CASTALIA
Strategic advisors

# Rwanda Electricity Sector Access Programme

## March 2009

## Volume I: Investment Prospectus



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# Glossary of Terms

## Abbreviations and Defined Terms

| | |
|---|---|
| AfDB | African Development Bank |
| AEPE | Programme d'alimentation en eau potable et electricité |
| BTC | Belgian Technical Cooperation (Coopération Technique Belge) |
| DRC | Democratic Republic of Congo |
| EDPRS | Economic and Development Poverty Reduction Strategy |
| EICV | l'Enquête Intégrale sur les Conditions de Vie |
| Government | The Government of Rwanda |
| ICT | Information and Communications Technology |
| IDA | International Development Agency |
| MIFOTRA | Ministry of Public Service and Labour |
| MINALOC | Ministry of Local Government |
| MINISANTE | Ministry of Health |
| MINECOFIN | Ministry of Economy and Finance |
| MINEDUC | Ministry of Education |
| MININFRA | Ministry of Infrastructure |
| MOU | Memorandum of Understanding |
| MTBF | Medium Term Budget Framework |
| NELSAP | Nile Equatorial Lakes Subsidiary Action Programme |
| NIS | National Institute of Statistics |
| NGO | Non Governmental Organization |
| NUR-CGIS | National University of Rwanda – Centre for GIS |
| PEPFAR | U.S. President's Emergency Plan for AIDS Relief |
| RECO | Rwanda Electricity Corporation |
| RPPA | Rwanda Public Procurement Agency |
| RURA | Rwanda Utilities Regulatory Agency |
| RWASCO | Rwanda Water and Sanitation Corporation |
| STEG | Société Tunisienne de l'Electricité et du Gaz |
| UERP | Urgent Electricity Rehabilitation Project |
| UNDP | United Nations Development Programme |

## Technical Terms

| | |
|---|---|
| ADMD | After Diversity Maximum Demand |
| CFL | Compact Fluorescent Light bulbs |
| EBITDA | Earnings Before Interest, Taxes, Depreciation and Amortization |
| EPC | Engineering, Procurement and Construction |
| GIS | Geographic Information System |
| ICT | Information and Communications Technology |
| IPP | Independent Power Producer |
| MOU | Memorandum of Understanding |
| PPA | Power Purchase Agreement |
| PSP | Private Sector Participation |
| Solar PV | Solar Photovoltaic |
| VAT | Value-Added Tax |

## Currency Conversion

RWF 550 = US$1 (as at January 2009)

# Executive Summary

The Government of Rwanda is leading a nationwide initiative to extend access to electricity. This initiative involves a coordinated effort across all power sector participants to connect new customers, commission new generation facilities to supply new and existing customers, reduce the cost of generation by switching to more efficient supply sources and develop domestic industries to supply materials for electricity sector expansion. Rwanda's electricity access programme will begin with a five-year investment plan designed to achieve the Government's stated targets set out in the Economic Development and Poverty Reduction Strategy (EDPRS). These targets call for the total number of electricity connections to increase from 100,000 in 2008 to 350,000 by 2012, with a special emphasis on connecting social infrastructure—health facilities, schools and administrative offices.

The Government acknowledges that the targets set for electricity access are ambitious. However, the planning presented in this Prospectus shows that the targets are achievable:

- The total cost of required sector investments can realistically be met through affordable customer charges, Government funding and support from development partners
- The national electