. 100% access to much more efficient cookstoves than currently used
    b. Reduction in losses from charcoal and partially replace charcoal with biomass pellets
    c. Increasing production by improving forestry management
3. To ensure that the efficient cookstoves solutions noted above address health issues by significantly reducing indoor air pollution

If these targets are met, the biomass sector in Rwanda can be put onto a sustainable footing, making it the largest renewable energy sector in the country providing renewable heat to households and several industrial sectors. The sector is complex, and spans across the mandates of multiple government ministries. Concerted action is therefore required by government to prioritise this area.

Whilst considerable investment is needed to achieve some aspects of the biomass sector transformation, other aspects are not investment-heavy, but rather rely on a change to the enabling environment, and an increase in the political prioritization given to the sector.

4.6 Constraints to Off-grid Renewable Energy Development

Until recently, the focus of electricity access in Rwanda was on grid extension. However, with the new energy policy approved in March 2015, the off-grid sector has received much more emphasis, especially with the specific target to reach 22% of the population by 2018.

Small-scale off-grid electricity technologies provide a promising solution for rapid and cost-effective provision of electricity access for households and small businesses (Appendix 3). These small-scale systems are well-suited to being provided by private sector markets. Barriers to entry to the market are relatively low, and competition between different firms to supply households should help to bring down costs, and increase choice.

Private markets are already active in Rwanda. Very small solar equipment such as solar lanterns are already spreading widely, with over 300,000 households (15%) already having access to such equipment. However, electricity access implies more than just solar lanterns. There is some degree of organic growth towards larger solar home systems capable of running multi-room lighting and

[20] Rwanda Supply Master Plan for fuelwood and charcoal: Update and upgrade of WISDOM Rwanda and Woodfuels value chain analysis. Ministry of Natural Resources July 2013

basic appliances, and a number of companies providing such systems. However, so far this growth tends to be amongst the relatively wealthier households.

In order to meet the government's target for off-grid energy access, market transformation is needed to overcome a number of barriers[21] as noted below.

1. Financial constraints

Energy companies developing either mini-grids or providing pay-as-you-go business models for solar home systems face cash-flow risks because the main prospective customers are low-income households. Their overall ability to pay is limited because of their low incomes. Further, their incomes fluctuate, which makes it difficult to make regular monthly payments. This creates particular problems for companies that utilise a pay-as-you-go business model, identified as a promising approach for disseminating RE systems in Rwanda.

Because the market for these systems is still small in Rwanda, there is a lack of experience in the market, and these risks cannot be accurately assessed. This makes it difficult for local financial institutions to finance such investments. While various sources of equity are available, e.g. through impact investors, debt capital can be harder to raise due to the risk of default.

Access to capital therefore remains a barrier in the sector. Companies often face requirements for very high levels of collateral, and there is a lack of experience amongst local financial institutions of undertaking project financing based on future income as the asset base. International commercial capital generally requires some project guarantees or other forms of subordinated debt to reduce the risk of default.

Hence, energy companies often operate either with high levels of equity or use informal financing sources, which is expensive, and lack the ability to leverage these financial resources with cheaper debt. Companies are therefore constrained in their ability to access debt finance at a scale that would enable the required market growth rates.

Consultations with financial institutions have also identified that in some cases energy companies may also lack the necessary experience and technical capacity to submit high quality proposals and applications for finance.

Taxes and import duties for equipment can also be a barrier. These are in principle formulated in the East African Customs Management Act and the Law on VAT Nº 02/2015 of 25/02/2015. An updated list of RE equipment benefitting from VAT exemptions has been published by MINECOFIN on 30/07/2015. However, uncertainties still exist about the interpretation and implementation of these laws by the Rwanda Revenue Authority. E.g. on one occasion a company was able to import certain equipment VAT-free as solar equipment; while at another time it was required to pay VAT as RRA did not recognise the same equipment as solar equipment. And even if VAT and withholding tax on imports can be claimed back, companies have expressed difficulties in carrying out this lengthy process.

[21] This section draws on various reviews of market barriers in the off-grid sector in Rwanda including: 1) Sustainable Energy for All Action Agenda. 2) Market research carried out for the draft Report on Design of SME Renewable Energy Fund for SREP and development of this SREP IP. 3) EnDev note requested by MININFRA on challenges and recommendations for Village Mini-grids in Rwanda. 4) MARGE consulting 'TA for Solar PV Market Development. 4) EWSA Mid-term Review of EARP. 5) Draft Report on Design of SME Renewable Energy Fund for SREP.

Regarding access to finance for mini-grids in particular, most commercial banks are risk averse and consider the loan required for mini-grids < 50 kW as too small and the respective transaction costs too high to make such lending attractive. In contrast, the required loan amount is too big for most micro-finance institutions. The few financial institutions that work in that range do not have sufficient experience to do a sound due diligence for small scale energy projects and thus ask for exceptional high collaterals which are unfeasible for small project developers. Furthermore, banks require the evidence of a viable business case based on demonstrated support by the district/MINFRA, public available EARP planning and sound compensation mechanism in the off-grid.

2. The market is in the early stages of development

Households without electricity access rely on a mixture of kerosene, batteries and candles for their lighting requirements. Replacing these with solar PV means replacing a weekly or monthly expenditure on energy products with an upfront payment for the equipment, which then is very low cost to operate and maintain. This is cost-effective in the long-term, but presents an upfront barrier. Solar PV markets to date have had to focus on products with very low up-front costs to overcome this barrier, sometimes to the detriment of product quality. Alternative business models are required to support better quality and larger systems. Approaches that are proving promising in Rwanda are pay-as-you-go models where households pay a monthly fee, spreading out the capital cost over a number of years. This market model is in the early stages of development. Early signs suggest that it provides a good model for scaling-up the roll-out of stand-alone PV systems, but the market needs further development.

Awareness of such systems amongst households is low. According to recent market survey by MARGE consulting[22], "the lack of public education with respect to the advantages and availability of solar technologies is seen as a huge barrier to the development of the market". In particular there is a need to raise awareness about the difference between low quality and high quality equipment, and the role of product standards. To date, neither companies nor government institutions have had the resources to carry out sufficient marketing activities to underpin the rate of market growth that would be required to deliver the government electricity access target.

For mini-grids, investment is a long-term prospect, with a financial horizon of 5 to 10 years. Therefore companies will plan mini-grids in areas that are not immediately targeted for grid extension and the effective implementation of the compensation mechanism foreseen in the off-grid regulation will decide the success or failure of any private sector oriented mini-grid policy. While most companies are technically capable of constructing and operating a mini-grid, they would like to see a commercially-run, private sector-based mini-grid, demonstrating a commercial business case and successful customer tariff collection in order to better understand the commercial risks involved. Since these examples are currently lacking, investors face high levels of investment risk.

3. Inadequate technical standards

For stand-alone solar PV systems, there is a wide range of technologies available in Rwanda, but not all of it is of high quality. Although there are a number of internationally recognised standards that could be applied, these standards have not been officially adopted or enforced, and public awareness of the need for and benefits of higher-quality equipment are low, leading to a potential 'race-to-the-bottom' in quality terms in order to chase lower upfront prices.

In the case of mini-grids, the standards of previous and existing systems vary considerably from simple cables connecting several houses to grid-equivalent quality. While the Rwanda Grid Code only

[22] "Technical Assistance and Advisory Services for Solar PV Market Development" Final report Jan 2014, Marge Consulting for EWSA.

covers medium voltage distribution, the existing national standards are limited to electrical wiring of premises (RS 565-1: 2011) and to power installations exceeding 1kV (RS 474-1: 2011). EDCL is providing some guidance with their design standards and guidelines for EARP rural electrification, but there is no overall specification in the grid code to regulate standards for low voltage distribution and feed in of electricity into the low voltage grid from prospective mini-grid projects. This creates uncertainty over the technical standards that should be specified for projects, and uncertainty over the potential costs that might arise in the future should mini-grid projects that are initially isolated from the grid eventually become integrated with the main grid if it expands to that area.

4. Capacity constraints

Companies have begun develop networks of technicians to distribute, install and service the systems. Nevertheless, given the rapid scale-up of the market implied by the government targets, these will have to grow rapidly over the next few years, and a number of barriers need to be overcome regarding coordination, dialogue and exchange among all stakeholders in the PV sector including the private sector, consumers, training institutes, quality agencies (RBS) and rural development agencies including NGOs and finance institutions.

There are some training programs (e.g., Tumba College of Technology, KIST), but do not provide the numbers or range of different qualified technicians needed to service this sector. Links between training programs with technical developments in the field in Rwanda need strengthening, and licencing of technicians coming out of these training programs is not in place. For mini-grids in particular, due to the lack of market experience, the regulatory uncertainties, and limited commercial funding opportunities, there is a lack of companies able to present high quality proposals and / or develop bankable business cases.

5. Institutional constraints

The recent Energy Sector Strategy Plan has set out clear headline policy goals for the provision off-grid electricity access. However, the institutional structure of the energy sector has not yet responded to this shift in strategy. Institutional arrangements in the electricity sector have tended to focus on roll-out of the grid, with staffing levels and dedicated teams in place within REG to successfully implement the EARP programs. Off-grid access has received less attention to date within REG and other institutions. Given that off-grid access is planned to be mostly through private sector providers, there is not the need for such a large institutional arrangement as exists for EARP. Nevertheless, there is currently a lack of expertise and capacity within national and local institutions and agencies to inform the strategic decisions needed, and to provide the necessary support and coordination the sector needs between Government, donors and the private sector.

Specific issues include:

- No clear strategy has been communicated to specify which geographic area or socioeconomic strata of the population shall be targeted by off-grid service approaches such as stand-alone system (pico PV, SHS) or mini-grids.
- There is a lack of strategic coordination between different off-grid support programs. The design of some programs can distort competition, leading to investor uncertainty and a lack of long-term framework for market growth.

6. Legal and regulatory constraints

The legal and regulatory arrangements for stand-alone solar home systems in general do not represent a major barrier to market growth. More broadly, the sector needs clear specification of equipment quality consistent with internationally agreed standards. Currently these are lacking, and there is not a mechanism in place to effectively enforce these.

Mini-grids, particularly those based on micro-hydro plant, face a number of specific legal and regulatory barriers, which is creating challenges to the investment process:

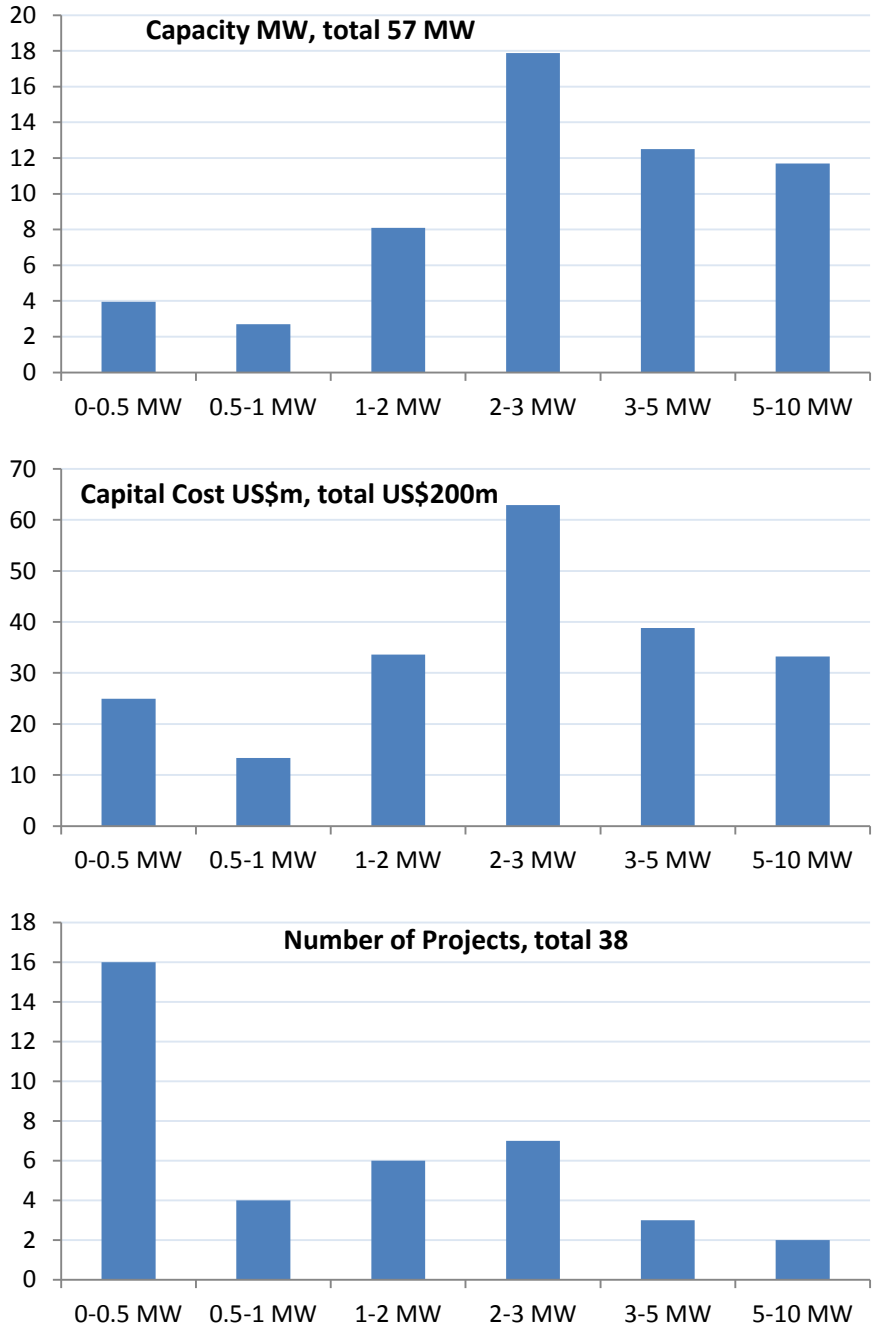
- RURA is developing a simplified licensing framework for rural electrification, but because the process is so new, there remains a lack of clarity about the commercial details regarding user tariffs and arrangements regarding eventual connection to the grid.
- Companies are often unaware of the administrative and legal steps that are required. As required by the Electricity Law of 2011. As part of the approval process, companies are required to get a letter of acceptance from the district to ensure that the companies are informed of existing electrification plans for the area, and that the local authorities approve of the project in their district. However, there are some barriers to issuing these letters, partly because of perceived conflicts with potential grid extension projects in their districts.
- According to the Organic Law on Environment Nº 02/2005 of 25/02/2015 an Environmental Impact Assessment (EIA) is required for any acts concerned with water resources and construction of roads and dams. Detailed proceeding for EIA are stipulated in the ministerial order of 2008 by MINIREMA and in the REMA EIA guidelines of 2006. Currently, EIA are implemented by RDB and companies need to clarify with RDB on a case by case basis to what extend an EIA is required for their projects. Until such a clarification can be reached, the costs for the EIA cannot be estimated in advance.
- Most pico-hydro developers are as yet unaware that the National Policy for Water Resource Management (2011, p. 126) provides MINIRENA with the possibility to levy water usage fees.

4.7 Renewable Energy Initiatives

4.7.1 Current Initiatives Involving Private Sector

Development of domestic power generation resources in Rwanda is dominated by IPPs. In the case of hydropower, there is an active project pipeline being developed by private generators as shown in Figure 10.

Figure 10: Private sector small-hydro project pipeline (<10MW) (Source: REG finance unit)



These projects are at various stages of development through the project pipeline, ranging from pre-feasibility studies, through PPA negotiation to financial close. The tariff component of PPA negotiations was based on a renewable energy feed-in tariff REFiT which varied with project size. The REFiT has expired and is no longer used for PPA negotiations. RURA is in the process of

reviewing the REFiT tariff for hydro power based on a review of project costs in Rwanda. New rates have not yet been published.

Energy for Development (EnDev) is also supporting micro-hydro projects as the power source for about 35 village mini-grids, at around 5-50kW each. They are providing €1.89m towards these systems, with the aim of connecting 3,750 households.

In terms of on-grid solar, there is currently one utility-scale solar PV plant installed in Rwanda, operating since 2014, which at 8.5MW is East Africa's largest solar plant. Plans for a second project, at 10 MW are under negotiation.

Regarding off-grid solar, there have been several recent activities in promoting solar solutions in Rwanda as summarised in Table 5 (data compiled by GIZ Rwanda). The table shows the scale and source of funding for each program.

Table 5: Summary of recent and existing solar home system programs (Source: GIZ)

Project name	Funding amount €m	Funded by	Estimated Target of project
Energy Small and Medium Enterprises Project (ESME)	3.1	Russian Federation through World Bank	46,773 solar lamps, eq. of 10,000 households
Mobisol	6.0	EU grant	49,000 households
Azuri / GVEP	0.9	USAID	10,000 Azuri Indigo solar systems, eq. of 8,000 households
Ignite Power		Liquidnet and the Agahozo-Shalom Youth Village	Pilot project: 1,000 solar home systems eq. to 1,000 households.
SNV IRES		Netherlands	20,000 households
Energising Development (Solar lighting)	3.4	Energising Development (Germany, Netherlands, Norway, Australia, UK, Switzerland)	328,000 solar lamps, eq. of 176,000 households
Energy and Environment Partnership		Finland, Austria, UK	1,840 households

It can be seen that together, the projects listed in the table reach over 300,000 households, although many of these are based on pico-solar products such as lanterns. The funds indicated in the table do not include the private sector contributions or other co-financing. For example, the €6m grant from the EU to Mobisol is helping to fund a program with an overall budget of €22m. The GVEP support program which ran to 2014 for small energy businesses managed by Rwanda Energy Group (REG)[23]. REG in cooperation with EnDev is now implementing a results-based financing (RBF) program for 'Lighting Africa' certified solar lighting systems and mini-grids – which combined expect a private sector leverage of 16.5 million EUR. The program provides financial incentives to Rwandese companies to sell these products in rural areas. Under the mini grid component, companies receive a top-up for every customer successfully connected to a privately run grid powered by renewable energy. The program is implemented by a Rwandese bank.

[23] http://www.gvepinternational.org/en/business/programmes

Looking ahead, BTC is planning a EUR 6 million program to support investment in renewable energy, also likely to be focussed on supporting markets for private sector off-grid systems. An agreement has been reached with the Development Bank of Rwanda (BRD) to act as the host for this fund, and details are being developed as to the type of projects to be supported. These activities will be coordinated and integrated within the SREP programming to help gear up the activities to be supported under the REF.

As noted in Section 4.2.2.2, the private sector is also preparing to substantially scale-up their investments in the country. Discussions with investment groups have identified companies with investment plans in Rwanda exceeding US$100m, and considerable sources of private-sector equity finance willing to back these plans.

In the mini-grid sector, a number of initiatives are underway:

- A GIZ program has been initiated to develop around 35 micro-hydro based village-scale mini-grids. Projects have not yet been selected, but the program provides a good platform for SREP to build on in terms of project pipeline and co-financing.
- Mesh Power Ltd. has developed 15 solar-powered mini-grids serving around 300 customers, and has secured financing for a further 70 grids to reach 2000 households by mid-2016. Following this proof of concept stage, the company expects to substantially scale up activities requiring bulk purchasing and substantial working capital needs.
- There are also a number of existing off-grid hydro projects which are in need of rehabilitation and upgrading. The Government of Rwanda has issued an international tender to carry out this work on 5 hydropower projects, amounting to a total of 3.4 MW, with a total investment of USD 6m. Public investment in these projects is expected to be around US$ 4.2m, with the remainder coming from private investors. Total output from these plant once rehabilitated are estimated at 13,000 MWh, and projects are expected to be operational by year end 2016.
- A Colorado State University project is building datasets and human resources within Rwanda through technician training programs etc. Their projections are that by year 3 of the program there would be enough teams to develop 180 village mini-grids, and by year 5 there would be enough teams in place to build over 500 village mini-grids.
- Several private developers of micro-hydro projects in Rwanda have also expressed interest in expanding their projects to include provision of local distribution systems to neighbouring villages.

4.7.2 Related National and International Initiatives

A number of important national and regional institutions and initiatives are already in place or being started which need to be taken into account when designing the REF. These initiatives in many cases have similar or compatible objectives with SREP, and it will be important to maximise leverage, cooperation and synergies:

- National Climate and Environment Fund (FONERWA). The purpose of the fund is to ensure financing is accessible to support environmental sustainability, resilience to climate change and green growth. FONERWA is the vehicle in Rwanda through which environment and climate change finance is channelled. FONERWA is currently reviewing how it can better tailor its activities to target private sector activities, further details in Appendix 5.
- Climate Finance. The Rwanda Environmental Management Authority (REMA) is developing funding proposals under the NAMA climate financing route, with energy as one of the potential areas of focus. The Green Climate Fund (GCF) could also provide a source of funding for future extensions of the REF to fund Phase 2 activities. The Ministry of Natural Resources has recently been accredited as an institution able to apply for GCF funding.

- Africa Renewable Energy Fund (AREF), a US$200m fund initially co-sponsored and capitalised by the African Development Bank (US$25m) and its Sustainable Energy for Africa fund (US$25.5m) and GEF (US$4.5m). Fund manager is Berkeley Energy, private equity investor and project developer. There is a possibility for AREF to co-finance projects with SREP.
- Rwanda SME fund. The Business Partners International Rwanda SME Fund is a local Rwandan Investment Fund providing integrated investment and added-value solutions for small and medium entrepreneurs.
- Rwandan Energy Development Fund (REDF). The ESSP calls for the setting up of a REDF to support development of the energy sector, particularly to support private sector participation. The proposed REF would be compatible with this wider REDF, acting as a specific funding window aimed at renewable energy sources.
- Belgian fund to support private sector participation in the generation of electricity from renewable sources (PSPE), a €6m fund to be administered jointly between the Belgian Technical Corporation (BTC) and the Development Bank of Rwanda (BRD). There are strong synergies with SREP and possibilities for co-financing.
- Universal Access Fund. This is not yet implemented, but is allowed for in the context of the Electricity Law, and proposals are being developed under the Rural Electrification Strategy being developed by consultants for the EU in consultation with MININFRA.
- Power Africa is planning to expand activities into Rwanda. Their activities typically include technical assistance and transactional support through regional and country focused Transaction Advisors who assist in removing obstacles and moving power sector energy investments to financial close.
- GETFiT. Building on the success of the Ugandan GETFiT program, KfW is proposing a roll-out of similar activities in 10 African countries, potentially including Rwanda. This provides top-up funding to help bridge the gap between project costs and official feed-in tariff rates, an approach that is consistent with the viability-gap financing proposed in this IP.

It can be seen from this list that there are several institutions with similar aims, creating strong opportunities for collaboration between different funds. The Government's coordination of donor activities in the energy sector is managed by MININFRA through the Energy Sector Working Group, supported by the Energy Sector-Wide Approach (eSWAP) secretariat hosted at the Ministry. The strategic framework guiding this coordination is the ESSP, together with the SE4All Action Agenda.

The REF approach should help the Government to strengthen its coordination of these various activities by allowing it to implement one of its key strategic aims set out in the ESSP, namely to set up a fund-based approach to supporting energy sector investments. The REF can thereby become the strategic focus for future donor activities in the sector, creating a streamlined funding landscape for companies, and potential focal point for raising funds from other international sources such as Green Climate Fund.

5 Screening and Prioritisation of Renewable Investment Options to be Supported under SREP

Rwanda's ESSP sets out the following high-level targets for the sector by 2018:

- Increase the electric power system equivalent installed capacity (domestic generation + imports) to 563 MW
- Increase household access to grid electricity to 48% and access to off-grid electricity to 22%
- Achieve savings from energy efficiency measures of 10% through demand-side management measures and grid-loss reductions (from a 2013 baseline)
- Reduce carbon intensity of the grid by 10% by 2018, and 25% by 2025 (from a 2013 baseline)
- Ensure 80% of all households employ clean cooking energy technologies
- Realise all EAC Regional Integration Policy priorities for the energy sector
- Ensure the necessary infrastructure is in place to meet current petroleum strategic reserve requirements

The draft SE4All Action Agenda also helps set strategic direction for the energy sector over a longer time frame to 2030. The Government is also in the process of developing its rural electrification strategy. Together with the selection criteria for SREP, these strategy documents set the context for choosing the long-list of potential project types (described in Section 5.1) that were then screened and short-listed for funding under the first phase of the Rwanda IP (screening process and outcomes described in Sections 5.2 and 5.3).

5.1 Potential Type of Projects

The following list of potential types of projects have been identified based on the analysis of energy sector needs taking account of the SREP eligibility criteria, the Government's priorities for the energy sector, and the results of stakeholder consultation.

5.1.1 Mini-grids

Support for mini-grids under SREP would address the barriers that mini-grid developments in Rwanda have previously met by facilitating access to finance, as well as providing risk capital in early stages of projects to address risks associated with low levels of power demand from rural households and the commercial risks of relying on households as the contractual counterparty to underpin the investment.

Projects could range from pico-grid solar PV systems serving clusters of 10-20 houses through to larger village mini-grids based on either solar PV or micro-hydro, each serving communities of 150-200 or more households, as well as providing electricity for productive uses such as telecoms towers, milk collection points, mining operations, and agricultural processing. The financing needs will depend on the specifics of the projects and the companies concerned, so there will need to be flexibility in the financing mechanisms. However, typically, projects are likely to be supported through a combination of debt finance to address access to finance barriers, with the possibility of risk financing (e.g. guarantees) and a grant component to address affordability issues, particularly regarding connection fees for distribution systems.

These projects will help to demonstrate the local benefits of mini-grid development in areas which are remote from the current grid roll-out plans, and provide an opportunity to help meet the government's access targets for more geographically dispersed communities.

5.1.2 Stand-alone Solar PV Systems

The SREP support would focus on growing the market for stand-alone solar PV systems for households, while exploring market opportunities for the provision of electricity to social infrastructure institutions (e.g., health clinics, schools). For solar PV systems servicing *households*, the SREP would support consumer choice for a range of products, sizes and specifications, but focussing on multi-room lighting and appliance systems, with less emphasis on solar lanterns which are adequately covered by existing initiatives. Minimum power levels for these systems would be decided, but likely to be at least 10-15W and above. Emphasis would be on supporting growth of private sector initiatives that can provide energy solutions on a sustainable long-term basis. This would include primarily provision of debt finance to overcome barriers to access to capital at the scale required, together with some grant financing for companies supplying larger systems to address affordability barriers, and actions to support market building and develop business eco-systems and supply chains necessary for market growth. A variety of financial products would be used, including results-based finance (RBF) to supplement income from households, provision of working capital through credit lines, and payment guarantees to help companies raise debt & equity for scaling-up investment in the sector. For solar PV systems servicing *social infrastructure institutions*, the SREP could support different business models for private-sector energy service provision, ultimately leading to the development of the solar PV market in this segment. Business models would be based on on-going energy services or maintenance contracts to ensure technical and financial sustainability. Electricity services may be partially paid through local government budgets to health clinics, and supported by SREP and other sources of social investment to address affordability barriers.

5.1.3 On-grid Renewable Generation

There is a pipeline of approximately 70 MW of renewable energy projects comprising micro-hydro and utility-scale solar PV at various stages of project development, some of which are close to readiness to proceed. However, for many projects there remains a viability gap between the project costs and the tariff that can be agreed with the utility, given the focus of government on lowering electricity costs to consumers. SREP grant support could be used to help close the viability gap between project costs and agreed tariff levels will help to unlock projects in the pipeline, and will help attract more developers to the country to continue developing Rwanda's renewable resources.

5.1.4 Hydropower with Storage

Supporting the development of renewable energy peaking plant will contribute to improving the sustainability of Rwanda's energy system by reducing dependence on diesel and HFO for peaking. These fossil fuels have been identified in the SE4All Action Agenda as a significant contribution to the sector's CO2 and sulphur emissions, as well as being expensive and leading to security of supply concerns regarding dependence on oil imports. Developing a domestic energy solution would therefore provide advantages from a cost and security point of view. This kind of flexible generation would also help with the ability of the electricity system to absorb greater levels of generation from solar PV, further helping to increase renewable energy levels in the country. Whilst the technology itself is not new, such an arrangement whereby IPPs develop peaking plant would be a first-of-a-kind arrangement in the Rwandan context. SREP would be used to provide financing (a combination of grants and loans) to support early projects helping to pave the way for further provision of such projects in the future. Other technology options for grid-scale electricity storage could also be considered as part of the program area.

5.2 National and SREP Prioritization Criteria

Each of the potential types of projects was evaluated and prioritized against national and SREP criteria. The criteria developed to rank the potential projects blend the Government of Rwanda's key energy sector priorities and SREP investment criteria. The proposed criteria were the following:

1. **Increased installed capacity from renewable energy sources**. A key criteria of the SREP fund is to increase installed generation capacity compared to a business-as-usual baseline.
2. **Increased access to energy through renewable energy sources**. Increased access is one of the major pillars of Rwanda's energy policy, supporting economic development by increasing electricity access to households.
3. **Replication potential.** Projects need to demonstrate the potential to catalyse additional investment in the markets concerned, above and beyond the direct investments made under the SREP program.
4. **Strategic relevance.** Extent to which projects help the Government of Rwanda achieve energy sector goals and priorities as set out in ESSP
5. **Affordability and cost-effectiveness of renewable sources.** An essential goal of government policy is to drive down the end-user cost of electricity to address affordability issues, and projects should contribute to a reduction in cost of providing energy access.
6. **Productive use of energy and economic co-benefits.** Providing energy access for small businesses, industry and other productive uses is an essential way to maximise the economic benefits of energy-sector investments and by stimulating economic growth address the affordability issues related to energy sector investments.
7. **Leveraging of additional resources and private-sector engagement.** SREP funds will need to be geared with other sources of co-financing in order to reach the levels of investment required to substantially impact the renewable energy sector in Rwanda.
8. **Gender impacts and other social and environmental development co-benefits.** Impacts on women's equality is an essential development criteria, and projects should contribute positively to these indicators as well as providing other social and environmental co-benefits.
9. **Project readiness.** All else equal, projects that are close to being ready for investment will tend to take priority since it is important to create momentum in the sector. Demonstrating that Phase 1 SREP funds can be spent on successful projects that meet the above criteria will help attract more funds to Rwanda's renewable energy sector.

5.3 Prioritisation of Programs for SREP Funding

The following table identifies a scoring for each potential project area against each of the selection criteria. Potential types of projects were scored either 'High', 'Medium' or 'Low', depending on their relative contribution to each criteria, as shown in Table 6.

Table 6 Prioritisation matrix of candidate programs

Criteria	A. Mini-grids	B. Stand-alone solar PV systems	C. On-grid renewable generation	D. Hydro-power with storage
1. Increase access	**High.** Investment likely divided between household access and productive uses, but access is a principle focus.	**High.** Investment primarily focussed on electricity access, especially in priority rural areas.	**Med.** Access rates determined by grid roll-out, but renewables can make access more affordable.	**Low.** Access determined by grid-roll out, not by specific sources of generation.
2. Increase installed capacity	**Med.** Mini-grids would contribute installed capacity especially for productive use.	**Med.** SHS tend to be relatively small, so contribute less to overall installed capacity.	**High**. On-grid utility-scale hydro is one of the least-cost ways to add installed capacity to the system	**High.** Grid-scale storage would increase renewable energy capacity replacing fossil fuels.
3. Replication potential	**Med.** Projects would demonstrate mechanisms for incentivising sustainable private-sector provision, with potential for scale-up.	**High.** Current market penetration is low, but market potential is high and projects would demonstrate commercial value.	**Med.** SREP investments demonstrate viability of private-sector engagement, and draw in additional investment.	**Med.** Projects would demonstrate potential to provide cost-effective replacement for diesel / HFO peaking plant.
4. Strategic relevance	**High.** Mini-grids contribute to the GoR's off-grid access targets for households, productive uses, schools & clinics.	**High.** Stand-alone solar PV contributes directly to the GoR's off-grid access targets for households, schools & clinics, productive uses.	**Med.** On-grid power contributes to GoR target for generation, though there isn't a specific target for renewables.	**High.** Balancing the grid to achieve a cost-effective provision of reliable peak power is an important GoR priority.
5. Affordability & cost-effectiveness	**Med.** Mini-grids to be located in areas where they are financially attractive compared to standard grid roll-out options.	**Med.** Stand-alone systems to be prioritised in areas where they are financially attractive.	**Med.** Renewable energy projects competitive with other available energy sources.	**Med.** Hydro projects competitive with diesel alternatives, although require higher capital outlay.
6. Productive uses	**High.** Productive use to be a key focus for mini-grid investments.	**Low.** Focus of investment is household access.	**High.** Large productive users likely to be connected to grid.	**High.** Projects will contribute to grid stability, improving reliability of supply.
7. Leveraging and private sector engagement	**High.** Projects driven by private developers bringing own sources of capital.	**High.** Projects driven by private developers bringing own sources of capital.	**High.** Projects driven by private developers bringing own sources of capital.	**High.** Projects driven by private developers bringing own sources of capital.
8. Gender and social / environmental co-benefits	**Med.** Projects directly related to providing energy access which will have important gender and other social benefits.	**High.** Projects directly focus on improving access, with gender and social co-benefits arising from improved security & safety as well as educational benefits.	**Low.** Gender and social impacts mostly driven by grid roll-out, not the source of generation. Renewable sources will have positive environmental co-benefits.	**Low.** Gender and social impacts mostly driven by grid roll-out, not the source of generation. Renewable sources will have positive environmental co-benefits.
9. Project readiness	**Med.** Projects can be identified, but require further development to bring to readiness.	**High.** Firms in place that can deliver market scale-up.	**High.** Project pipeline relatively mature and ready to implement once support mechanisms are in place.	**Med.** Projects can be identified, but require further development to bring to readiness.

Overall scores can be assessed by assigning a score of 3 to 'high', 2 to 'medium' and 1 to 'low' ratings. The overall scores are as follows:

Mini-grids:	22
Stand-alone solar PV systems:	23
On-grid renewable generation:	21
Hydro-power with storage:	20

Although the scores across the four areas are close, with all projects scoring well, two priority areas emerged from this prioritization exercise and will be considered for SREP support under Phase 1. These two areas are: (i) mini-grids, and (ii) stand-alone solar systems. Apart from scoring slightly higher, and being aligned closely with current Government priorities related to off-grid electricity access, a key reason to narrow down the scope of the REF at this stage is to provide some strategic focus to the fund, to allow it to make a material difference in a particular energy sub-sector, rather than spreading the fund too widely.

The remaining two types of projects (i.e., on-grid renewables, hydro with storage) also received high scores and would be considered for financing by the REF under Phase 2 subject to the availability of additional funding from SREP, Green Climate Fund (GCF), or other climate finance sources.

6 Program Description

6.1 National Objectives

The Government of Rwanda (GoR) is committed to provide off-grid electricity access to 22% of the population, or about 550,000 households, by 2018, recognising the cost-effectiveness of off-grid solutions, especially in rural areas. The design of this SREP IP responds to the need for transforming the country's electricity sector, in particular the off-grid sub-sector, from one that depends on donor funding in support of sporadic initiatives to one that provides adequate enabling conditions and leverages significant private investments in off-grid electrification. The implementation of the SREP IP for Rwanda will help to initiate a profound transformation of the off-grid electricity markets in Rwanda, providing electricity in the near-term to around 300,000 Rwandan households, and paving the way for larger impacts over the longer-term as markets become established.

6.2 Program Objectives

The objective of the Rwanda IP is to develop financially sustainable long-term markets for the private-sector provision of off-grid electricity services. The program aims to catalyse private investments in off-grid electricity provision, particularly on mini-grids and stand-alone solar systems. SREP funds will also help improve enabling environment conditions to unlock and systematically scale-up private investments in off-grid electrification.

6.3 Renewable Energy Fund (REF)

The focus of the Rwanda IP is to help enhance the enabling environment and overcome the barriers and constraints identified above. The primary instrument for the SREP program will be a Renewable Energy Fund (REF), which will be created by the Government. The REF is part of the wider Government strategy to support off-grid energy sector investments by the private sector. While the REF will have a broad mandate, the SREP funds will support only off-grid renewable energy electrification.

The creation of the REF in Rwanda is consistent with ongoing regional practice. The REF is similar to Uganda's Rural Electrification Agency (created in 2001, with initial and ongoing support from the World Bank) and Tanzania's Rural Energy Agency (created in 2007, with initial and ongoing support from the World Bank) in the sense that all of these agencies aim to promote, *inter alia*, private sector led off-grid renewable energy development by creating an enabling environment (Box 1). In keeping with this regional practice, the REF will have responsibilities for supporting investments and administering technical assistance.

The REF will be hosted by an existing financial institution within Rwanda, avoiding the need to create new institutions, and helping to build institutional capacity and local experience of lending into the energy sector. The concept of the REF is also closely aligned with the wider government strategy for mechanisms to support energy sector investments by the private sector[24]. The REF will become a coordinating mechanism that brings together government and donor support to help streamline the growth of off-grid electrification markets. The REF will be capitalized with capital and grant contributions from SREP, development banks, donors, and government. Proceeds from loan or other instruments can be re-invested making the REF a revolving fund. The REF could also attract

[24] The ESSP proposes to set up a Rwandan Energy Development Fund. The REF would focus on renewable energy aspects, and is the initial capitalisation and starting point for the fund proposed in the ESSP.

additional funding from other sources in the future, contributing to the transformation of the market well beyond the initial 5-year investment period envisioned under the SREP-funded program.

Box 1. Regional Practice - Uganda and Tanzania Off-grid Activities

Uganda and Tanzania are both promoting and facilitating independent mini-grids and stand-alone solar PV systems. In Uganda, the World Bank is supporting these activities via the Energy for Rural Transformation project; similarly, in Tanzania, the World Bank is supporting these activities via the Tanzania Energy Development and Access Project.

In both countries, this includes a focus on mini-hydro mini-grids. Uganda is undertaking a program of installing solar PV systems in remote health clinics and schools. In Tanzania, government has launched a One Million Solar Homes initiative, aimed at providing a million Tanzanian homes with access to reliable solar electricity by the end of 2017.

In Uganda, the focal point of rural electrification and renewable energy is the Rural Electrification Agency (REA), which created in 2001. The REA is responsible for grid extension, independent grids, photovoltaic systems (solar electrification), and renewable energy generation projects.

In Tanzania, the focal point for rural electrification and renewable energy is the Rural Energy Agency, which was created in 2007. The REA, *inter alia,* aims to: (i) promote modern energy access for productive uses in rural areas; (ii) promote rational and efficient production and use of energy, and facilitate identification and development of improved energy projects and activities in rural areas; (iii) finance eligible rural energy projects; and (iv) build capacity and provide technical assistance to project developers and rural communities.

Source: World Bank documents; websites of concerned agencies.

Windows for barrier removal. The REF will help overcome different types of financial constraints affecting the growth of the off-grid electrification market in Rwanda. Based on preliminary consultations with energy sector stakeholders undertaken during the preparation of the Rwanda SREP IP, it is envisaged that the REF will have two windows for barrier removal:

- **Investment support**. This would include (i) pre-investment support, such as seed capital / catalytic fund facility, and (ii) investment support including loans and grants some of which would consist of result-based finance (RBF).
- **Technical Assistance.** This would include (i) market development facility: technical assistance to cover market assessment, development and sensitisation activities linked to specific investment programs; and (ii) Transaction development facility: technical assistance to cover pre-implementation business set-up costs including resource mapping, feasibility studies, transaction skills, training etc.

Financing instruments. Further work is currently underway to establish the instruments to be used across these facilities to address the various project development barriers identified in the renewable energy off-grid sector. The range of instruments will consider include:

a) Direct provision of debt and equity to energy companies to finance expansion;
b) Facilitate third-party debt finance via (i) credit lines to local Financial Institutions, and (ii) Credit enhancement facilities – e.g. first loss risk guarantees: to cover customer default risks and other forms of risk or mezzanine financing;
c) Grants and results-based finance to cover viability gap financing and improving affordability of off-grid renewable access;
d) Consumer finance via micro-finance institutions, or indirect via energy companies.

Institutional arrangements. It is expected that the REF will be managed and hosted under existing financing arrangements in order to avoid the need to establish new institutions. A final decision on

institutional structure will be made at a later date as the details of the fund are finalised. One example scenario is that the Development Bank of Rwanda (BRD) could take the lead on loan disbursements, with the Business Development Fund (BDF) taking a downstream role in business development and coordinating relations with SACCOs and microfinance, and FONERWA taking an upstream role in fund mobilisation. Further discussions of possible institutional arrangements are provided in Appendix 5.

Possible areas of engagement. The prioritization exercise described in Section 5 has revealed that initially the REF may focus on two sub-programs, namely the mini-grids and stand-alone solar PV sub-programs. In the future, the scope of the REF could expand according to future strategic needs. The REF will also provide technical assistance to improve the enabling environment for private investment in off-grid electricity markets.

Box 2. Complementary off-grid Approaches

Stand-alone PV systems and mini-grids are the two main routes being addressed in the off-grid electricity sector in Rwanda under the SREP program. These two options bring different attributes and advantages to rural energy access.

Stand-alone solar PV systems have the advantage being available in small modular units, improving affordability of initial capital outlay. Systems include over-the-counter (OTC) products like solar lamps and solar systems with minimal infrastructure and relatively low levels of technical skills required for buyers and sellers, through to larger solar home systems that require moderate technical support. Stand-alone PV systems are particularly cost-effective for low-power usage applications.

Mini-grids by contrast require more investment in fixed infrastructure, and are more complex and require professional input for initial construction and ongoing maintenance. The advantages of mini-grids is that they can provide higher levels of power to support productive uses (e.g. commercial, light industrial, agricultural processing etc.) that can support rural economic development, and can be more cost-effective at higher levels of consumption. Mini-grids can also be designed to be compatible with the mains electricity grid, so in the longer-term they can be integrated into grid expansion plans.

Further analysis is provided in Appendix 3.

6.3.1 Mini-grids sub-Program

Objective. The objective of the mini-grids sub-program is to build markets and private sector capabilities to develop financially sustainable and scalable mini-grids systems to contribute towards the overall objectives for the off-grid electricity sector.

Rationale for SREP financing. SREP support will help demonstrate that renewable energy for off-grid electrification using mini-grids is indeed an economically viable and scalable option. The program will help demonstrate the commercial and technical viability of mini-grid business models in order to trigger further growth in this market segment. Compared to grid extension, mini-grids can provide a cost-effective and scalable option to increase off-grid electrification in Rwanda. Since the mini-grids would focus to serve local communities (e.g., a single village-level scheme), the distribution system would be localised, minimising the need for costly long-distance transmission systems and substations for transforming high to low voltages. Initial estimates reveal that fixed connection fees at the village scale could be reduced to around US$400 per household or less, compared to US$800-1,000 or more per household for grid extension. Mini-grids can provide off-grid electricity for productive uses, supporting socio-economic development, diversification of the economy, and employment generation. Potential customers may include telecommunications towers, mining activities, milk collection centres, agricultural processing plant, and small businesses.

Approach. The mini-grids sub-program will help develop the enabling conditions and provide financing to unlock the scaling-up of privately-led mini-grid projects. The program will build on lessons learned from a number of initiatives on mini-grid development that are currently underway in Rwanda to catalyse private investments in mini-grids. The program will consider various business delivery models based on the specifics of each individual sub-project. The private sector will be expected to take the lead, typically owning the generation and distribution systems, although hybrid ownership models could also be considered with public ownership of the distribution system and private ownership of the generation plant under a PPA arrangement. The program will be technology neutral, allowing support for multiple technologies for electricity generation, as long as SREP funds are only used for renewable energy sources. Hybrid systems including diesel back-up could also be supported, noting that the diesel component must be financed from sources other than SREP. The program will target areas which are not covered by grid expansion plans and/or are located furthest away from the grid.

It is expected that in addition to financing support for mini-grids, the sub-program will benefit from the technical assistance elements of the SREP program, notably; (i) technical assistance for project preparation; (ii) technical assistance to improve legal and regulatory framework, and increasing institutional capacity for mini-grids development; and (iii) technical assistance for the promotion of productive uses.

Expected impact. The mini-grid sub-program will benefit directly households and businesses in rural areas, establishing the enabling conditions and catalysing the financing required to deploy 100-200 mini-grid systems depending on their size (total 9.5MW of renewable energy capacity) estimated to provide electricity access to approximately 250 villages (38,000 households, at least 250 businesses). This sub-program will also contribute to all of the SREP program's key results and outcomes, supporting low-carbon development pathways, reducing energy poverty, increasing access to renewable energy and modern energy services, stimulating private sector participation, attracting new and additional financial resources, and reducing environmental impact of energy consumption and generation.

6.3.2 Stand-alone Solar PV Systems sub-Program

Objective. The objective of the stand-alone solar PV systems sub-program is to build markets and private sector capabilities to develop stand-alone solar PV systems as a significant contribution towards the overall objectives for the off-grid electricity sector.

Rationale for SREP financing. While there are initiatives in Rwanda promoting low-powered solar PV systems (e.g., lanterns), the approach for off-grid electrification using stand-alone solar PV systems has not been systematic and the proposed solar products proved to be unreliable and incapable of providing adequate levels of electricity access. The stand-alone solar PV sub-program will focus on initiating and catalysing the market for quality-certified and higher-powered systems capable of providing reliable and increased level of electricity access to multi-room lighting, mobile phone charging, and other low-power appliances such as radios and TVs. The program will substantially shift market perceptions and demonstrate the technical and commercial viability of stand-alone solar PV systems, establishing the businesses able to deliver these solutions at scale, whilst leaving substantial remaining market potential for subsequent growth. SREP support aims to provide the catalyst for replication of the technology and long-term sustainability of the associated business models.

Approach. SREP support through REF will lead to a shift in market perceptions of stand-alone solar PV systems that will ultimately stimulate greater market demand and could establish stand-alone systems as a viable and even desirable long-term solution for households and social infrastructure institutions which are not expected to be covered by centralised electricity grid in the foreseeable

future. The program will help demonstrate the viability from both a commercial perspective and from a consumer satisfaction perspective, in order to lay the foundations for substantial further growth in the sector.

REF will support companies to develop business models that help consumers address affordability issues associated with these solar home systems, noting that a range of products will be needed in the market in order to cater for different consumer's ability and willingness to pay, and the program will support diversity without distorting these choices while ensuring compliance with minimum internationally-agreed quality standards. An example is the provision of rent-to-own or pay-as-you-go (PAYG) contracts in which households pay a monthly fee to solar system providers instead of an upfront lump-sum. This helps improve the sustainability of the project because suppliers are responsible for maintaining equipment reliability for the duration of the PAYG contract, and gives the supplier an incentive to use high quality products. SREP will investigate alternative methods for payment and application procedures for gaining new electricity connection (e.g. cash/in-kind, remote payment for relatives living in the cities, mobile banking and women's funds/group lending) which could increase the connection rates/technology adoption rates of illiterate women/female headed household/customers.

The REF will provide a combination of direct loans, first-loss guarantees to gear commercial finance, grant funding to address affordability barriers and technical assistance to improve business capacity and market-building. The balance between these mechanisms will be tailored to individual business needs as they apply to the REF, and is therefore flexible at this stage.

This support would be provided through a number of different mechanisms, including:

- Direct debt to companies and /or credit lines via local financial intermediaries to fund companies' working capital. Some companies may face barriers in raising sufficient capital to finance the working capital needs of procuring units to sell into this market, given that they would be paid back over a longer period of time.
- Results-based finance grants to companies. These will take the form of top-up payments above the amount received from consumers in monthly payments. These payments will allow companies to reduce the amount charged to consumers, allowing access to these systems for poorer households. These payments will also be financially secure, improving the credit-worthiness of the businesses providing the SHS.
- Risk guarantees. The risks associated with monthly payments from households in these markets are not well known, making it difficult to borrow money from either international or national financial markets. Risk guarantees providing some share of first-loss associated with payment defaults could be provided to off-set these risks and help companies to raise capital to finance their investments.
- Support for consumer finance. Support will be provided for business models that partner with providers of consumer finance (e.g., micro-finance institutions or SACCOs). This support will be via a credit line directed through a bank or other financial institution which already has working relationships with these micro-credit organisations. Interventions could also include e.g. support to distribution chain through pico-PV solar solutions microcredit/finance with opportunities for women and men.
- Technical assistance for market-building activities. Starting from a relatively low base, the rapid scaling up of this market will require substantial input to build the necessary business ecosystem and supply chains, as well as to build market demand through customer awareness campaigns.

Expected impact. The stand-alone solar PV sub-program aims to bring electricity access to the population and social infrastructure institutions which are expected to be unserved either by the central grid, or by mini-grids by 2020. The program will provide access to electricity to 250,000 households and 175 social infrastructure institutions (e.g., schools, health clinics).

6.4 Technical assistance / Enabling Environment

In addition to addressing financial barriers in the renewable energy market through the REF, the Rwanda IP will cover technical assistance and enabling environment activities to address some of the key non-financial barriers discussed in Section 4.6. Examples of activities under the TA element of the program include:

Market development. TA is needed to increase demand for off-grid solutions, and particularly to raise awareness of the need for and availability of high quality solar products. This will include public awareness campaigns. Market development activities will also develop business eco-systems and supply-chains to enable growth in supply of off-grid businesses. This will include developing national off-grid databases and other market intelligence tools to show which suppliers and customers are active / have been connected in different areas, to share best-practices, and to help identify supply chain gaps and other aspects of the market that need support.

Targeted project pipeline development is also expected to assist developers with the preparation of mini-grid investments especially, since this is a relatively new area in Rwanda. This may include conducting an assessment of different business models that may work in Rwanda, understanding of the viability gap for these models, financing instruments requirement, standard legal agreements (important if the mini-grid were to service anchor customers), and improving clarity on grid codes and commercial arrangements for potential interconnection with the main grid. Project feasibility studies could also be supported, for example in the area of social infrastructure projects, as well as sector-wide analysis such as solar resource mapping.

Promotion of business use of electricity in rural areas. Activities will be supported to promote productive job-creating uses of electricity in rural areas (e.g. commercial, light-industrial and agricultural processing). This will include training and awareness campaigns in targeted areas, as well as assistance with negotiations of arrangements between potential businesses and electricity project developers.

Increasing technical capacity. TA will assist GoR institutions in the adoption and enforcement of technical standards for off-grid electricity equipment. International standards such as Lighting Africa can be used as the basis. These are still being developed for the types of SHS to be supported under the REF, and this TA element will work with institutions including the Rwandan Bureau of Standards (RBS) on how to adopt and integrate these standards into the existing legislative framework, and how to enforce these standards in the market. TA will also help define technical standards for mini-grids.

TA will also be provided to help assess the adequacy of local and regional training provision, and to expand training capacity to increase the number and quality of qualified technicians.

Increasing institutional and regulatory capacity. TA will be provided to GoR institutions to help build their capacity to provide a coherent strategy for the off-grid sector, e.g. the specification of geographic areas or socioeconomic strata of the population to be targeted by off-grid services and to improve coordination between different off-grid support programs and donor activities.

Institutional arrangements for M&E in the off-grid electricity sub-sector will be supported including establishing a reliable baseline data for the sub-sector and support the GoR to establish an on-going monitoring system from which all programs in the off-grid sector can be evaluated.

Support will also be provided for implementation of the regulatory framework for off-grid, especially mini-grids where a regulation is in place setting out a simplified licencing framework, but for which tariffs and other commercial arrangements have not been negotiated leaving some uncertainties and risks remaining in the sub-sector.

6.5 Expected Impact

It is expected that SREP-funded REF will provide access to electricity to over 300,000 households and at least 425 businesses and community services, including social infrastructure institutions such as schools and health clinics, through mini-grids and stand-alone solar PV systems. For further details, refer to Section 10 for the results framework for the SREP IP for Rwanda.

6.6 Co-benefits

The Rwanda IP will have direct positive benefits to many aspects of people's lives in Rwanda, bringing improvements in living conditions and economic prospects. Some of the key co-benefits communities of the REF include:

- *Enhanced energy security*. Scaling up renewable energies will diversify the energy mix, helping reduce dependence on imported fossil fuels, and hence enhancing the security of energy supply in the country.
- *Improved access to electricity*. Mini-grids and stand-alone solar PV systems will increase access to electricity in isolated areas where the grid is not expected to reach in the short term. It will also ensure that a renewable energy delivery infrastructure is established before diesel generation becomes standard.
- *Capacity building*. SREP activities will build and sustain management and technical skills within rural communities.
- *Job creation and income generation*. The program will maximize economic development opportunities, including new activities that create jobs and raise incomes, especially in rural towns.
- *Improved quality of life in rural areas*. Household and institutional access to electricity in rural communities can lead to better education, health and public security, especially for women and children.
- *Improved gender equality and women's socioeconomic status*. SREP initiatives will improve women's access to productive uses of electricity, and reduce women's barriers to information and training options for new energy services and technology. This might include development and implementation of feasibility study for job/income opportunities for women in connection with various energy systems/technologies e.g. private operators and developers and solar systems under the programs. In addition, SREP will try to leverage partnerships with other organizations to provide capacity building activities to train women in instillation/maintenance and development of energy services.
- *Improved access to communications*. Increased access to electricity will boost use of communications through mobile phones, televisions, and the internet, improving access to information and empowering local communities.

7 Financing Plan

Phase 1. The financing plan shown in Table 7 provides an indicative budget for the SREP program for 2017-2021, amounting to US$183.2m. As the table shows, US$50m of SREP funding is expected to leverage US$133m, mainly from the private sector (debt, equity). The SREP co-financing leverage ratio is expected to be 1 to 2.7. Co-financing amounts are tentative and will be further refined and confirmed during preparation and implementation, respectively, of the SREP-funded project. Indicative sources of co-financing identified to date are included in Table 8.

Table 7 SREP indicative financing plan (US$ million)

Project / sector	Project component	Total investment US$m	Private Sector US$m	Other dev. partners US$m	REF budget US$m, of which:		
					MDBs (WB, AfDB)	GoR	SREP
Mini-grids	Feasibility & TA	1		1			
	Investment	64.3	34.3	3.9	14.0		12.1
	Sub-total	**65.3**	**34.3**	**4.9**	**14.0**	**0.0**	**12.1**
Stand-alone solar PV systems	Market building	2		2			
	Investments	108.4	40.0	12.0	16.0	5.3	35.1
	Sub-total	**110.4**	**40.0**	**14.0**	**16.0**	**5.3**	**35.1**
TA / Enabling Environment	TA / Enabling env't	7.2		4.7			2.5
	IP prep. grant	0.3					0.3
	Sub-total	**7.5**	**0**	**4.7**	**0**	**0**	**2.8**
TOTAL US$m		**183.2**	**74.3**	**23.6**	**30.0**	**5.3**	**50.0**

Table 8 Identified potential co-financing (US$ million)

Funding Source	Comments	Amount (US$m)
MDBs (WB, AfDB)	Provisional co-financing	Up to 30.0
SEFA / AfDB	Country program (separate approval process)	1.0
DFID/ EnDev	Village grids	1.8
DFID/ EnDev	Solar lighting	3.3
BTC	Technical assistance	6.7
Private sector	Acumen / African Renewable Energy Fund / Commercial banks / investors	65.0
GoR	Provisional allocations for social infrastructure	5.3

Phase 2. An outline financing plan is provided in

Table 9 showing the total budget requirements for Phase 2 of the program, which is subject to the availability of additional funding from SREP, Green Climate Fund (GCF) or other climate finance sources.

Table 9 Outline funding requirements for Phase 2

Project / sector	Project component	Total investment US$m	Private Sector US$m	Climate finance sources (e.g., SREP, GCF, others) US$m	Other Co-financing US$m
Accelerating on-grid RE pipeline	Viability gap finance for hydro (current pipeline)	207[25]	177 (range 135-192)	15[26] (range 14-72)	15
	Access to finance smaller hydro (<1MW)	38[27]	25	13	
	TA to private sector – hydro	5		5	
	Viability gap finance large-scale solar PV (~10MW)	30	10	10	10
	TA to GoR – standard bankable PPA	0.5		0.5	
Hydro and grid-scale storage	TA – support feasibility studies for candidate projects	0.3		0.3	
	TA to GoR – design of a PPA allowing flexible output levels and appropriate pricing regime	0.3		0.3	
	Tariff support for 1 – 2 projects	50[28]	35	15	
Total Phase 2		**331**	**247**	**59**	**25**

[25] Estimated capital cost of currently identified projects in the project pipeline
[26] Based on mid-range level of tariff support, assumes that SREP funds could be geared 1:1 with other donor support
[27] Total capital requirement for current pipeline of projects <1MW
[28] Based on $5m/MW for hydro with storage, and approx. one third concessional finance from SREP, rest based on commercial financing.

8 Environmental and Social Framework for Energy Sector

The overall responsibility for overseeing the program is with the MININFRA, who will designate key contact personnel for ensuring the following environmental and social framework is adhered to. This will include the following aspects.

8.1 Environmental and Social Management Framework

As specific investment locations will be determined during project design, an Environmental and Social Management Framework will be prepared for the subprogram supported by the World Bank. Environmental and social specialists from the World Bank will explore options for a nationwide assessment and framework to define the environmental and social planning (screening of projects), review and clearing process that follows national legislation and safeguard policies.

8.2 Detailed Environmental and Social Studies

For each of the sub-projects financed under the REF, separate comprehensive environmental and social assessments will be undertaken. These assessments will include detailed studies to uncover the specific environmental and social impacts and corresponding mitigating measures for each subproject. The detailed studies include an Environmental and Social Impact Assessment, an Environmental and Social Management Plan and an RAP. Stakeholder consultations must be undertaken throughout the project lifecycle and will guide study development. The detailed studies must adhere to Rwandan laws and regulations as well as World Bank environmental and social safeguard policies. Additional, specialized environmental and social management plans and/or initiatives may also be required to address impacts associated with a given subproject.

The assessments undertaken will also take into account gender barriers and identify key gender issues, risks, constraints and opportunities associated with the SREP sub-projects in order to identify concrete actions that can help improve the delivery of and access to energy services for both men and women. Gender informed market research and gender disaggregated surveys might be conducted to better understand women's need and concerns in developing and accessing energy services. Interventions could include considering preparation of installations for productive uses other than lighting, providing services to key "social" infrastructure (e.g. water distribution, public lighting, training, and health centres).

8.3 Responsibilities

Subproject operators are responsible for compliance with national law and regulations and the World Bank safeguard policies, guidelines and standards. These operators are also responsible for preparing the required detailed studies; obtaining clearances; implementing all required mitigation and monitoring measures; conducting monitoring activities; providing adequate budgets to sustain mitigation and monitoring activities; and complying with any directives issued by relevant parties. MININFRA have overall responsibility for implementing the environmental and social frameworks and any specialized management plans and/or initiatives.

8.4 Stakeholder Consultations

In preparing the detailed studies, the subproject operators will adhere to the requirements for ensuring participatory stakeholder consultations. Project-affected people and other critical stakeholders must be informed and consulted about the nature, timing and scope of the relevant project impacts and the mitigation measures. Participatory approaches must be used in organizing and conducting the consultations. Gender considerations will also be factored in, given that in Rwanda women and men have different access to information, mobility and literacy rates which impacts how they participate in public meetings and community decision making process around e.g. energy investment priorities and project design. The opportunities for women around lower-cost

and cleaner energy and improving income-generating opportunities places additional importance on a gender-sensitive consultation process. Consultations will also feed into the design of a grievance redress mechanism. Environmental and social impacts and mitigation measures that will be considered are shown in Table 10.

Table 10: Environmental and social impacts and mitigation measures

Impact	Impacts	Mitigation Measures
1. Solar		
Environmental	• Construction waste and noise • Disposal of components at end of life (batteries, PV panels, inverters)	• Proper disposal of construction waste • To minimize adverse social impacts, employ local populations during project construction and operation stage • Proper siting decisions can help prevent aesthetic impacts to the landscape. Siting decisions will be taken in consultation with all local stakeholders • Good construction management practices in place that reduce negative environmental impacts • Arrange for safe disposal of solar panels and batteries on decommissioning and replacement
Social	• Reduced fossil fuel-based power generation and reduced dependency on fuel import costs • Increased community resilience to change in fuel prices • Encouraging productive energy use in rural areas • Improving women's access to energy • Impact on land-use	• Maintaining site cleanliness during construction • Carrying out work during acceptable hours of the day in consultation with households; contractor prepares schedule of activities and keeps public informed of schedule and any changes • Equipment and machinery kept in good condition to meet acceptable noise standards • Public complaint registration system • Consider land-use impacts in project EIAs, restrict to lower-value land and less populated areas.
2. Micro-hydro		
Environmental	• Water flow disruption and diversion causing loss of aquatic habitat • Disturbance to the sediment flow • Increased sediment load during construction phase • Disturbance of traditional water usage • There might be some deforestation/destruction of vegetation and river/soil erosion • Temporary construction dust, noise and waste • Petroleum products associated with equipment maintenance (hydraulic fluids, oil, solvents) are used in small quantities • Spills damage aquatic organisms	• Excavation should be done in dry season and river bank vegetation should be restored to mitigate river bank erosion • Proper disposal of construction waste • To minimize adverse social impacts, employ local populations during project construction and operation stage • Good construction management practices in place that reduce negative environmental impacts, including risk of chemical spills
Social	• Reduced fossil fuel-based power generation and reduced dependency on fuel import costs • Increased community resilience to change in fuel prices • Encouraging productive energy use in rural areas • Possibility of land acquisition and/or restriction of access to resources and subsequent resettlement • Improving women's access to energy	• Maintaining site cleanliness during construction • Conducting social and environmental impact assessment to identify potential impacts and prepare a mitigation plan (including a RAP for land acquisition or resettlement) • Assistance to communities in case of disturbance to livelihoods or access to resources • Carrying out work during acceptable hours of the day in consultation with households; contractor prepares schedule of activities and keeps public informed of schedule and any changes • Equipment and machinery kept in good condition to meet acceptable noise standards • Public complaint registration system

9 Implementation Potential with Risk Assessment

The overall implementation risk is *Moderate*. Table 11 elaborates on key implementation issues and specific risk factors identified with potential types of sub-projects (mini-grids, stand-alone solar systems) to be financed under the SREP-funded REF project.

Table 11 Implementation potential and risk assessment

Risk Factor	Description / Mitigation	Residual Risk
Legal and regulatory risks	Legal and regulatory frameworks are relatively well established in the on-grid power generation sector, but less developed for off-grid and mini-grid projects. SREP will support the establishment of the required legal and regulatory framework as well as project design for mini-grids and off-grid projects (for example, required contractual agreements) until this framework is in place.	Moderate
Institutional capacity risks	Energy sector institutions are strengthening in Rwanda, although there are still institutional capacity constraints. Capacity to handle procurement, financial management and environmental and social safeguards will be assessed before project appraisal and, where necessary, developed during project implementation.	Low / Moderate
Technology & resource risks	While technology for small hydropower and solar lighting projects is proven and less complex to handle, technology for hybrid mini-grids will require investment in technical expertise due to lack of local skills. Information on renewable energy resources is limited, but evidence indicates that hydropower, biomass and solar resources are available in the target regions. Project preparation supported by SREP will take special care in assessing the seasonal availability of hydropower resources and biomass, and design projects accordingly.	Moderate
Financial risks	However, successful business models for small hydropower projects, hybrid mini-grids and solar lighting systems will require a well-balanced program of grants and subsidies—tailored to each case—that guarantees their financial sustainability while incorporating incentives for quality service.	High
Private sector participation/investment climate	Business environment in Rwanda is good by sub-Saharan Africa standards. Perception of country risk is relatively low, and rule of law generally good. In the off-grid energy sector, private sector participation is still at an early stage and entrepreneurs face barriers to mobilizing private investors because of unknown market risks. SREP will help create an enabling environment for investments by supporting the required legal and regulatory framework, the preparation and grant financing of projects and the use and testing of diverse business delivery models that will help attract investors.	Moderate
Environmental / Social	As described in Section 8	Low

10 Monitoring and Evaluation

Implementation of the Rwanda IP will be supported by a comprehensive M&E framework that will respond to country needs to track the results of the prioritized program and projects, and identify their contribution to the identified strategic goals for the energy sector. The M&E framework for the off-grid sector, together with institutional capacity to implement the framework, would be strengthened with technical assistance support under the Rwanda IP. As far as possible, the M&E arrangements will be aligned to existing practices undertaken by energy institutions in Rwanda in order to streamline M&E efforts and improve institutional efficiency. Attention will be paid to generating sex-disaggregated data in the overall SREP program activities (e.g., in training and surveys to better understand the barriers women/female-headed business owners face in accessing energy services and to capture the development impacts). The proposed M&E framework is outlined in Table 12.

Table 12: Rwanda IP M&E framework

Result	Indicator	Baseline	Target	Units	System of verification
SREP Transformative Impacts					
Support low-carbon development pathways: • **reduce energy poverty** • **increase energy security** • **increase access to renewable energy**	National Measure of Energy Poverty (MEPI)	Not available	Not available	Not available	National M&E
	Annual electricity output from RE	316,000	422,000	MWh/yr	National M&E
	Increased private and public investments in targeted subsectors	0	40	US$m/yr	National M&E
SREP Program Outcomes					
Increase access to modern energy services: • **diversify supply** • **stimulate private sector participation** • **attract new and additional resources for energy projects**	Increased annual electricity output as a result of SREP interventions	316,000	358,000	MWh / yr	SREP M&E
	Increased number of women and men benefiting from improved access to electricity due to SREP interventions	0	1,490,000 [29]	people	SREP M&E
	Increased number of businesses and community services benefiting from improved access to electricity due to SREP	0	425	businesses and community services	SREP M&E
Reduce environmental impact of energy consumption and generation	Offset of fossil fuel electricity offset[30]	0	22,000	MWh	SREP M&E
	Offset of CO_2 emissions[31]	0	20,000	tCO2 / yr	SREP M&E

[29] Assuming 5 people per HH.
[30] Based on the share of potential plant on the system by 2018 as identified in Table 1
[31] Assumes average emissions factor of the grid in 2018 is 0.5 tCO_2/MWh

11 Responsiveness to SREP criteria

The Rwanda IP is responsive to all of the SREP criteria as summarized in Table 13 below.

Table 13: Summary of REF's responsiveness to SREP criteria

SREP Criteria	Renewable Energy Fund (REF)
Increased installed capacity from renewable energy sources	The REF will unleash the potential of the private sector to provide renewable energy-based off-grid solutions. The REF is expected to lead to 19.6 MW of additional installed capacity, comprising a mixture of micro-hydro and decentralised solar PV.
Increased access to energy through renewable energy sources	Approximately 300,000 households (1.5 million people) are expected to gain access to distributed renewable energy as a result of the REF, representing approximately 12% of the national population. Additionally, the deployment of stand-alone solar PV and mini-grids will provide electricity to 425 businesses and community services (e.g., schools, health clinics).
Low Emission Development	The distributed renewable energy technologies will help to displace electricity that would otherwise need to be provided from grid-based sources which is a mixture of renewable and non-renewable sources. The REF will therefore contribute to Rwanda's low-carbon development strategy.
Affordability and competitiveness of renewable sources	De-centralised electricity provision using renewable energy sources is more cost-effective than grid-based power for low consumption levels found in rural households targeted by the REF. Mini-grids will be located in areas where they are financially attractive compared to the grid extension alternative. Likewise, stand-alone solar PV systems will be prioritized in areas where they provide access at the least cost. By scaling-up stand-alone solar PV systems and mini-grids, the REF will contribute to a reduction in cost of providing electricity in the country as a whole.
Productive use of energy	The mini-grids sub-program will combine electricity access for households with supply of electricity for productive uses such as telecom towers, agricultural processing and light commercial uses which can help provide an anchor load to improve the cost-effectiveness of the energy investments, whilst providing potential for job creation and added value for local economic development.
Economic, social and environmental development impact	Electricity access for households is expected to lead to educational and health benefits due to the improved level and quality of lighting and reduced indoor air pollution from reduced use of kerosene. Economic benefits are expected to accrue from reduced monthly expenditure on energy, as well as the potential to support local micro-business opportunities, improved access to telecommunications and media.
Economic and financial viability	The investments are private-sector led. SREP funds will be used to pump-prime the market, which should then be in a position to stand on its own feet to supply commercially viable business models for ongoing provision of electricity access.
Leveraging of additional resources	The REF is expected to leverage SREP funds by a factor of 2.7:1. The largest additional source of funds is expected to come from the private sector, who will be the main driver of the investments to be made under the sub-programs.

	Other significant contributions will come from MDBs and other development partners.
Gender	Off-grid electrification improves equality and women's socioeconomic status. Further positive impacts include improved quality of lighting and indoor air quality which are expected to lead to better education, health and public security, especially for women and children, as well as improving women's access to information technology and communications. Opportunities to maximize gender benefits and other socioeconomic benefits will be sought during implementation of the REF.
Co-benefits of renewable energy scale-up	The REF is expected to lead to a wide range of co-benefits as described in Section 6.6 (Co-benefits).

Appendix 1: Assessment of Absorptive Capacity

Macroeconomic Situation and Outlook

Current macroeconomic situation: Rwanda is widely recognized as one of the best performing economies in the world. In the past 10 years, between 2004 and 2014, the annual average economic growth rate reached 7.9 percent. High aid flows and effective use of aid have enabled the government to maintain high level of public expenditures (especially public investment). The high public expenditures have stimulated domestic demand such as private consumption. In recent years, economic growth recovered to 7.0 percent in 2014 after the low growth of 4.7 percent in 2013 due to the aid shortfall which resulted in delays in budget executions in 2012. The 2014 growth recovery mainly reflected increased government expenditure, which boosted domestic demand (private consumption and investment). The growth momentum continued in the first half of 2015. Macroeconomic stability measure by inflation rates has been maintained. Consumer price index (CPI) stayed at around 5 percent between 2011 and 2013 before it further improved to 1.8 percent in 2014. In the external sector, the current account deficit as a share of GDP significantly deteriorated from -7.4 percent to -11.8 percent of GDP.

Despite its strong performance, Rwanda's per capita GDP stood at US$652 in 2014 and the economy has several remaining challenges. The 2012 aid shortfall followed by the economic slowdown in 2013 revealed structural bottlenecks such as heavy reliance on aid and the dominance of the public sector in the economy. As demonstrated in the deterioration of the current account in 2014, the decline in aid (especially grant aid) is of immediate concern. Given a possible further decline in the share of aid in the economy in the medium term, the role of public expenditure is expected to shift from driving growth to catalysing it.

Maintaining high growth and creating sufficient jobs to accommodate a fast-growing working-age population will require a shift to growth driven by the private sector. Such a structural transformation will depend on addressing the underlying constraints to private investment and continuing to make effective and efficient use of public resources through enhanced public financial management. In particular, it is important to mobilize additional domestic resources to create fiscal space and to further prioritize expenditures, including through improved public investment management. It is equally important to find alternative financing sources such as workers remittance and foreign direct investment for development to compensate the decline in aid.

Macroeconomic outlook: The baseline scenario is that the growth momentum will continue in the next few years. Economic growth is projected to reach 7.4 percent in 2015, 7.6 percent in 2016 and 2017, close to the country's potential growth. There are broadly four reasons / assumptions underlying the growth projections: (i) macroeconomic stability (mainly inflation rate and exchange rate); (ii) resulting policy flexibility; (iii) expected acceleration of budget execution; and (iv) positive regional economic outlook.

A number of factors pose risks to this projection. As the public sector plays a key role in both investment and consumption, Rwanda's near-term outlook depends on the implementation of the government budget, especially to overcome the strong stop-and-go cycle in investment. A second risk is the continued decline in commodity prices of Rwanda's main export items (coffee, tea, and minerals), which could expand current account deficits. A third risk is regional instability: tourism receipts are Rwanda's largest source of foreign exchange but are heavily dependent on regional security. A fourth risk is the rain-fed nature of Rwanda's agriculture. Abnormal rain and floods severely affect not only the agricultural sector but also the food manufacturing and trade sectors. There are also three global emerging downside risks to be aware of, including an increase in US interest rate / appreciation of the US dollar, slowdown of Chinese economy, and slowdown of the Euro economy, that could cause projections shortfalls.

Table A1.1 Rwanda - Selected economic and social indicators, Projections 2015-17

	2011	2012	2013	2014	2015 f	2016 f	2017 f
Real Gross Domestic Product	7.9	8.8	4.7	7.0	7.4	7.6	7.6
Private Consumption	9.0	6.9	2.9	5.3	6.1	6.3	6.3
Government Consumption	3.8	14.7	1.0	14.5	1.5	6.5	6.9
Gross Fixed Capital Investment	9.3	21.8	7.2	9.4	7.8	8.5	8.7
Exports, Goods and Services	40.5	17.7	13.7	4.2	2.7	16.4	15.1
Imports, Goods and Services	24.5	21.3	5.6	7.2	8.2	5.2	3.5
GDP, at market prices	7.9	8.8	4.7	7.0	7.4	7.6	7.6
Primary	4.7	6.4	3.3	5.3	3.9	3.9	3.9
Secondary	17.6	8.5	9.3	5.8	10.6	9.7	9.7
Tertiary	8.0	11.6	5.3	8.9	8.7	9.1	9.1
CPI Inflation, period average	5.7	6.3	4.2	1.8	2.0	2.0	2.0
Current account balance, % of GDP	-7.3	-10.2	-7.4	-11.8	-12.3	-10.9	-8.9
Fiscal Balance, % of GDP	-0.3	-3.0	-4.0	-6.2	-4.7	-5.1	-5.6

Sources: Rwandan authorities, World Bank staff estimates.

Debt Sustainability

The latest IMF/World Bank Debt Sustainability Analysis (DSA) in November 2014[32] concluded that Rwanda has kept a low risk of debt distress. Under the baseline scenario all debt burden indicators are projected to remain below the policy-dependent thresholds. Standard stress tests show in 2023 (when the Eurobond issued in 2013 is set to mature) a marginal temporary breach of the debt service-to-revenue (24.9 percent) ratio, and the debt service-to-exports ratio being identical to its threshold. These findings highlight the vulnerability of the Rwandan economy to external shocks and liquidity pressures at the time the Eurobond matures. Reflecting the situation, Rwanda's credit ratings improved since last Summer. Most recently, in March 2015, S&P upgraded Rwanda's rating from B to B+.

Fiscal Policy and Public Expenditure Effectiveness

Fiscal policy is the key policy instrument to realize Rwanda's development objectives. Government expenditures as a share of GDP has increased from 22-23 percent in the early 2000s to 31 percent in 2014. Between 2010 and 2014, pubic investment accounted for more than half of the total investment. Thus, effective use of public expenditures (including smooth budget execution) is critical for Rwanda's development. In this regard, the government is in the process of reforming public investment management (e.g., formulating of national investment policy, and mandatory submission of feasibility studies on public investment projects during the budget formulation process). Building institutional and human capacities of line ministries in the whole project cycle (including financial management and procurement) is critical to ensure disbursement of capital expenditures as budgeted. For example, in FY2013/14, the disbursement rate of capital expenditures was 95 percent.

The importance of building institutional and human capacities especially applies for the Ministry of Infrastructure (MINIFRA). Lower than budgeted execution of capital expenditures are mostly associated with energy and infrastructure projects. Also, MININFRA accounts for a third of the 2015/16 capital expenditures. The implementation of projects under the SREP would increase MININFRA's capital expenditure budget by more than 10 percent after FY2016/17.

[32] http://www.imf.org/external/pubs/ft/scr/2014/cr14343.pdf

Appendix 2: Institutional Framework in the Energy Sector

This Appendix describes the key institutional arrangements and responsibilities in the energy sector, drawing on the work of the SE4All Rapid Assessment report.

Central Government

Ministry of Infrastructure (MININFRA)

MININFRA is the lead Ministry responsible for developing energy policy and strategy, monitoring and evaluation of projects and programs implementation. The Ministry is in charge of setting an enabling policy and legal framework for the energy sector, including a suggested general approach to the optimal use of state subsidies in the sector, budget preparation, resource mobilization (together with MINECOFIN), and political oversight over government programs designed to expand energy access and service provision. A key coordination mechanism for the sector in Rwanda is the energy Sector Wide Approach (eSWAP)[33], which has a secretariat within MININFRA, and is in charge of energy sector consultation and coordination through the Energy Sector Working Group (see below section on energy sector governance and coordination)

Rwanda Energy Group Ltd.

The legal mandate of Rwanda Energy Group Ltd (REG) is to translate energy sector policies and programs into the implementation of tangible projects to achieve the government vision in the sector and to efficiently operate and maintain the power system of the country. Operating under company law, it will have a more corporate orientation and greater autonomy from political interference whilst still being accountable to MININFRA and the Rwanda Utilities Regulatory Authority (RURA) in charge in terms of project development activities, utility services and performance standards, respectively. This reform is expected to ensure more operations efficiency and financial sustainability in the medium-term.

REG has two subsidiary companies: the Energy Development Corporation Ltd (EDCL) and the Energy Utility Corporation Ltd (EUCL). EDCL has primary responsibility for developing new energy generation assets, both government and privately owned. Its mandate includes preparing comprehensive energy development plans, increasing investment in generation and transmission capacity, and planning and executing energy access projects to meet national targets. EUCL has the mandate for operation and maintenance of existing generation plants together with the transmission and distribution network. They act as counterparty to independent power producers once projects are up and running. They are also responsible for network growth and increased connections within the foot print of electrified areas. EUCL has the mandate for retail of electricity. The electric utility also functions as a systems operator. Further, as the Secretariat for the Grid Code Advisor Committee, REG has several related obligations including sharing critical information with other market participants and operators on the grid. Both a weekly and annual operations plan must be developed and issued to the regulator as well as any other registered participants.

REG is responsible for the flagship grid roll-out and electrification project, Electricity Access Roll-Out Program (EARP). EARP is a thematic program for implementing government strategies related to improving electric grid access. It is implemented by the energy utility and has already greatly increased the number of customers connected to the system from about 11% 2010 to over 22% in December 2014.

[33] Further details on Rwanda's eSWAP available at http://www.esmap.org/sites/esmap.org/files/ESMAP_Energy_Access_RwandaSWAp_KS013-12_Optimized.pdf

Rwanda Development Board (RDB)

Rwanda Development Board plays the lead role in investment mobilization and promotion for the energy sector, acting as a gateway and facilitator. It actively promotes private investor participation in the energy sector, including local financial institutions. It leads on facilitation of foreign direct investment (FDI) into strategic energy generation projects, as well as other programs and activities involving cleaner, more energy-efficient technologies. RDB also issues Environmental Impact Assessments for all energy projects for which one is required. It is expected to also host a centralized authority or advisory agency for PPPs across government.

Ministry of Finance and Economic Planning (MINECOFIN)

The Ministry of Finance and Economic Planning leads on resource mobilization to support energy investment and related financing requirements, such as the funding proposed for national strategic energy reserves[34] and any related replenishments under progressive budget commitments or other modalities as appropriate. Provision of sovereign guarantees for strategic investment projects and IPPs is also granted from MINECOFIN as this is accounting for in a similar way as a debt obligation. MINECOFIN will support in resource mobilization to prove the feasibility of energy resources

Rwanda Utilities Regulatory Authority (RURA)

The Rwanda Utilities Regulatory Authority (RURA) is an independent entity with its own board of directors appointed by Presidential Order and supervised by the Prime Minister's Office.[35] The scope of RURA's mandate extends to public utilities involved in renewable and non-renewable energy, electricity, industrial gases, pipelines and storage facilities, and conventional gas extraction and distribution. As the regulator, RURA's principal mandate is to ensure consumer protections from uncompetitive practices while ensuring that such utilities operate in an efficient, sustainable, and reliable manner. This includes oversight of the financial sustainability of public utilities to ensure that they can provide the goods and services necessary to fulfill market demand. RURA also has the important role of updating the electric grid code and ensuring quality of service standards for electric power. Although it is not primarily responsible for the formulation of energy policy, RURA plays an important role, including assessing and reviewing energy tariff structures that promote the availability, accessibility and affordability of energy services to all consumers including low income, rural and disadvantaged consumers. RURA is also responsible for licensing of all power generation, transmission, and distribution companies.

Ministry of Natural Resources (MINIRENA)

The Ministry of Natural Resources is responsible for ensuring the sustainability of natural resources exploitation including water, and also has the mandate for developing and managing compliance to the environment policy and law. As such it is the custodian of environmental welfare in Rwanda. It works closely with the **Rwanda Natural Resources Authority (RNRA),** an autonomous authority charged with management of Rwanda's natural resources including hydrological resources such as land (peat reserves, etc.) RNRA provides technical services in the Upstream Petroleum activities and promotes the productive exploitation of Rwanda's petroleum prospects.

[35] See Law 39/2001 of 13/09/2001 Establishing and Agency for the Regulation of Certain Public Utilities and Law 09/2013 of 01/03/2013 Establishing the Rwanda Utilities Regulatory Authority (RURA) and Determining its Mission, Powers, Organisation and Functioning.

Rwanda Environment Management Authority (REMA)

REMA has the mandate to coordinate, oversee and implement environmental policy and also acts as a think-tank for MINERENA. REMA is mandated to enforce environmental compliance in the development of energy resources, such as upstream petroleum activities, hydropower plant construction, gas extraction and geothermal drilling among others. REMA monitors and evaluates the impact of exploiting energy resources on the environment. REMA also plays an important role in coordinating approval of national climate finance projects, of which several are likely to be in the energy sector, including Nationally Appropriate Mitigation Actions (NAMAs) and projects and programs eligible to generate carbon credits under the Clean Development Mechanism (CDM).

National Fund for Environment and Climate Change (FONERWA)

The Law establishing FONERWA (2012) outlines its organization, functioning and mission. While it is housed within REMA, FONERWA has an independent board and is charged with harmonizing funds across various areas to support Rwanda's green growth and sustainable development. The fund was fully operational at the end of 2013. FONERWA has been a key player in mobilizing national funding and donor support for climate compatible development and infrastructure projects, with a particular focus on energy.

Rwanda Standards Bureau (RSB)

As an agency under the Ministry of Trade and Industry, RBS develops national technical regulations including national technology and performance standards. While RBS currently has an energy officer, the policy calls for RBS to play an increasingly important role in establishing, publishing, and disseminating national standards for energy technologies such as biogas digesters and solar appliances. Standards should be made freely available online to interested investors and project developers.

Ministry of Education (MINEDUC)

The Ministry of Education plays a role in the energy sector by building the competency and human resources base for sector development and by helping to link to research, technology development, and innovation to sector strategies. MINEDUC ensures that Technical and Vocational Education and Training schools (TVETs) address chronic skill shortages in the sector, including jobs related to electrical engineering and renewable energy technology installation and maintenance. Currently, Rwanda has 307 TVETs with each district having at least four schools.

Ministry of Local Government (MINALOC)

As the lead ministry for promoting decentralized basic services delivery, the Ministry of Local Government plays a critical role in promoting, disseminating, and monitoring the use of modern energy technologies, such as improved cook-stoves, biogas digesters, portable solar lamps and battery chargers, and solar home systems. Land siting for energy projects should be in line with District Land-Use Plans or Master Plans as well as Local Land Development Plans. In order to ensure conformity with local development plans, districts shall interact with MININFRA and furnish a letter of non-objection prior to the award of concessions for IPP projects, including micro-hydro and solar PV, that may involve use of public lands.

Local Government

Local governments have the authority and mandate to implement discrete enabling policies to drive local economic transformation. Under Rwanda's decentralization policy, local governments (districts) are responsible for the development of their District and for maintaining the District's infrastructure. Specifically, they have direct responsibility for all decentralized service delivery, including those that may be related to energy at the grassroots. This includes national programs to scale-up sustainable energy consumption currently being implemented by the electricity utility targeting communities. District Councils are responsible for approving local Development Plans, which should incorporate

technical guidelines and policy directives from central government to ensure implementation strategies are effectively devolved to the lowest administrative level possible. With increased public finance available through the Capacity Development Fund (CDF) and direct transfers, local authorities have considerable resources to finance their DDPs and Performance Contracts (Imihigo), and energy service delivery should comprise a key part of such obligations.

Financial Institutions and Development Partners

Financial institutions and development partners have a critical role to play by offering access to credit and financial services to the government, energy developers, and individual end-users. Development finance institutions such as MIGA and KFW could offer guarantees and risk insurance products to ensure high-risk energy investments reach financial closure. Development partners also support feasibility works undertaken by either government or the private sector to prove energy resources potential as well as technical support to commercialize those proven resources. Finally they have played an important role in supporting technology and knowledge transfer and institutional capacity building.

Research and Educational Institutions

Rwanda's research, educational, training and technology institutions include IPAR, NUR, KIST, IRST, ISAE and others. These institutions play an important role in developing the right skills and knowledge needed to implement the energy policy and strategy in supporting research and capacity building for the sector.

Civil Society

Civil society also plays a vital role in support of implementation of energy policies and programs and in undertaking policy advocacy, civic education and community empowerment. Through its umbrella organization, the Rwanda Civil Society Platform, over 15 member organizations actively participate in promoting sustainable energy resources and advocating for service delivery. In addition, MININFRA is in the process of actively supporting more formalized, accredited civil society organizations in Rwanda dedicated squarely to promoting renewable and cleaner energy technologies and related local entrepreneurship. Under the Energy Sector Working Group, there is also now a civil society group which meets on a regular basis to provide input and coordination from members with representatives of MININFRA.

Energy Sector Governance and Coordination Framework

Policy oversight and regulation of the energy sector falls under the auspices of several state actors, while other non-governmental stakeholders, such as development partners, NGOs, and private investors play an important role in sector development through investment and capacity building programs. Inter-institutional coordination with government is through the following channels:

- **Energy Sector Working Group (SWG)** Similar to other key sectors, the Energy SWG is a forum in which government meets its development partners to discuss matters influencing the sector, and to approve long-term plans and policy measures. SWGs are expected to convene at least quarterly. The Energy SWG is chaired by the Permanent Secretary of MININFRA and co-chaired by the Belgian Delegation. Chairs report directly to MINIECOFIN.

- **Energy SWAP and Secretariat.** The Ministers of Finance and Energy and senior development partners (DPs) established an Energy Sector Wide Approach Program (eSWAP) and instituted an Energy SWG in 2008 in order to better coordinate activities between government and development partners. Tasked with inter-sectorial and intra-governmental coordination, the eSWAP Secretariat's main mandate is to harmonize processes, procedures, and policies so as to align government and DP efforts to achieve sector policy objectives and to better coordinate external assistance toward national sector priorities.

Appendix 3: Techno-Economic Analysis

This appendix provides a comparative analysis of the costs of renewable and non-renewable energy options being considered by the Government of Rwanda. This is intended to inform the SREP decisions regarding the cost-effectiveness of different types of investment.

The first section considers the costs of generation, excluding the cost of transmission and distribution of power to people's homes. This provides a suitable comparator for the relative cost of renewable vs. non-renewable sources of bulk power, and allows a calculation of the costs of carbon abatement. The analysis shows that there is considerable cost-effective potential for renewable energy to replace costly diesel plant, and that deeper cuts in emissions would also be possible by replacing other thermal generation sources such as peat and methane with renewable energy.

The second section then considers the relative costs of different delivery mechanisms, namely on-grid, mini-grid and off-grid solutions. These costs are particularly relevant to decisions regarding the extent of development of grid infrastructure versus alternative methods for providing electricity access. It shows that off-grid solutions are particularly suited for low-power uses, whilst mini-grid and on-grid solutions may be most suited to mid-size applications. The economics will be sensitive to local conditions. The analysis then assesses the potential for mini-grid and off-grid solutions, and outlines the assumptions made regarding the costs of SREP interventions in these applications.

A3.1 Cost of On-grid Generation

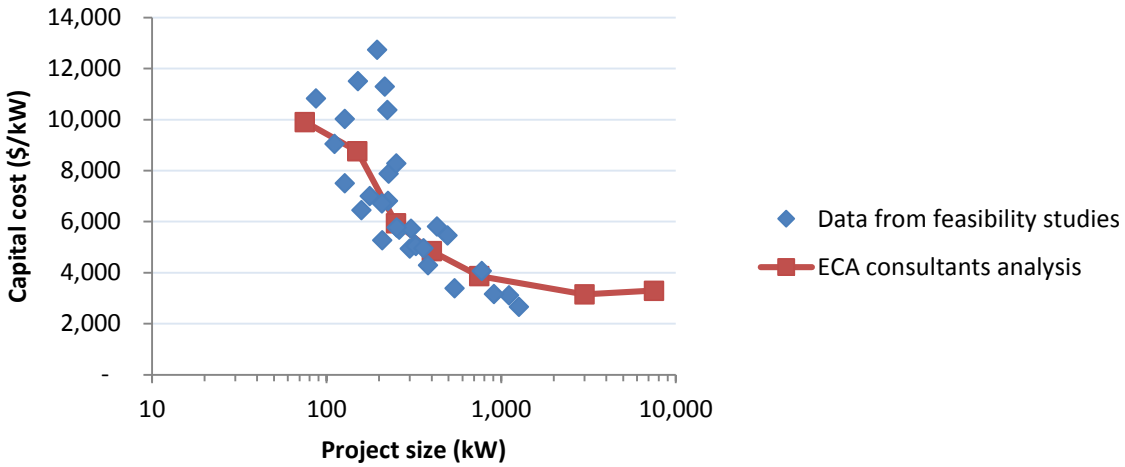
Considering the cost of generation on its own without including the cost of distributing electricity to end-users allows a comparative analysis to be carried out of different generation sources. in particular this approach permits a comparison of renewable and non-renewable generation which is needed in order to assess the likely cost-effectiveness of SREP interventions.

The first section considers hydropower costs in some detail because the impact of location and plant size on project costs has important implications for the costs of hydropower in Rwanda. The second section then considers generation costs more generally for the range of energy resources available in Rwanda. The third section presents the CO_2 abatement curve associated with the various emission reduction options available in the electricity sector.

A3.1.1 Hydropower Capital Costs

As noted in Section 4.1, Rwanda has an active pipeline of 38 or more micro-hydro projects. Many of these had pre-feasibility studies undertaken by REG, providing data on project costs. In addition, analysis carried out by consultancy firm ECA for the RURA tariff review also estimates project costs, as shown below. The chart shows that there is a strong degree of economy-of-scale for hydro, with costs of a 1000 kW plant being approximately one third that of a 100 kW plant. The economies of scale in terms of capital cost also combine with economies of scale in terms of overall project overheads and commercial viability. The cost of feasibility studies can be similar irrespective of the size of projects, making project preparation costs a greater burden for smaller projects.

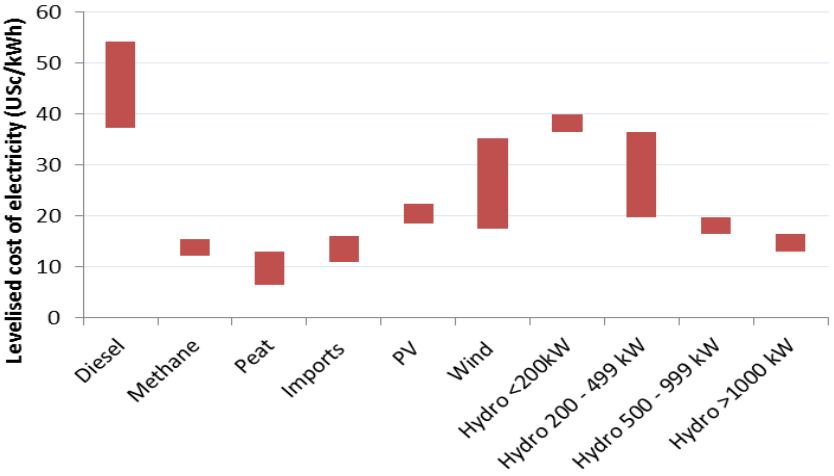
Figure A3.1: Capital cost estimates for hydro projects of different sizes[36]



A3.1.2 Cost of Electricity Generation from Different Sources

A common way of comparing the cost of electricity generation from different sources is to calculate the 'levelized cost' of generation – that is the total costs incurred (including annualised capital costs), divided by the amount of electricity generated by the plant in a year. Whilst this is not a perfect comparator, since it excludes some important properties of generators such as risk, flexibility, reliability and externalities such as CO_2 emissions, it is nevertheless provides a useful overview of the relative costs of different forms of generation. The chart below shows the range of levelized costs for different sources of generation in Rwanda[37]. These costs are all based on an assumption that plant would operate at baseload (or in the case of intermittent technologies, which they would operate whenever they were available). In practice, in order to balance supply and demand, some plant would be required to operate at peak times only, reducing utilisation rates, and increasing the unit costs of generation. Overall system costs of electricity generation will therefore tend to be higher than indicated here.

Figure A3.2: Cost of electricity generation from different sources



[36] Sources: feasibility study data provided by REG. RURA tariff review data from ECA report "*Assistance to RURA for the development of various secondary regulations and agreements*" February 2014

[37] Data from the model developed for the Sustainable Energy for All Action Agenda analysis. They are based on Rwanda-specific data, supplemented with the World Bank META model https://www.esmap.org/node/3051

The range of costs reflect variation in key input variables. The main cost drivers and risk factors vary according to the generation source, as noted in the table below.

Table A3.1: Cost drivers & risk factors for different generation sources

Generation Source	Cost Drivers
Diesel	Fuel prices (driven by international energy prices). Current cost of large-scale diesel generation is US¢40/kWh[38]
Methane	Capital and operating cost of methane extraction from Lake Kivu
Peat	Capital and operating cost uncertainty, plus uncertainty over resource
Imports	Tariff agreements
PV	Capital costs and utilisation rates
Wind	Resource and utilisation rates of plant
Hydro	Plant size and utilisation rates

Putting together the cost of generation and the technical resource allows an approximate representation of the cost-supply curve in Rwanda. This needs to be treated with caution, since different sources are at different stages of readiness, have different risks, and provide different levels of utilisation, so levelized costs are an imprecise tool for comparison and planning. With that caveat in mind, it can be seen that there is considerable technical potential for additional renewable energy in Rwanda. These can be sorted according to their long-run levelized cost of generation to create a cost supply curve. Key sources and available capacities[39] include:

1. Regional hydro, Rusumo & Ruzizi III (75 MW)[40]
2. Regional hydro, Ruzizi IV, technical potential (95 MW)
3. Geothermal (47 MW)
4. Domestic hydro 1-10MW (50 MW)
5. Imports from renewable sources in neighbouring countries (>90 MW)[41]
6. Domestic hydro 0.5-1 MW (7 MW)
7. Solar PV (112 MW)[42]
8. Domestic hydro 0.2-0.5 MW (8 MW)
9. Domestic hydro <0.2 MW (11 MW)

The supply cost curve for Rwanda is shown in the figure below. The cost of electricity generation varies according to project size and location, so the costs and potentials shown are approximate averages for each technology category.

[38] Source: REG

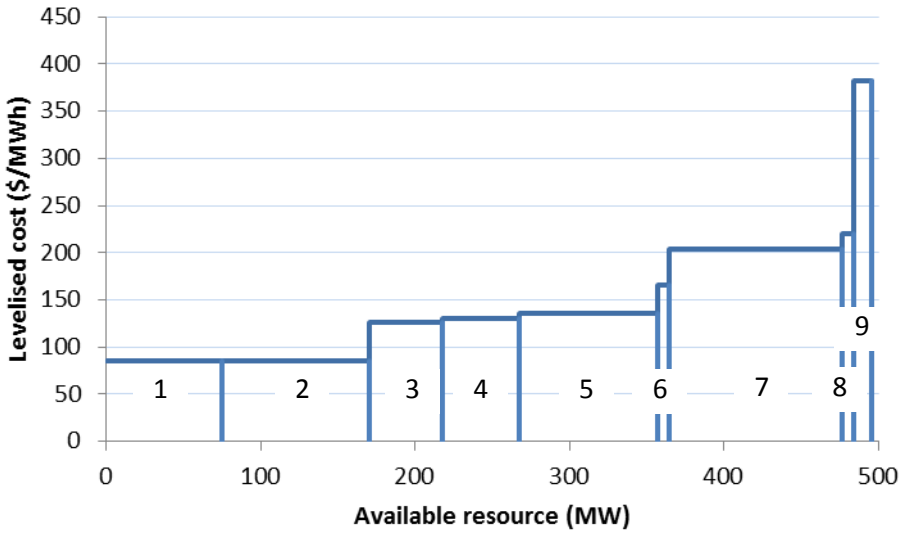
[39] These capacities are based on installed capacity, and do not take account of different utilisation rates for different technologies.

[40] Rusumo and Ruzizi III are shown separately because they are projects under preparation whereas Ruzizi IV is identified as a technical potential. Prices for all regional projects are assumed the same, but are approximate based on data for Rusumo and Ruzizi III.

[41] Technical potential is up to 400 MW, but is limited by a strategic policy to restrict imports to a maximum of 30% of total supply. Only 90MW import capacity has been negotiated to date.

[42] See Section 4.2.1 – available resource for solar has not been fully assessed. Assumption here is that capacity would be limited to 20% of installed capacity of system as a whole (i.e. 20% of 560 MW expected by 2018).

Figure A3.3 Supply cost curve for Rwanda



A3.1.3 CO_2 Abatement Costs

Diesel costs are high and represent the highest carbon density form of electricity generation available to Rwanda. However, other thermal generation sources including peat and methane generation also emit carbon dioxide. The carbon dioxide abatement curve presented below represents the costs of reducing emissions from their baseline level which would be around 1100 $ktCO_2$ / year if generation followed the 2018 potential generation mix as set out in Table A3.2.

Table A3.2 Assumed baseline energy mix for calculating the CO_2 abatement curve

	Baseline fuel mix (MW)
Solar PV	18
Domestic hydro	122
Regional hydro	16
Import	94
Gas (methane)	79
Peat	145
Diesel	8
HFO	80
Total	560

With this fuel mix, the CO_2 supply curve can be calculated, based on the costs presented in the previous section. This CO_2 supply curve is based on a 2018 baseline. Total technical abatement potential from renewables and low-carbon imports far exceeds Rwanda's projected emissions for 2018. Therefore, this CO_2 supply curve is based on options that could technically be implemented in the medium term to reduce emissions based on identified opportunities. The curve does not however take into account the economic costs associated with stranded assets of thermal plant that could occur under such a rapid decarbonisation, so does not necessarily represent a feasible economic scenario.

The curve only includes new and additional sources of generation, so therefore excludes existing renewable energy plant already on the system. For regional hydro, the curve includes Rusumo and Ruzizi III, but excludes Ruzizi IV, since this is unlikely to materialise until the mid-2020s. Imports are limited to 30% of supply according to strategic decisions made in the ESSP. Geothermal is not included in the abatement curve because of its uncertain role over these timescales. Domestic hydro

plant greater than 1MW are taken from the current project pipeline (although data for smaller plant are taken from the hydro atlas, since it is assumed these could be developed more quickly). The assumptions on availability are outlined in the table below.

Table A3.3: Assumed maximum technology contributions for calculating the CO_2 abatement curve

Abatement Technology	Max Capacity (MW)	Comments / Assumptions
Solar PV	112	Limited to approximately 20% of total system installed capacity
Hydro 1 (>1MW)	50	Based on current project pipeline
Hydro 2 (0.5-1MW)	7	Technical potential based on Hydro Atlas
Hydro 3 (0.2-0.5 MW)	8	Technical potential based on Hydro Atlas
Hydro 4 (<0.2 MW)	11	Technical potential based on Hydro Atlas
Regional Hydro	75	Rusumo (27MW) plus Ruzizi III (48MW)
Imports	78	Limited to 30% of total supply[43]
Methane	225	Technical potential (Rwanda share)

The costs are based on average utilisation rates, but primarily relate to decarbonisation of baseload. Costs would be higher for decarbonisation of peak-loads because of the lower utilisation rates concerned. The transition from one source of generation to another is assumed to be frictionless. In reality, costs could be higher than shown for rapid transitions that might create stranded assets. Because of the lower carbon intensity of methane (extracted from Lake Kivu), the first two steps of the supply curve involve shifting from diesel to methane. To make deeper cuts in emissions requires increasing the level of renewable sources of generation including regional hydro, imports, domestic hydro and solar plant. These incremental steps are shown in the CO_2 abatement curve below, and the underlying data is provided in the table.

[43] See policy targets in ESSP p27

Figure A3.4: CO_2 abatement curve

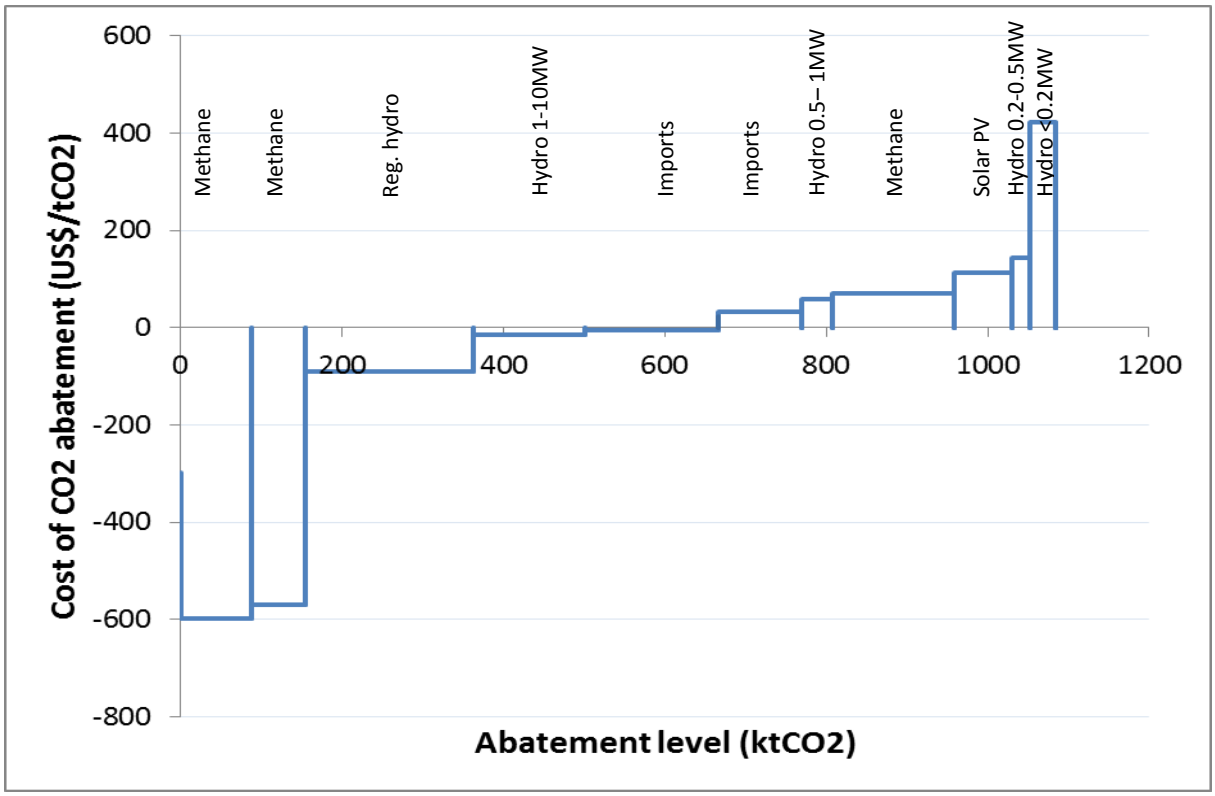


Table A3.4: Values in the CO_2 abatement curve

Steps in the supply curve	Abatement cost US$/tCO$_2$	Abatement for each step ktCO$_2$	Cumulative abatement ktCO$_2$	Emissions source	Abatement tech
1	-597	88	88	Diesel	N-Methane
2	-570	66	155	HFO	Methane
3	-91	208	362	Methane	RegHydro
4	-14	139	501	Methane	Hydro 1-10 MW
5	-5	164	666	Methane	Imports
6	33	104	769	Peat	Imports
7	59	39	808	Peat	Hydro 0.5-1 MW
8	71	150	958	Peat	Methane
9	113	72	1031	Methane	Solar
10	142	22	1053	Methane	Hydro 0.2-0.5 MW
11	422	31	1084	Methane	Hydro <0.2 MW

A3.2 Cost of Delivering Electricity

A3.2.1 Comparison of Off-grid, Mini-grid and On-grid Solutions

Whichever source of renewable energy is utilized, an essential issue to consider is how this energy is to be delivered to the consumers. The scale of projects can range from extremely small household-scale equipment, to very large multi-national hydropower schemes. In between are small scale mini-grids which can provide electricity from a micro-hydro project or centralised solar power plant to a

single village. The relative advantage of off-grid, mini-grids, and on-grid supply are outlined in the table below.

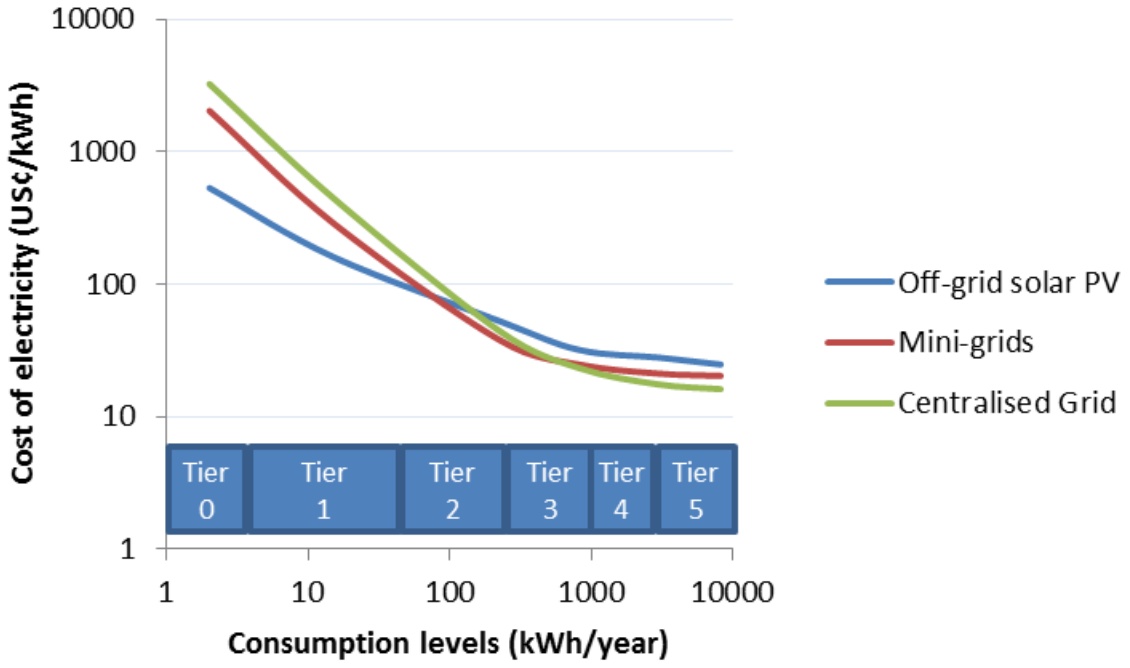
Table A3.5: Advantages and weaknesses of different types of electricity access

	Advantages	Weaknesses
Off-grid solar	Small modular units suitable for low-power usage makes initial capital outlay affordable. This can include over-the-counter products like solar lamps and solar systems with minimal infrastructure requirements and relatively lower levels of technical skills for buyers and sellers.	Need for storage if used during the night time. Unit cost of electricity can be high. Power levels generally not suited to higher demand productive loads such as larger industrial uses. Requires monitoring and quality enforcement procedures suited to dispersed nature of product.
Mini-grid	Moderate economies of scale can reduce generation costs relative to off-grid. Lower cost of connection compared to on-grid. Can share power between households, reducing total power requirement. Can provide captive power. For productive uses, creating employment opportunities.	Economies of scale not as great as on-grid. Moderate unit costs. Needs greater levels of infrastructure and technical expertise than stand-alone off-grid systems.
On-grid	Greater economies of scale lead to lower generation costs. Mixed portfolio of plant means that storage not so essential except at high levels of intermittent renewable energy in the mix. Unit costs can be low for households with moderate-higher usage. High potential to attract private sector investment/financing.	High fixed costs of transmission & distribution lead to high unit costs for households with low consumption levels. System relies on centralised utility model, with less control for consumers over timescale of connection.

Modelling carried out for the SE4All action agenda calculated the costs per unit of electricity between these three forms of electricity provision. As shown in Figure A3.5, unit costs vary strongly according to demand. Off-grid electricity costs (based on solar home systems) are expected to come down in price over time due to global reductions in solar PV and related storage costs, as well as economies of scale in the supply within Rwanda. Mini-grid systems in this analysis are based on a mix of small centralized solar plant and micro-hydro. Mini-grid costs are assumed to just include generation and distribution costs, without the need for high voltage transmission lines and substations.

For smaller users, less than around 80kWh/year, in the range of access level Tier 1 and below, off-grid solutions are clearly more cost effective. In the mid-range of consumption, around 100kWh/year, the solutions are all quite similar in terms of cost. Above around 200 kWh/year, mini-grids and centralised grid extension looks more cost effective. Centralised grid electricity becomes the cheapest source of electricity above about 600-800 kWh/year.

Figure A3.5: Comparative levelized cost of electricity delivered to households via on-grid, off-grid and mini-grid systems (Source: Analysis for Rwanda IP based on SE4All model)



Note: Figure A3.5 uses a logarithmic scale for both axes.

Based on available information on consumption levels for different households, and the above cost structure, we can identify sectors of the population for which different solutions are likely to be favourable.

Table A3.6: Current household electricity consumption levels in Rwanda

Consumption per household (KWh / year)	Tier Level	% of households[44]	Likely cost-effective solutions
0 to 60	Tier 1	18.4%	Off-grid
61 to 240	Tier 2	31.2%	Off-grid / mini-grid / on-grid
241 to 600	Tier 3	26.1%	Mini-grid / on-grid
601 to 1800	Tier 4	17.3%	Mini-grid / on-grid
1800 and greater	Tier 5	7.0%	On-grid

These roles are based on current consumption patterns In the future, household consumption will rise in line with economic development. This increase would increase the role of grid and mini-grid solutions.

Further, in practice, the actual unit costs of electricity paid by a particular household will depend on specific details such as the level of consumption, the location and type of local energy resources, constraints (such as terrain and accessibility), which will affect the cost of grid extensions and provision of technical services to consumers. The best technical solution for any particular place is

[44] Data from ESSP Table 16 p39

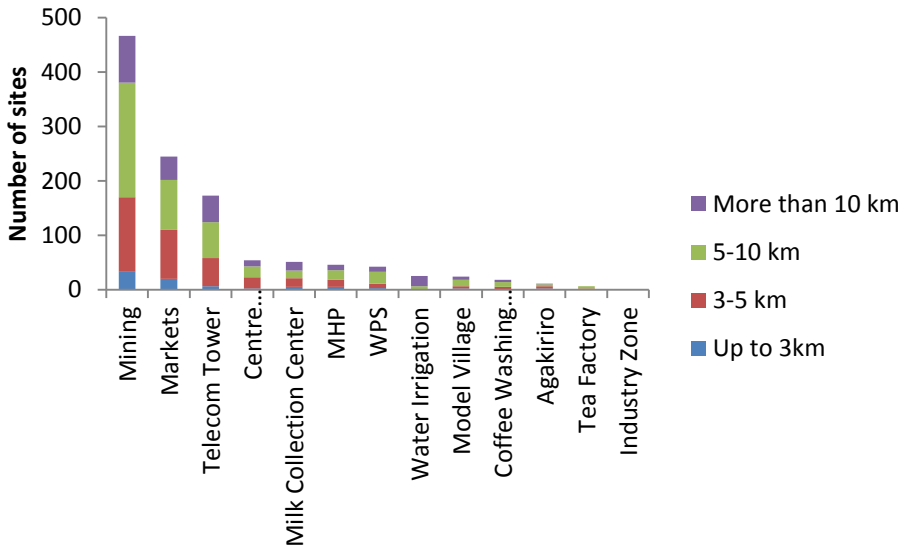
therefore likely to depend on local circumstances, and cannot be entirely prioritised on the basis of generic techno-economic assessments.

A3.2.2 Mini-grid Potential

Because of the economies of scale associated with generation costs, particularly for hydropower plant (see previous section), mini-grids will be most cost-effective in areas where the mini-grid can supply productive uses of electricity in addition to the household loads. These productive uses can include mines, markets, telecoms towers, milk collection centres, water pumping / irrigation, coffee washing stations, tea factories and other light industry.

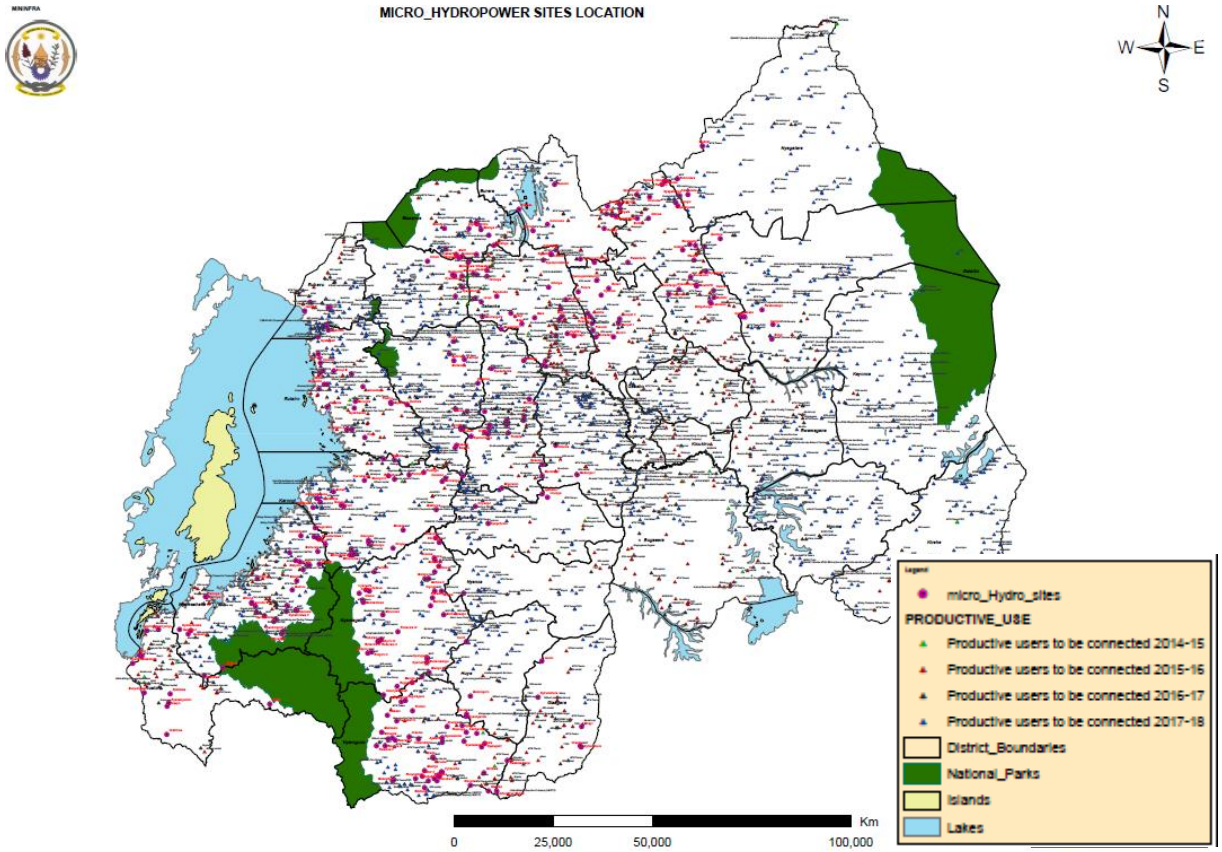
Rwanda has a program (electricity access roll-out program EARP) to extend the grid to many of these productive loads, prioritised according to economic need and cost of connections. As noted in the chart below, many of the loads scheduled for connection 2017/18 are still expected to be more than 10km from the grid (Figure A3.6). In such cases, a mini-grid could be a cheaper than main-grid extension, depending upon the local conditions. These are therefore good candidate sites to plan for the SREP program. Further work is required to fully coordinate mini-grid investment programs with EARP.

Figure A3.6: Distance to grid of off-grid productive uses (source: MININFRA)



The optimal siting of mini-grids would be in areas where one or more of these productive loads could be served by a nearby generation plant, in an area where there is a reasonable density of households. Micro-hydropower sites and the location of off-grid productive users have been extensively mapped across Rwanda (Figure A3.7) which will help to facilitate the selection of sites for mini-grids.

Figure A3.7 Map of micro-hydropower and off-grid productive uses



Unlike hydro-based mini-grids, solar PV (with battery storage) mini-grids are less site-specific, and have less pronounced economies of scale. This makes them more flexible, and would allow mini-grids to be developed for smaller villages with around 100-200 households each. Further, the existence of the demand for electricity from productive users is not critical for solar-based mini-grids, although if there is such a demand at a particular site, it will provide a useful boost to the project's financial viability.

It is also important to note that RURA's Simplified License outlines what will happen when the grid eventually reaches any mini-grids, which is particularly likely to happen where large productive users are already being served by mini-grids. This assurance helps to reduce project risk for mini-grids.

The financial viability of mini-grids will be more challenging in poorer villages, especially in the early years until electrification has brought about economic benefits that help households to pay the full economic costs of the systems.

Pilot studies are already underway into mini-grids in Rwanda. A group led by Colorado State University has been working on a Smart Village Microgrid Project (SVMP) which aims to bring mini-grid solutions to over 3000 villages, giving electricity access to around 450,000 households over a period of 8-9 years. The project is currently at the stage of piloting in few locations to demonstrate and develop the business model, and more information will emerge as these schemes are developed and rolled out.

The SREP program aims to support renewable energy based mini-grids providing electricity access for about 22,500 households. The key intervention is to support the initial capital investment so that the systems can be sized to allow for increased use of electricity over the longer term. Evidence is still being collected on electricity consumption patterns for newly connected households in Rwanda,

but it is expected that it may take a period of up to three years for the positive effects of electricity access to feedback into increased economic activity and increased demand for electricity.

The key assumptions underlying the estimated costs of mini-grids are provided in Table A3.7

Table A3.7: Key assumptions for estimating costs of SREP supported mini-grids

Quantity	Value	Units
Planned installed capacity (per mini-grid)[45]	27	kW
Generation for households (per mini-grid)	15	MWh/yr
Generation for productive users (per mini-grid)	30	MWh/yr
Capital cost of generation[46]	7000-8000	US$/kW
Capital costs for electricity generation (total)	49	US$m
Capital costs for distribution (total)	15	US$m
Unit costs (excluding connection fee)[47]	0.27-0.50	US$/kWh
Connection cost (per household)	400	US$

A3.2.3 Off-Grid Potential (stand-alone systems)

As noted above, for households using up to around 100kWh/year, off-grid solar is likely to be the lowest cost solution. Even above this level of consumption, off-grid solar will be competitive, especially in areas where extension of the grid is particularly costly, for example due to remoteness of settlements, difficult terrain or where settlements consist of scattered households with relatively low population density.

A full economic assessment of the potential for off-grid in comparison with mini-grid and centralised grid roll-out has not yet been carried out for Rwanda. However, some estimates can be made.

The ESSP 2018 target is for 22% of households to be connected via off-grid or mini-grid solutions. While the longer-term economically efficient maximum rate of grid connection is not yet determined, it seems likely that the market for off-grid or mini-grid solutions will remain at least at no less than the 22% level.

There are currently around 2.2 million households in Rwanda. Assuming that 48% will be connected to the grid over the short-term, 1.2 million households will be without grid connection, and form the potential market for off-grid interventions. Subtracting the potential contribution from mini-grids, the remainder is the potential market for stand-alone solar home systems (SHS). For the purposes of estimates in this IP, this total market potential is taken to be 1 million households.

In order to demonstrate potential for market change for SHS, the SREP program plans to directly target around 25% of this market, around 250,000 households. This will be an intervention that is large enough to change the market dynamics by building private sector capacity to deliver at scale, whilst leaving substantial space for market growth. Demonstrating the ability of the private sector to

[45] Allowing for a doubling in demand over 5 years resulting from economic stimulus

[46] Costs will depend on the details of the project. For the purposes of budgeting, these costs are based on $8000/kW for micro-hydro (<500kW) and $7000/kW for solar PV including all installation costs, battery storage and balance of system costs. The choice of technology will depend on the resources and demand characteristics for the location of the each mini-grid.

[47] Unit costs depend on the level of consumption – the lower end of the range corresponds to the higher level of consumption after 3 years taking account of consumption growth.

deliver at this scale will not only put Rwanda in a good position to replicate the business models in the remainder of its own market, but will also act as a demonstration for the approach which can be replicated in other neighbouring countries.

Support costs for this intervention have been calculated as follows. For 250,000 households, the estimated system costs are US$110m including all financing costs and customer servicing costs based on monthly payments model. The assumptions and values behind these figures are set out in the table below.

Table A3.8: Key assumptions estimating costs of SREP supported off-grid solar home systems

Quantity	Value	Units
Total number off-grid	1,000,000	Households
Number of HH targeted by program	250,000	Households
Average total commercial cost of system[48]	380	US$/HH
Capital costs of system	170	US$/HH
Average size of system[49]	45	W
Total installed capacity	11,700	kW
Electricity supplied	17,000	MWh
Total commercial cost of systems	98	US$m
of which:		
Private sector co-financing	*45*	US$m
Indicative debt financing through REF	*34*	US$m
Indicative grant financing	*18*	US$m

[48] Includes all business costs, covering financing costs, installation, operation & maintenance and profit margins.

[49] Costings are based on a range of sizes from 20W-70W. Actual costs will depend on market demand.

Appendix 4: Stakeholder Engagement

The Rwanda IP been developed through a series of participatory consultations led by the Rwandan government under the stewardship of the Ministry of Infrastructure (MININFRA) and with the participation of key stakeholders including government representatives, development partners, the private sector and civil society. Consultations with stakeholders that took place during (1) a Scoping Mission (December 2014) to present the program, initiate preparation activity and gather sector information, (2) a Joint Preparatory Mission (June 2015) to discuss the technical aspects of the investment options with stakeholders, and (c) a Technical Mission (September 2015) to hold the stakeholder workshop to validate the suggested investment priorities and implementation framework. The lists of stakeholders consulted during the joint missions are available in various Aide-Mémoire posted on the Climate Investment Funds (CIF) website for the Rwanda program: http://www-cif.climateinvestmentfunds.org/country/rwanda/rwandas-srep-programming. In addition, a list of various stakeholders consulted in the formulation of the IP are mentioned in the last section of this appendix.

SREP Scoping Mission (December 2014)

A joint World Bank Group (WBG), including the International Finance Corporation (IFC), and African Development Bank (AfDB) Mission Team visited Rwanda in the period December 8-11, 2014 to support the Government of Rwanda (GoR) with the preparation of the Rwanda Investment Plan under the Scaling-up Renewable Energy Program (SREP). The objective of the Mission was to hold preliminary consultations with key sector stakeholders to: (i) introduce the key features of the SREP program to the key stakeholders who are expected to interact with GoR in the development of the investment plan; (ii) hold preliminary consultations with key stakeholders; (iii) do an assessment of necessary technical assistance and resources required to develop the investment plan based on the country readiness and available relevant studies and documents; and (iv) agree on next steps and develop a detailed timeline for the preparation of the investment plan.

The Mission had extensive discussions with government institutions, the Ministry of Infrastructure (MININFRA), the Rwanda Energy Group (REG) and the Energy Development Corporation Limited (EDCL). The Mission met with various stakeholders from private sector, bilateral agencies, and development partners engaged in the energy sector.

During the mission it was recommended to the technical team that it should consult closely with the Energy Sector Working Group (ESWG). The ESWG would review, discuss and endorse the investment plan (IP) before its official submission for SREP Sub-Committee approval.

The Government and the Mission agreed that the proposed IP should be well aligned with national priorities as defined under the Rwanda's Vision 2020, Economic Development Strategy and Poverty Reduction Strategy (EDPRS) and the SE4ALL Action Plan for Rwanda. The potential areas of engagement under the SREP program might include renewable energy technologies such as mini-hydro and solar with a strong focus on increasing access to electricity leveraging private sector participation. To achieve this, the Government proposed to explore setting up a Renewable Energy Development Fund, which would operate as a revolving fund aimed at scaling-up the deployment of renewable energy technologies. The Government agreed to request up to US$300,000 grant from SREP for investment plan preparatory activities (e.g., consultancy services, consultations, workshops). The Government requested the World Bank to execute the grant on behalf of the client (i.e., Government).

SREP Joint Preparatory Mission (June 2015)

A World Bank team, together with AfDB and IFC teams, participated in the SREP Mission (June 22-25, 2015) to advance the preparation of the Rwanda IP. The Mission team met with MININFRA, other

relevant government institutions, private sector and development partners to agree on priority areas of the Investment Plan.

During the Mission consultations it was agreed that the implementation mechanisms of the SREP funds could be through a Renewable Energy Fund (REF). The GoR advised the mission team to use existing financing mechanisms and frameworks, rather than creating new ones; one of the options would be to establish the REF through Development Bank of Rwanda (BRD).

It was further agreed that the Rwanda IP should focus on off-grid/mini-grid energy access and generation based on the Government's priority areas as identified in the Energy Sector Strategy Plan (ESSP) which lays out the key policies and investments required to meet the energy sector's contribution to the Rwanda's Economic Development and Poverty Reduction Strategy II (EDPRS-II) covering the period 2013-2018.

During the mission, a presentation was made to the ESWG on the SREP IP, highlighting (i) the background research underlying the proposed IP; and (ii) identifying a "long list" of projects that could be supported under the REF. The proposed long list included (i) on-grid renewable energy generation; (ii) small hydro; (iii) mini-grids; (iv) off-grid solar home systems; (v) off-grid solar power for social infrastructure; and (vi) technical assistance (TA) for creating an enabling environment (in line with SE4ALL targets). Identified financing components were, (i) viability gap finance for small hydro; (ii) direct loans to small projects, supporting investments; (iii) results-based finance mechanisms; (iv) TA for capacity and institutional building for the Government as well as private sector, preparation of feasibility studies, etc.; and (v) market development programs. The ESWG also discussed the inception report related to the setting up of the REF.

It was agreed during the Mission with the Government that potential priority investments to be funded by SREP may include: solar home systems; mini-grids, off-grid solar powered social infrastructure and technical assistance. More details on investments shall be defined further based on an off-grid strategy that will be developed by the GoR. The agreements reached with the Government were discussed with and endorsed by the ESWG.

The Mission team advised the GoR up to 5 percent of SREP funds would be allocated towards TA. The Government agreed to explore co-financing options for outstanding TA support with other developing partners.

SREP Technical Mission (September 2015)

The WB team conducted a technical mission (September 21-25, 2015) to progress towards the finalization of the Rwanda IP. The objective of the mission was to follow-up on the progress of the IP, present the updated IP and hold consultations with key sector stakeholders (and the ESWG) on the proposed focus and structure of funds under the IP.

The Mission held consultations during one-on-one meetings with MININFRA and development partners and also during the ESWG workshop held on September 25th, 2015. From the consultations, it was agreed that REF is well-suited to leverage private sector funds by overcoming financing and other barriers to the scale-up of renewable energy investments. Further, it was envisaged that the REF could help harmonize Government and Development Partners' interventions in the off-grid renewables sub-sector thereby improving effectiveness and efficiency of the engagements.

Sector stakeholders also supported the focus of the SREP IP on off-grid investments due to on-going activity in on-grid electricity assets and the critical importance of off-grid electricity access to meet the Government's targets. It was decided that REF should remain sufficiently flexible at this stage to be able to respond to market demands based on consumer choices and viable private sector

business models, subject to meeting minimum quality standards and conforming to government strategy for the off-grid sector.

The consultations confirmed that REF will be capitalized with the US$50 million from Phase I SREP funding and will attract potential co-funding from other developing partners and the Government of Rwanda. A proportion of REF will be allocated for TA to support renewable off-grid electricity investments by the private sector. It was decided that implementing arrangements of the REF would ideally make use of existing institutional frameworks.

MININFRA also noted that the SREP Investment Plan will be integrated with the Government's off-grid strategy that is currently being developed with the support of the European Union (EU) as a part of the Rural Electrification Strategy. The Mission was informed that a draft strategy has been submitted to MININFRA and will be discussed at the Sector Working Group by the end of October, 2015.

Consensus Development through Stakeholder Consultations

Extensive stakeholder consultations were carried out by the technical team to assess the demand for and the proposed REF and its expected effectiveness given the ground realities of the off-grid sector in Rwanda. Broadly, the objective of stakeholder consultations was to (i) understand and incorporate stakeholder views into the IP; (ii) understand latest trends in each segment of the RE market and related challenges; and (iii) ensure inclusivity by establishing channels for communication with key sector stakeholders.

Stakeholder consultations have involved primary target groups on the both the supply and demand-side, financial services providers, development partners / donors, Government and regulatory institutions. A series of meetings were held with stakeholders in the Rwanda energy and financial sectors including: the ESWG, RURA; GIZ, DFID, BTC; SNV; associations such as the Solar Group, Hydro Power Group (15 companies), the Private Sector Foundation; Bank of Kigali; Rwanda Development Bank (BRD); East African Development Bank; FONERWA; the Business Development Facility (BDF); and RUGO rural village with 100 SHS installations.

Additional meetings were held with: John Ward, Managing Director, Vivid Economics – doing work on FONERWA strategy; Andrea Marroni – working on the Rwanda rural electrification strategy; Alastair Vere Nicoll – working at Berkeley Energy, an energy projects developer and founder (related to AfDB's SEFA – Sustainable Energy Fund for Africa); Christine Eibs-Singer – who has ground experience setting up innovative financing mechanisms for RE projects in Africa; also a senior advisor to SE4All.

The consultations resulted in the following recommendations on the design of the fund:

(i) multiple tools/windows that remove financial barriers to investments including: equity for startups and access to working capital for growth; credit lines for enterprises and consumer finance;
(ii) funding mechanisms that catalyze investments, private sector leverage in RE and lead to transformational impact;
(iii) tools that strengthen the enabling environment and build implementation capacity;
(iv) structuring that improves the long-term economic viability of the RE sector and ultimately causes scaling-up renewable energy capacity and access to energy;
(v) the use of existing organizations to manage the REF and NOT the creation of a new fund management body;
(vi) "avoid more grants-based programs for household-based solar systems that distort a market which is becoming commercial"; and
(vii) incorporate lessons and experiences from existing funds.

Full list of stakeholders consulted:

- Acumen.org
- AfDB
- Afritech Energy
- Amahoro Energy
- ARED
- Azuri
- Barefoot Power
- Belgian Embassy
- Belgian Development Agency
- Berkeley Energy (African Renewable Energy Fund)
- Colorado State University – Smart Village Microgrid Team
- DfID
- FMO
- FONERWA
- GIZ
- Goldsol
- Great Lakes Energy
- IFC
- Inkomoko
- KfW
- Mesh Power
- Micro-hydro Power Roundtable Group (15 companies)
- MININFRA
- Mobisol
- Ngali
- Power Africa (Rwanda)
- Project Developer Rukarara
- REG
- REMA
- Rocky Mountain Institute
- RURA
- Rwanda Development Bank (BRD)
- Serve & Smile
- SNV
- Societe des Grand Lacs
- Vivid Economics
- World Bank

Appendix 5: Concept Note: Renewable Energy Fund (REF)

Problem Statement

The development of sustainable private sector-led markets for off-grid renewable electricity has the potential to transform energy access arrangements in Rwanda. The private sector has completed a number of successful pilot programs, and is in a good position to increase investment, but faces a number of challenges and barriers to achieve the level of market scale required to meet the Government's goals and ambitions for the off-grid sector.

Primary amongst these constraints is the lack of access to capital at the scale required to achieve growth rates required in the sector. Debt needs just for off-grid solar PV for households alone is estimated to be at least US$100 million over the next 2 years in Rwanda. Longer-term debt needs in the off-grid sector as a whole are considerably higher. While individual companies have closed credit lines up to US$10 million, the time to close debt financing transactions is intensive and the size ultimately insufficient for the scale of market transformation envisaged. Companies seeking debt finance face requirements for very high levels of collateral, and there is a lack of financing that accepts future income streams as the asset base. Hence, energy companies tend to operate with either high levels of equity, which is limited, or use informal financing sources, which is expensive. As a result, energy companies lack the ability to leverage debt to enable growth through adequate working capital.

This problem of access to capital is compounded by the fact that the market for off-grid electricity is at an early stage of development, so that there is a lack of data and experience regarding the commercial risks. Financing institutions are therefore often reluctant to lend to companies facing uncertain cash-flow risks relating to the fact that the main prospective customers are low-income households or institutions, whose ability / willingness to make regular repayments on equipment purchases or rentals is uncertain. This creates particular problems for companies that utilise a pay-as-you-go business model, identified as a promising approach for disseminating RE systems in Rwanda. The extent of these risks is not clear because, at present, there is not enough experience to assess these risks accurately.

Several initiatives have been undertaken in recent years to promote off-grid solutions, and have had some promising results in terms of piloting different business models and products. However, this has led to a patchwork of different grant mechanisms, and there is now a need for a more coordinated and strategic approach to the sector, and a focus on standardisation both in terms of funding mechanisms and in terms of supporting and enforcing high quality equipment standards.

Project Objectives

The REF will provide a harmonised funding mechanism, aligned with Government strategy for the off-grid sector, and coordinated with support mechanisms of other development partners, in order to create a coherent and attractive investment environment for the private sector.

The aim is to provide households, businesses and institutions with greater access to electricity. It will achieve these aims by removing barriers to business growth, particularly access to finance and affordability, whilst reducing market distortions to allow market growth to be led by consumer choice.

The REF will finance a variety of renewable energy investments, as well as provide technical assistance for enhancing the enabling environment for private investments in off-grid energy markets. The main sub-programs envisaged under the Rwanda IP include:

- **Stand-alone solar PV**. The objective of this sub-program is to build markets and private sector capabilities to develop stand-alone solar PV systems as a significant contribution

toward the overall objectives for the off-grid electricity sector. The SREP support will focus on a short-term aim of providing electricity access to over 250,000 households and 175 social infrastructure projects (health clinics, schools etc.). The longer-term aim is to help grow a number of businesses able to service the off-grid power sector on a sustainable basis. The REF will help raise Solar PV product standards, promoting the dissemination of systems that are certified to internationally agreed quality standards.

- **Mini-grids**. This sub-program will contribute to the financing of mini-grid projects, estimated to provide electricity access to around 250 villages (around 38,000 households, at least 250 businesses), and supporting electricity use by businesses to support job creation and productive use. The aim is to demonstrate the benefits to local communities, and the commercial and technical viability of business models in order to trigger further market growth.

Scope of Work

The preliminary range of financing instruments offered under the REF may include:

a) Direct provision of debt and equity to energy companies to finance expansion;
b) Facilitate third-party debt finance via (i) credit lines to local Financial Institutions, and (ii) Credit enhancement facilities – e.g. first loss risk guarantees: to cover customer default risks and other forms of risk or mezzanine financing;
c) Grants and results-based finance to cover viability gap financing and improving affordability of off-grid renewable access;
d) Consumer finance via micro-finance institutions, or indirect via energy companies.

There are a number of key matters to be considered in the operationalization of the REF in Rwanda. The first is accessibility of the fund and the second is the speed of processing of transactions. Based on views from stakeholders, an efficient fund management structure must ensure a high degree of accountability on the part of the fund manager, should ensure effective and prompt delivery of service to the intended clients, and should demonstrate transparent operations, maintaining of high levels of integrity with clients are fully appraised of opportunities, process, progress and limitations related to their funding requests.

Further work is currently underway to establish the instruments to be used across these facilities to address the various project development barriers identified in the renewable energy off-grid sector. For example, total support levels to individual companies may be capped to avoid creating over-dominant players in the market. Details of such arrangements will require further analysis. The REF should be managed by a competent and qualified team of professionals, comprising a REF Transactions Manager, the Investment Committee and the Investment Board. The REF may require access to advice from independent technical experts to assist with project appraisals. Staffing levels, recruitment and contractual arrangements including incentive arrangements for Fund disbursement will be arranged as part of setting up the REF.

Funds will be disbursed to the host organisation based on an agreement between that organisation and the Government of Rwanda through MINECOFIN. The agreement will give the fund host a renewable fund management mandate; renewal will be based on success in implementation of the fund according to its objectives and targets. The agreement will give MININFRA oversight role in the implementation of the fund. The fund will be subject to fiduciary regulations that apply ordinarily to Government funded projects

Implementation Readiness

The REF will be established as a fund within an existing institution that is already involved in financing the energy sector. Hence REF will be a financing facility and not a new institution. Institutions in Rwanda that could fulfil the needs identified above include BRD, BDF and FONERWA, either individually or in combination. Rwanda already has experience of implementing such funds through FONERWA which is the primary mechanism for channelling finance in support of the government's green growth and climate resilient objectives. This includes support for renewable energy initiatives. FONERWA's private sector credit mechanism is managed by BRD, which is another potential host. The REF could either be set up as a separate funding window or combined with existing funding arrangements, depending on the outcome of the current review of FONERWA operations. Whilst there are similarities between the REF and FONERWA, there are also significant differences as noted in Box 5.1 below. The final decision on institutional structures for hosting and managing REF will be taken by the Government in consultation with stakeholders.

Whichever institution hosts the REF, technical assistance will be needed to build institutional capacity to handle the technical aspects of lending decisions, since support from these institutions into the off-grid energy sector are still at an early stage.

Box 5.1. Relationship between REF and FONERWA

This box aims to clarify the similarities and differences between the REF, and the National Fund for Environment in Rwanda (FONERWA). FONERWA was established to respond to the needs of national climate and environmental financing. Its role is to support activities that conserve and protect the environment, land, water, forestry, mines and quarries, as well as managing climate change and its impacts. It is structured as a revolving fund to be replenished each year with environment levies and taxes plus other funds e.g. from donor funds. It operates a private sector funding window via a credit line disbursed by BRD. Proposals are currently under consideration to restructure FONERWA's private sector window. The following table provides a comparative summary of the private sector facilities and market support currently offered by FONERWA and REF.

Feature/Support	FONERWA	REF
1. Focus	Activities that conserve and protect the environment, land, water, forestry, mines and quarries, as well as managing climate change and its impacts.	Building capacity in renewable energy generation and access through market development, private sector participation and partnership with the public sector (PPP).
2. Sector Focus	ENVIRONMENT	ENERGY
3. Dedicated energy fund	NO	YES
4. Current potential allocation to energy	US$ 12m (current energy CL at BRD US$ 6m)	US$ 50m (leveraged, over US$ 200m)
5. Implementation of private sector investments	Via BRD	Hosted fund
6. Innovation Grants	YES	REF will aim to scale-up commercially viable renewable energy solutions.
• Proof of Concept (prototyping) Grants	YES	
• Research and Development Grants	YES	
• Demonstration: Piloting & Commercialization	YES	
7. Credit Line for energy investment	YES	The range of financing instruments to be offered under REF will be determined during preparation of the SREP-funded REF project.
8. Viability Gap Finance	NO	
9. Results-based Finance	NO	
10. Market Development Finance	LIMITED (via UNDP TA facility)	
11. Equity	NO	
12. Guarantees	NO	
13. End-user Finance	NO	
14. Trade Finance	NO	
15. SME Finance	NO	
16. Project finance syndication	NO	
17. Funding cycle	Call for proposals	OPEN
18. Approval period	8 to 9 months	OPEN
19. Management Team	INTERNAL	INTERNAL
20. Appraisal and business development team	Internal (FMT) and supported by call-down consultants.	Internal and supported by Implementing Partner Organisations.

Rationale for SREP Financing

The Rwanda IP will initiate the transformation of private-sector markets for off-grid electricity solutions. The program will be implemented through the newly established REF, which will provide a range of financing instruments aim at stimulating the growth of a privately-led market for off-grid electricity provision. The design of the REF will be flexible to respond to market demands and consumer choice for different types of technologies and business models, subject to meeting minimum quality standards and government strategy for the off-grid sector, and ensuring financial sustainability of the investments. The REF is aligned with the wider government strategy for mechanisms to support energy sector investments by the private sector. The REF will become a coordinating mechanism that brings together government and donor support to help streamline the growth of off-grid electrification markets. The REF will be capitalized with capital and grant contributions from SREP, development banks, donors, and government. Proceeds from loan or other instruments can be re-invested making the REF a revolving fund. The REF could also attract additional funding from other sources in the future, contributing to the transformation of the market well beyond the initial 5-year investment period envisioned under the SREP-funded program.

Results

The expected impacts and outcomes of the REF investments are shown in Section 10.

Financing Plan

The financing plan for the REF is shown in Section 7.

Implementing Agency

The Government's aims to minimize transaction costs related to the preparation and implementation of the SREP-funded project and has expressed interest in having one MDB implementing Phase I. In this regard, the World Bank will take the lead in structuring and implementing the REF, with AfDB and IFC invited to collaborate and contribute to the successful implementation of the REF.

Timetable

The World Bank will develop the REF project according to the following:

- World Bank Project Concept Review (PCN) in Q2 2016,
- SREP Sub-Committee Approval in Q4 2016,
- World Bank Board Approval in Q2 2017

In parallel, the enabling environment barriers will be addressed through the use of the project preparation grant to build the project pipeline in readiness for a planned start of disbursements. These activities are described in Appendix 6.

Appendix 5-bis: REF Sub-Programs

A. Mini-grids Sub-Program

Problem Statement

About 77% of the Rwandan population do not have access to electricity. Of these, an overwhelming majority lives in rural areas. Expansion of the central electricity grid can be a costly way to provide electricity to rural households. Connection fees for dispersed populations can be up to US$1,000 per household. If household energy expenditure is high enough, such connection fees can be justified on the basis that they represent a long-term infrastructure investment. However, electricity expenditure of rural households in Rwanda in the early years of electrification is likely to be only in the region of US$5 per month; at these levels, the initial investment cannot be repaid, although the marginal cost of generating the electricity might be covered. So far, the fixed costs of grid extension have relied mostly on external subsidies in order to address affordability barriers.

Compared to grid extension, mini-grids can reduce the fixed up-front costs of electrification. Because the grid would be focussed on a local community (e.g., a single village-level scheme), the distribution system would be localised, minimising the need for long-distance transmission systems and substations for transforming high to low voltages. Initial estimates are that fixed connection fees at a village scale could be reduced to around US$400 per household, providing a more cost-effective way for the government and donors to support electrification in some areas. 'Pico-grids' have even lower connection costs. They supply small clusters of 10-20 households, and have minimal infrastructure costs. These pico-grids may also be covered by the 'mini-grid' program, but are technically distinct – for example, they use low power DC equipment that is not compatible with the mains grid.

Mini-grids can readily support productive uses. These include telecommunications towers, mining activities, milk collection centres, agricultural processing plant, and small businesses. Mini-grids can therefore provide support for development, diversification of the economy and job creation. In turn, these productive users improve the cost-effectiveness of mini-grids because they increase the utilisation rates of the system, making better use of the fixed assets.

However, this co-dependency between supply of electricity and demand for electricity creates a bottleneck to development. Currently, there is a lack of productive demand in rural areas because there is no electricity provision, and *vice versa*. Where isolated productive users do exist, they tend to operate with stand-alone diesel generators which are expensive to operate. Renewable energy solutions can be significantly cheaper in the long-run, but require more up-front capital, and face investment risks with respect to levels of future demand due to uncertain economic growth prospects.

The REF aims to break down these barriers by providing a source of capital that could be used to help private sector companies overcome these initial risks, and help to demonstrate the economic potential that would act as a catalyst for expansion of the approach.

Sub-program Objectives

The objective of this sub-program is to build markets and private sector capabilities to develop financially sustainable and scalable mini-grids systems to contribute toward the overall objectives for the off-grid electricity sector. This program component will contribute to the financing of 100-200 mini-grid systems with 9.5 MW of renewable energy installed capacity, estimated to provide electricity access to around 250 villages (around 38,000 households, at least 250 businesses), demonstrating the benefits to local communities, and demonstrating the commercial and technical viability of business models in order to trigger private sector led growth in this market segment. Mini-grid systems will comprise the generation plant, setting up low-voltage distribution systems to

the villages and connecting productive users in the vicinity of the generation projects. SREP support will help overcome legal, regulatory, and institutional constraints necessary to attract private investments into off-grid electricity provision.

Current Efforts

The REF mini-grids sub-program can build on a number of initiatives already underway in Rwanda some of which include projects being developed by private companies, e.g Mesh Power, which has developed 15 solar-powered pico-grids serving around 300 customers in total . and development partner some of which include the GIZ program supported by EnDev which aims at developing 35 micro-hydro based village-scale mini-grids and it creates an opportunity for co-financing for the SREP-funded program. In addition there are other initiatives being carried out, and some of these are developed by research institutions like the Colorado State University and Massachusetts institute of Technology which are developing projects on village mini-grids in Rwanda, aimed at building datasets and human resources within Rwanda through technician training programs. Several private developers of micro-hydro projects in Rwanda have also expressed interest in expanding their projects to include provision of local distribution systems to neighbouring villages.

Approach

Renewable energy technologies. The sub-program will be technology neutral, allowing support for renewable energy technologies using micro-hydro, solar, and potentially wind as the basis for the electricity generation. Hybrid mini-grid systems (e.g., solar/diesel) including diesel back-up will also be eligible under the program, noting that the diesel component of the hybrid system shall be financed from sources other than SREP.

Geographic focus. The main focus will be on areas which are not covered by grid expansion plans and/or are located furthest away from the grid. The mini-grids are expected to serve a combination of productive and household loads, especially to take advantage of economies of scale associated with electricity generation costs, particularly for hydro-based power. For example, there are over 250 productive use sites that are scheduled to be grid-connected by 2018 and are located over 10km from the grid, including mines, markets, telecom towers and milk collection centres. Although these sites are formally included in the grid expansion plans, given the budget constraints for those expansion plans, and noting that the provision of grid-based electricity to these sites will be prioritized on the basis of distance from the grid, these sites will be the last to be connected. The mini-grids sub-program would therefore target these sites as potential anchor loads, while attempting to connect nearby households.

Business models. The sub-program will consider various business models for the generation and distribution of energy using mini-grids.[50] The private sector will be expected to take the lead, typically owning the generation and distribution systems, although hybrid ownership models could also be considered with public ownership of the distribution system and private ownership of the generation plant under a PPA arrangement. A full assessment of potential delivery models will be conducted during the preparation of the Project, drawing on global best practice and learning from initiatives on mini-grid development in other SREP countries.

Specifications and load sizing. The sub-program will be flexible in order to attract a variety of different approaches to mini-grid provision, ranging from micro-hydro and solar systems of around

[50] See World Bank "*From the Bottom Up: How Small Power Producers and Mini-Grids Can Deliver Electrification and Renewable Energy in Africa*" 2014.
https://openknowledge.worldbank.org/bitstream/handle/10986/16571/9781464800931.pdf?sequence=1

10-50kW which would aim to serve whole villages to pico-grid 1kW systems serving housing clusters or sub-groups of houses within a village, or alternative models such as battery exchanges. Village-scale mini-grid systems would typically be expected to provide access to villages of 100-200 households each. Additional generation capacity for productive use capacity would bring the scale of mini-grid systems to the range of 10-100kW each.

Financing support. Depending on market demand for this sub-program, the REF will provide financing support to develop mini-grid systems totalling an estimated US$12m from SREP funds, with co-financing bring total investment up to US$65m, based on the uptake scenario developed for costing this IP. This financing is expected to be provided in two main forms. Firstly, loans will be provided to help companies access the necessary financing for the project. Secondly, grant financing will be available to help offset the connection costs associated with fixed infrastructure costs of the distribution systems. Other forms of financial support such as risk guarantees and consumer financing instruments will also be considered in line with the final REF design.

Technical assistance for project preparation. To overcome the technical capacity constraints of companies developing mini-grids, TA will be made available to help bring project proposals and business plans to a bankable quality, and help to build and accelerate the project pipeline.

Implementation Readiness

As noted above, the host institution for the REF will require some capacity building and / or arrangements to partner with a technical support organisation to provide the technical expertise required to assess mini-grid projects. This will take place as part of the preparatory arrangements during setting up of the REF. In addition, technical assistance will be provided to support development of the project pipeline to facilitate implementation readiness of this sub-project.

Rationale for SREP Financing

SREP support will help demonstrate that renewable energy for off-grid electrification using mini-grids is indeed an economically viable and scalable option. The program will help demonstrate the commercial and technical viability of private sector led mini-grid business models in order to trigger further growth in this market segment and therefore sustainable provision of electricity access. SREP will directly benefit many households and businesses in rural areas targeted by the specific mini-grids supported. More importantly, SREP will also help establish the enabling business conditions and capital for scaling up private sector business models, and help catalyse further additional resources and private participation in rural electrification.

Expected Impact

Overall targets for the Rwanda IP, including targets for the mini-grids sub-program, are set out in Section 10. The following outcomes and outputs are based on the provisional budget allocation of US$12m, but are subject to change depending on market demand and uptake.

The mini-grid sub-program would benefit directly households and businesses in rural areas, establishing the enabling conditions and catalysing the financing required to deploy 100-200 mini-grid systems (9.5MW of renewable energy capacity) estimated to provide electricity access to approximately 250 villages (38,000 households, at least 250 businesses).

The program will also contribute to all of the SREP program's key results and outcomes, supporting low-carbon development pathways, reducing energy poverty, increasing access to renewable energy and modern energy services, stimulating private sector participation, attracting new and additional financial resources, and reducing environmental impact of energy consumption and generation.

Financing Plan Costing

Project / sector	Project component	Total investment US$m	Private Sector US$m	Other dev. partners US$m	REF budget US$m, of which:		
					MDBs (WB, AfDB)	GoR	SREP
Mini-grids	Feasibility & TA	1		1			
	Investment	64.3	34.3	3.9	14.0		12.1
	Sub-total	**65.3**	**34.3**	**4.9**	**14.0**	**0.0**	**12.1**

For the purposes of costing the financing plan, it is assumed that mini-grids will comprise a mixture of micro-hydro power and solar PV systems with battery storage. It is also assumed that a local distribution system would be built serving one-or-more productive loads, and serving a local population of around 100-200 households per mini-grid based on AC systems compatible with the national grid. Program costs are based on mini-grids serving a productive load of 6 kW (approximate power requirement to serve a mobile phone base station), and assuming 150 households with an initial load requirement of 70 W, and consumption of 100kWh per year each (Tier 2 access). Allowing for over-sizing of the system to allow for economic growth and development of additional productive activities leads to a total power requirement for the mini-grid of around 20-30 kW.

Based on previous feasibility studies, the capital cost of a hydro plant of this sizes in the range of US$ 6,000 – 10,000/kW, bringing the capital cost of generation for a single mini-grid to US$ 0.2m. Costs of solar-based systems would be similar. Connection costs for whole village distribution systems would be similar to the costs of rolling out the distribution system of the central grid. These costs amount to around US$ 60k for a village of 150 households (US$400 per household), although other systems (e.g., pico-grids) could result in significantly lower connection costs. For budgeting purposes, it is assumed that support would be provided for 100-200 mini-grids depending on scale serving up to 250 villages, with a total capital requirement of US$65m. Private sector investment is expected to be over US$44m, with a contribution from SREP of just over US$12m.

B. Stand-alone Solar PV Systems Sub-Program

Problem Statement

Although Rwanda has ambitious plans for roll-out of the electricity grid, there remains a significant potential for off-grid solutions. For *households,* the government's target is for 22% of the total population to have off-grid access by 2020. This equates to about 33% of the rural population having off-grid solutions, since urban areas will be more rapidly electrified through planned grid extension programs. For *social infrastructure* such as schools, health facilities and administrative offices the target for 2018 is for 100% access through either on-grid or off-grid solutions. According to ESSP, as of June 2014, roughly 63% of health facilities, 41% of primary schools, 66% of secondary schools and 64% of administration centres had access to electricity.

As noted in Appendix 3, grid extension can be an expensive way to provide electricity access in remote rural areas, and stand-alone PV systems can be more cost-effective especially for users with low consumption levels. A program of support is needed for market building activities, e.g. training of retailers on marketing schemes, loans for last mile retailers so these are able to purchase lanterns in bulk to achieve economies of scale, provision of market intelligence, business incubator support for companies to innovate their business models, and support through financing.

For *households,* upfront costs of solar systems for households can be up to US$300 or more depending on specification which presents a serious affordability barrier. Current rural household expenditure on non-cooking energy based on kerosene, torches, candles and commercial phone charging is around US$3.40 per month[51].

Regarding *social infrastructure,* the SE4All Action Agenda identifies energy for health as a 'High Impact Opportunity'. Off-grid electricity access is an essential element to upgrading and modernising provision of healthcare in rural areas. Where such provision is currently made through diesel generators, there is often a lack of affordability for clinics to run the generators, with provision often only a few hours per day. Replacement with solar PV units can considerably reduce running costs, allowing money to be prioritised for provision of health services.

Sub-program Objectives

The objective of this sub-program is to build markets and private sector capabilities to develop stand-alone solar PV systems as a significant contribution toward the overall objectives for the off-grid electricity sector. The SREP support will focus on a short-term aim of providing affordable electricity to over 250,000 households and 175 social infrastructure institutions, and with the longer-term aim helping to grow a number of businesses able to service the off-grid power sector on a sustainable basis.

Current Efforts

There are a number of private companies serving the solar PV market for stand-alone solar PV systems. These systems range from solar lanterns in the 1-5W range which can often also charge a mobile phone (Tier 1 access) which can cost in the range US$15-50, through to multi-room lighting systems in the 15-100W range costing in the range US$100-300 per system. Larger systems of up to 2kW or more can be used for social infrastructure applications such as health clinics and schools, or for productive uses such as water pumping, telecommunication towers, mining operations and processing of agricultural products.

[51] Correspondence with Colorado State University – data based on village household surveys

The solar market is reasonably active, but still quite small, and companies vary considerably regarding their ability to rapidly scale-up. A small number of international companies are ready to enter the market at scale, so SREP finance could in principle flow quickly into this sector. Whilst it is important maintain the momentum that has been building over recent years with these companies, it will also be important to work on increasing the absorption capacity of a wider set of local companies which will take more time. A balanced approach over a number of years will be taken, with some early deployment aimed at demonstrating the potential of the market, whilst at the same time working with local companies to help build business models and allow access to reasonable market share.

Market scale is likely to be achieved by supporting companies with existing plans for scale-up in Rwanda. Financing needs of these companies have been identified at above US$100m, and significant sources of equity capital at scales of US$50-100m are preparing to enter the market to support these companies. However, commercial debt is not available at this scale without risk mitigation, and SREP will primarily address this barrier. Significant work is also required to support company growth through market building and awareness programs which should start implementation during 2016.

Approach

Technology options and specification. These will be made flexible in order to promote a range of options to satisfy a diverse consumer choice. There will be minimum quality standards applied (e.g., Lighting Africa approved equipment). In the case of *households*, a minimum size threshold would likely be introduced to distinguish solar home systems from individual solar lanterns which is considered to be a separate market. For *social infrastructure*, technical assistance funds would be made available to provide robust feasibility studies and technical specifications prior to project financing.

Scale of program and geographical focus. Of the estimated 1 million households not being provided with electricity from the grid by 2018, this program component will target 25%, or approximately 250,000 households and 175 social infrastructure institutions. The figure is large enough to make a significant impact on Rwanda's electricity access rates, and will in addition demonstrate the technical and commercial viability of stand-alone systems, and establish the businesses able to deliver these solutions at scale. The remaining 75% represents the market potential for subsequent growth; in this way the SREP program aims to provide the catalyst for replication of the technology and associated business models.

Business Models. The REF will provide flexible support to different types of business model, with an emphasis on helping consumers to address affordability, and providing an incentive for on-going maintenance. These could include pay-as-you-go contracts, consumer financing arrangements and other approaches to improving the sustainability of the project by providing suppliers an incentive to use high quality and reliable products.

Electricity provision to social infrastructure. The sub-program can help to modernise public services. For example, in health provision facilities by expanding potential for refrigeration, improved lighting, and modern healthcare appliances, and in schools and administrative centres by providing lighting and electricity for appliances such as computers and communication equipment. Provision of off-grid power can be combined with advanced control equipment to result in improved quality of power supplies, which can help to reduce damaging impacts of power fluctuations.

Financing support. The REF will provide a combination of direct loans, first-loss guarantees to gear commercial finance, grant funding to address affordability barriers and technical assistance to improve business capacity and market-building. The balance between these mechanisms will be

tailored to individual business needs as they apply to the REF, and is therefore flexible at this stage. Financing support would be provided through a number of different mechanisms, including:

- Direct debt to companies and /or credit lines via local financial intermediaries to fund companies' working capital. Some companies may face barriers in raising sufficient capital to finance the working capital needs of procuring units to sell into this market, given that they would be paid back over a longer period of time.
- Results-based finance grants to companies. These will take the form of top-up payments above the amount received from consumers in monthly payments. These payments will allow companies to reduce the amount charged to consumers, allowing access to these systems for poorer households. These payments will also be financially secure, improving the credit-worthiness of the businesses providing the SHS.
- Risk guarantees. The risks associated with monthly payments from households in these markets are not well known, making it difficult to borrow money from either international or national financial markets. Risk guarantees providing some share of first-loss associated with payment defaults could be provided to off-set these risks and help companies to raise capital to finance their investments.
- Support for consumer finance. Support will be provided for business models that partner with providers of consumer finance (e.g., micro-finance institutions or SACCOs). This support will be via a credit line directed through a bank or other financial institution which already has working relationships with these micro-credit organisations.
- Technical assistance for market-building activities. Starting from a relatively low base, the rapid scaling up of this market will require substantial input to build the necessary business ecosystem and supply chains, as well as to build market demand through customer awareness campaigns.

Implementation Readiness

As noted above, the host institution for the REF will require some capacity building and / or arrangements to partner with a technical support organisation to provide the technical expertise required to assess stand-alone solar PV projects. This will take place as part of the preparatory arrangements during setting up of the REF. In addition, technical assistance will be provided to support development of the project pipeline to facilitate implementation readiness of this sub-project.

Rationale for SREP Financing

While there are initiatives in Rwanda promoting low-powered solar PV systems (e.g., lanterns), the approach for off-grid electrification using stand-alone solar PV systems has not been systematic and the proposed solar products proved to be unreliable and incapable of providing adequate levels of electricity access. The stand-alone solar PV sub-program will focus on initiating and catalysing the market for quality-certified and higher-powered systems capable of providing reliable and increased level of electricity access to multi-room lighting, mobile phone charging, and other low-power appliances such as radios and TVs. The program will substantially shift market perceptions and demonstrate the technical and commercial viability of stand-alone solar PV systems, establishing the businesses able to deliver these solutions at scale, whilst leaving substantial remaining market potential for subsequent growth. SREP support aims to provide the catalyst for replication of the technology and long-term sustainability of the associated business models.

Expected Impact

Overall targets for the Rwanda IP, including targets for the stand-alone solar PV sub-program, are set out in Section 10. The following outcomes and outputs are based on the provisional budget allocation of US$35m, but are subject to change depending on market demand and uptake.

The stand-alone solar PV systems sub-program would benefit directly over 250,000 households and 175 social infrastructure institutions in rural areas. The program will also contribute to all of the SREP program's key results and outcomes, namely, supporting low-carbon development pathways, reducing energy poverty, increasing energy security, increasing access to renewable energy and modern energy services, improving diversity of supply, stimulating private sector participation, attracting new and additional financial resources, and reducing environmental impact of energy consumption and generation.

Financing Plan Costing

Project / sector	Project component	Total investment US$m	Private Sector US$m	Other dev.partners US$m	REF budget US$m, of which:		
					MDBs (WB, AfDB)	GoR	SREP
Stand-alone solar PV systems	Market building prog.	2		2			
	Supporting investments	108.4	40.0	12.0	16.0	5.3	35.1
	Sub-total	**110.4**	**40.0**	**14.0**	**16.0**	**5.3**	**35.1**

The financing plan is based on the following assumptions.

- For *households*, the total system cost, including financing costs servicing of monthly payments and provision of maintenance for over 250,000 households is estimated at US$110m. The final amount of expenditure on SHS may vary, depending on the level of demand for this element of the SREP program compared to the other elements (i.e. mini-grids and investments in social infrastructure), but these assumptions provide the basis for financial planning at this stage.
- For *social infrastructure*, approximately 160 health clinics, 1,100 primary schools and 500 secondary schools were without electricity access as of June 2014. Approximately 10% of these will be targeted by the Rwanda IP, so that up to 175 institutional off-grid systems totalling approximately 530 kW capacity, and generating 1,900MWh/year would be installed. Total system costs including installation etc. would amount to an estimated US$5.3m. Setting the systems up as on-going payments for energy services will help to ensure that systems are maintained, providing high levels of reliability of energy provision. The scale-up potential arises from the sustainability benefits arising from additional energy access for these facilities, which should help to sustain the allocation of adequate budget from central government to support these services.

Appendix 6: Project Preparation Grant Request

SCALING UP RENEWABLE ENERGY PROGRAM IN LOW-INCOME COUNTRIES **Project Preparation Grant Request**				
1. Country / Region	Rwanda	**2. CIF Project ID #**	to be added	
3. Project Title:	Renewable Energy Fund (REF)			
4. Tentative SREP Funding Request (in US$ million total) for project at the time of Investment Plan submission (concept stage)::	Grant: Total US$ 49.7 million, of which US$ 22.2 million grant		Loan: Total US$ 49.7 million, of which US$ 27.5 million loan	
5. Preparation Grant Request (in US$):	US$ 800,000		MDB: World Bank	
6. National Project Focal Point	Mr Robert Nyamvumba, Head of Energy Division, Ministry of Infrastructure (MININFRA), Rwanda			
7. National Implementing Agency (project / program):	Ministry of Infrastructure (MINIFRA), Rwanda			
8. MDB SREP Focal Point and Project / Program Task Team Leader	Federico Querio Energy Specialist World Bank		Yadviga Semikolenova Senior Energy Economist World Bank	
9. Description of activities covered by the preparation grant:				
	Activity	**Description**		
a	REF Implementation Plan and institutional support	Develop fund implementation plan, scope and decide on host institution and capacity needs. Hire consultants to prepare the detailed design of the REF, including project selection criteria, institutional structure etc. Finance incremental costs incurred by the host of the REF to set up and operationalize the fund (professional legal and financial advice etc.).		
b	Building the pipeline of projects	Assess the market potential and identify pipeline of potential projects. Provide targeted support for companies to develop projects, particularly for mini-grids, since this is a relatively new area in Rwanda. This may include conducting an assessment of different business models, helping businesses define financing instruments to address viability gaps, and assist with REF proposals.		
c	Expand the market	Work with Government and development partners to design and co-finance awareness campaigns and other marketing activities to grow demand especially targeting ways of increasing the productive uses of energy in rural areas.		
d	Improve enabling environment	Help overcome institutional, legal and regulatory constraints through: i) developing technology standards for off-grid sector, ii) helping institutions to design and to enforce technology standards, iii) improvements in legal and regulatory framework for off-grid (especially mini-grids) including developing standard legal agreements and getting clarity on grid codes for potential		

		interconnection with the main grid iv) assessment of technical training requirement to address skills shortages
e	Develop M&E framework	Set up an M&E system in the off-grid electricity sub-sector and establish reliable baseline data for the sub-sector, building on upcoming efforts for applying the multi-tier framework (MTF) for measuring energy access in Rwanda. Work together with other development partners to support a comprehensive baseline assessment and support the Government to establish an on-going M&E system from which all programs in the off-grid sector can be evaluated.

10. Outputs: Policy Framework

Deliverable	**Timeline (CY)**
a. REF implementation plan	Q2 2016
b. Project pipeline development	On-going through 2016
c. Marketing activities	Campaign design: Q2 2016 Campaign implementation on-going 2016-2017 with development partner co-financing
d. Report on recommended interventions	Q3 2016
e. M&E design document Baseline study M&E system in place	Q2 2016 Q3 2016 Q4 2016

11. Budget (indicative):

Expenditures	**Amount (US$)** - estimates
Consultants	US$ 750,000
Workshops/seminars	US$ 20,000
Others (admin costs / operational costs)	US$ 10,000
Contingencies (Max 10%)	US$ 15,000
Total Cost	US$ 800,000
Other contributions:	
Government	US$ 50,000 (in-kind staff-time, organization of stakeholder consultations, etc.)
MDB	US$ 30,000 (staff time, etc.)

12. Timeframe (CY, tentative):
SREP Sub-Committee approval of REF Project: Q4 2016
World Bank Board approval: Q2 2017

13. Other partners involved in project design and implementation:
Following consultations with various stakeholders and partners, it is expected that the REF Project will be supported by several bilateral partners. They include the EU Delegation, the Belgian Delegation, and various implementing agencies including Belgian Technical Cooperation, GIZ, SNV

etc.
14. If applicable, explanation for why the grant is MDB executed: A recent reorganization in the energy sector led to the separation of the Energy, Water, and Sanitation Authority (EWSA Ltd) into two new companies, namely the Rwanda Energy Group Limited (REG Ltd) and Water & Sanitation Corporation Ltd (WASAC Ltd). REG Ltd is expected to be the implementing agency of all energy-sector related grants. In order to ensure the timely preparation of the REF project, the Government of Rwanda has requested the Project Preparation Grant (PPG) be executed by the World Bank with close consultation with REG Ltd and MININFRA.
15. Implementation Arrangements (incl. procurement of goods and services) The World Bank's procurement guidelines will be followed to hire consultants and procure other goods/services. The implementation of the preparation grant will be conducted in close collaboration with the World Bank and MININFRA where the SREP Focal Point is hosted.

Appendix 7: MDB Request for Payment of Implementation Services Costs

<table>
<tr><th colspan="5">SCALING UP RENEWABLE ENERGY PROGRAM IN LOW-INCOME COUNTRIES
MDB Request for Payment of Implementation Services Costs</th></tr>
<tr><td>1. Country/Region:</td><td>Rwanda/Africa</td><td colspan="2">2. CIF Project ID#:</td><td>(Trustee will assign ID)</td></tr>
<tr><td>3. Project Title:</td><td colspan="4">Renewable Energy Fund (REF)</td></tr>
<tr><td>4. Request for project funding (US$ million):</td><td colspan="2">At time of country program submission (tentative): US$ 49.7 million</td><td colspan="2">At time of project approval: n/a</td></tr>
<tr><td rowspan="2">5. Estimated costs for MDB project implementation services (US$ million):</td><td colspan="2" rowspan="2">Initial estimate - at time of Investment Plan submission: US$ 428,000

Final estimate - at time of project approval:</td><td colspan="2">MDB: World Bank</td></tr>
<tr><td colspan="2">Date: October 2015</td></tr>
<tr><td>6. Request for payment of MDB Implementation Services Costs (US$ million):</td><td colspan="2">First tranche: US$ 128,000</td><td colspan="2"></td></tr>
<tr><td>7. Project/program financing category:</td><td colspan="4">a - Investment financing - additional to ongoing MDB project o
b- Investment financing - blended with proposed MDB project X
c - Investment financing - stand-alone o
d - Capacity building – stand-alone o</td></tr>
<tr><td>8. Expected project duration</td><td colspan="4">5 years</td></tr>
<tr><td>9. Explanation of final estimate of MDB costs for implementation services:</td><td colspan="4">If final estimate in 5 above exceeds the relevant benchmark range, explain the exceptional circumstances and reasons: n/a</td></tr>
<tr><td colspan="5">10. Justification for proposed stand-alone financing in cases of above 6 c or d: n/a</td></tr>
</table>

Appendix 8: Independent Review and Team Responses

Part A: Full text of independent review undertaken by Dr Mike Allen, 6th October 2015

Introduction

The review of the Investment Plan for Rwanda has been undertaken ahead of the submission of the plan to the SREP Sub-Committee of the Strategic Climate Funds, within the Climate Investment Funds at the World Bank.

These notes are based on a review of the draft plan provided on 25th September 2015.

It should be noted that the reviewer has not visited Rwanda as part of this review, nor been involved in the preparation of this plan. The lack of a visit to Rwanda and any contact with the ministries, agencies, institutions and various stakeholders necessarily limits the personal background knowledge but the nature of the situation is common to many such economies. The reviewer is familiar with the energy issues facing Rwanda (most recently through involvement with the SREP Expert Panel) and the energy situation in the country through personal background work.

The Investment Plan (IP) provides a thorough background on the current energy situation in Rwanda, electrification efforts that are planned and underway with existing support and the relative cost effectiveness of the various technology solutions.

The hurdles to deployment are described in detail providing justification for the approach to utilise the requested SREP funds.

The IP outlines a proposal that SREP funds would be channelled through a purpose designed Renewable Energy Fund (REF) that will focus on supporting off-grid electrification. The IP suggests that the key focus will be on the promotion of mini-grids (both hydro and solar) and standalone solar installations.

It is noted that:

A proposal is currently under consideration to implement a Rural Electrification Fund in Rwanda with the aim of promoting rural electrification coverage. The scope of the proposed fund is wider than the Renewable Energy Fund described in the previous section, because it incorporates expansion of the central grid as well as off-grid and mini-grid projects. Nevertheless, there is considerable overlap, and it will be important to strongly co-ordinate the two initiatives. For example, one scenario could be that the Renewable Energy Fund (REF) is established using SREP as seed money, focussing on renewable sources of generation, plus off-grid and mini-grid applications. The rural electrification fund is set up to manage additional sources of revenue (such as levies raised on electricity sales), with expenditure channelled through the REF where appropriate (e.g. for off-grid and mini-grid access projects), and managed separately for projects outside the REF scope (e.g. grid extension).

Further work is required to assess the details of how the funds should be coordinated, and what institutional arrangements need to be made to manage them.

Throughout the discussions about the proposed fund there is a good recognition of parallel activities by others development partners and the need for close collaboration / integration of activities.

Experience elsewhere would suggest that it can be a difficult task to effectively integrate a fresh fund operation into an existing financing activity. The latter is likely to have established lending criteria and often these may not sit well with (for example) a more liberal offer of lower interest rate / smaller scale debt provisions, reduced collateral and the potential for some grant facilities.

Specific Comments on Investment Plan

The Country Energy Policy

The IP notes that:

The Energy Sector Strategy Plan (ESSP) has set a target of increasing electricity from around 22% (2014) to 70% by 2018. The plan calls for about 48% of the households to be connected to the grid, with the remaining 22% (about 550,000 households) to be served by off-grid solutions. Rwanda's Rural Electrification Strategy and Sustainable Energy for All Action Agenda, both of which are currently at the draft stage, provide the framework for serving rural households with renewable energy.

That these plans are evolving is not unexpected and other information in the IP provides a full review of current energy usage, electricity generation and plans for expansion. The grid connected supply from hydro and solar is shown to be some 65% of total capacity and there is capacity for additional growth. The off grid focus for SREP funds has been agreed based on a prioritisation of resources through the IP preparation.

It is encouraging that by 2025 it is anticipated that the technical generation potential is likely to be larger than demand at that stage allowing selection amongst competing new developments. Renewable energy should represent some 46% of generation by 2020.

Proposed SREP Programme

The IP outlines the rationale for the proposed SREP programme and its structure as follows:

The SREP programme in Rwanda will support the GoR's strategic objective of developing off-grid renewable electricity provision. The priorities for the programme are to support growth in private-sector markets for off-grid electricity services. The programme will be implemented via a Renewable Energy Fund (REF) to be set up to provide access to financing for companies providing off-grid electricity systems. SREP funding, together with various sources of co-finance, will provide the seed capital for the fund. It is expected that the fund will comprise a balance of grant and loan financing. The latter can be re-invested making the REF a revolving fund. It could also attract additional funding from other sources in the future, giving long-lasting influence in the sector beyond the initial 5-year investment programme of SREP.

The stand-alone and mini-grid solutions being promoted are to be through private-sector led market growth. This requires that there is a high degree of clarity and transparency of any support mechanisms, in order to avoid creating additional policy risk in the market, and to avoid crowding out private capital. In particular, grant support will only be provided where it is deemed essential to overcome specific market barriers. The main emphasis of the fund will be to help the market access the necessary level of capital. For example, the provision of debt-financing through SREP would be targeted to help catalyse private sources of financing.

Technical solutions for off-grid electricity range from whole village mini-grids down to solar systems for individual households. Both of these off-grid solutions have different advantages and niches, and they are at different stages of development in Rwanda. The programme will therefore need differentiated support mechanisms operating over different timescales, and it is planned to implement these via two distinct sub-programmes, albeit with flexibility in budgeting between the two programmes.

Financing

The table that follows summarises the anticipated SREP financing, co-financing and potential private sector financing leverage. ***{Note: comments included an earlier version of the financing plan. This has not been included here as it has been superseded by Tables 7 and 8 in Section 7 of the IP}.***

It appears that the MDB and private sector funds have been provisionally identified and are anticipated but they are clearly a significant (implied) contribution to the suggested leverage. The confirmation of their availability and application within the SREP programme should be a key point for clarification as the IP is being considered.

Comments on Components

From the information provided in the IP it would appear that there are a number of existing programmes supported by various donors within the renewable energy sector in Rwanda. Discussions around hurdles to accelerating development in this market are well identified but it is important to recognise that alternative (additional SREP) funding alone will not necessarily result in a rapid expansion of market activity.

The various technology questions around hydro and solar are well considered and should not present difficulties; the issues of availability of appropriate funding for companies, customer awareness of renewable options, a willingness and capacity to pay are however ongoing challenges.

The proposal to flow the SREP funds through the Renewable Energy Fund, in close collaboration with the Rural Electrification Fund, while looking to offer a wide range of financial products directly and through other organisations, may however be a bigger challenge that it may appear on paper. For example, in the IP it is suggested that:

The concept design report recommends that the REF makes investments through:

- *Local financial institutions, such as commercial banks and MFIs;*
- *Local and International NGOs operating funding activities;*
- *International technical cooperation agencies, such as GIZ, SNV and GVEPI;*
- *Fund / equity managers;*
- *Established guarantee programmes such as that operated by BDF;*
- *Formal sector savings and credit cooperatives such as Mwalimu Sacco;*
- *Umrenge Saccos;*

This breadth of activity may be hard to achieve in practice; care should be taken to ensure that the complexity of the fund design, its management and operation do not in themselves limit the opportunity to provide real and sustainable growth in the target energy markets; developing simple yet fully transparent criteria supported by strong governance will be key to success. Despite a good level of discussion around possible structures, there would appear to be work still required to more tightly describe the fund structure and its operations.

Given the experience in Rwanda in undertaking renewable projects to date the projects and focus suggested for support through SREP appear reasonable. The main concern is in implementation capacity and a clear demonstration that other funders / investors can be attracted to support the initial and subsequent programmes.

It may be of value to critically review the specific roles that the SREP funds would play in expanding the off-grid activities, given the programmes being supported by other donors and the presence of a reasonable number of private companies in the market.

The IP discusses a wide range of support mechanisms and there should be an early effort, as the fund is being designed, to ensure further discussion with likely recipients – companies, other financial institutions or end users – to confirm that these facilities are those most appropriate at the time and that they will allow available funding to be drawn down in a timely manner. (The IP does note this need for flexibility).

Compliance with SREP Goals

Key focuses within the SREP programme can be summarised under the following headings; the response of the IP to each of these aspects is noted in the following comments.

Catalyse increased investments in renewable energy:

The plan outlines how it is anticipated that SREP investments and programme support will help attract other donor and private funding. As noted this is an aggressive plan with SREP funding the basis for what is anticipated would see significant leverage of other funds. This has yet to be clearly demonstrated as achievable. In particular it will be important to confirm the level of private sector interest and capability. The design and implementation of the proposed fund operation will be a key element of this programme.

Enabling environment

The IP acknowledges that there are a number of unaddressed hurdles to renewable implementation; there are strategies and an allocation of responsibilities to improve the enabling environment. Without prior engagement with national agencies it is hard to assess whether these tasks can reasonably be achieved by these entities. This process will require close monitoring as the success in establishing a sound enabling environment will be a key control on the value of the SREP investments.

Increase energy access:

The need for increased access to energy is clear. The SREP support should help accelerate this and the off-grid focus implies the opportunity to improve access at an individual level. Mention is made of SREP funds being used to reduce cost / increase affordability; use of funds for these purposes needs to be judicious to ensure that any subsidies, their impacts and eventual withdrawal are carefully considered.

Implementation capacity:

The actual construct of the proposed Renewable Energy Fund, its management and governance have yet to be resolved. Wider programme implementation using SREP funds will require considerable collaboration with a variety of institutions, both public and private sector. There is limited information on the capacity within these organisations but appropriate training will be a key element of success at all levels.

Improve the long-term economic viability of the renewable energy sector:

The (non-hydro) renewable energy sector in Rwanda is relatively young but appears to be growing steadily. The IP notes that there are an increasing number of private sector entities that have been engaged in the domestic PV market and this is encouraging. Clearly there are still policy and regulatory issues that need resolution; attention appears to be directed at resolving the issues that are being faced and the SREP intervention should support these efforts.

It is often suggested that SREP funded activities will drive a more focused and sustainable basis for future growth; there needs to be increased private sector engagement and this will only occur, on a sustained basis, when regulatory and pricing signals are clear and acceptable to the market. SREP funds must therefore be directed into projects where conditions are conducive to ensuring such outcomes. As noted, care must be taken to avoid inappropriate subsidies that cause market distortions.

Transformative impact:

The targeted nature of the proposed SREP investments in Rwanda is seen as pragmatic given the current energy market status, limited electricity access and a need to enhance the enabling environment. Given the renewable sector is relatively immature it is not to be expected that there will be major transformations in the market through SREP alone but if well managed and executed the proposed programme should help further develop the wider renewable energy sector in the country.

Experience suggests that demonstration projects with specialist funding, such as SREP, will not necessarily ensure that an attractive commercial market place results quickly.

Comments and Recommendations

The IP demonstrates the effort that has gone into the background research and evaluation of potential options that could be supported under SREP funding in Rwanda.

The Investment Proposal in itself is thorough and comprehensive. The off-grid focus appears to be a sensible option in terms of helping grow the renewables contribution as rapidly as possible; the growth in grid connected hydro will continue to address the question of broader access to energy for those on the existing grid networks.

Providing facilities that will reinforce the attraction of the private sector into renewable projects is recognised as challenging but the potential innovation of the Renewable Energy Fund approach under this SREP programme will test the practicality of such a mechanism. It will no doubt provide experience that can only be of value in determining the best models for future expansion of the energy sector.

The complexity of designing and operating an effective fund within such a targeted market should not be underestimated. Simplicity, transparency and strong governance must be provided to ensure that the funds are employed in a responsible and cost efficient manner. Reference to similar efforts internationally (through MDB contacts and others) will be valuable to ensure lessons learnt by others can improve the effectiveness of the fund proposed for Rwanda.

Solar PV activities are noted as already attractive to the private sector and care should be taken to ensure that the availability of SREP funds does not discourage this participation. Particular care should be taken where any direct or implicit subsidies are contemplated to provide interim market support.

Part B: Response to Comments from Independent Reviewer

The following table outlines how the review comments of Dr Mike Allen have been addressed in the revised version of the Rwanda IP.

Location of comment	Response to Comments
Introduction	The need for collaboration with other agencies is well noted. The quoted text referring to a 'Rural Electrification Fund' has been removed from the final text of the IP, since the ideas for such a fund are still at draft stage. All actors agree on the need for integration of any such activities in the future, and the text of the IP has been adapted to imply that the REF would be set up with a broad mandate, albeit with an initial focus on SREP funding to be used for off-grid renewables. This should allow it to fulfil the wider mandate of a rural electrification fund at a future date in line with developing government strategy. These issues will be further addressed during the final design phase of the REF. Regarding the issue of who is responsible for improved quality standards, the IP text has been clarified to describe how the issues of quality standards will be addressed through the TA component of the fund. The Appendix on stakeholder engagement has been extended to include summaries of key issues identified through consultations.
Specific Comments on Investment Plan	Acknowledging the reviewers point regarding the complexity of the fund design, the IP now focuses attention on anticipated core activities for the REF, reducing the level of complexity. Comments regarding the design issues of the REF are well taken, and these are expected to be addressed during the detailed design phase of the fund. The concern regarding implementation capacity is noted. The section on Technical Assistance in the IP now describes more clearly how this will be addressed. The reviewer's suggestion to maintain dialogue with likely recipients is also incorporated into the activities planned under requested project preparation grant described in Appendix 6.
Compliance with SREP Goals	Discussions with private sector investors have been carried out throughout the consultation process, and the need for these to continue are duly noted to confirm that plans of all co-financiers for the program are evolve in step with each other. As noted by the reviewer, various issues regarding enabling environment and institutional capacity need to be addressed; the text of the IP has been clarified regarding arrangements for TA to achieve this.
Comments and Recommendations	The positive comments from the reviewer are duly noted and welcomed. The recommendation to simplify the REF approach where possible have been noted, and reflected in the revised IP text. Reference has been made to other similar regional practices from which the REF design team can learn. The note of caution regarding use of subsidies is duly noted; this is noted in the IP text, and will be taken fully into account in the detailed design phase to follow.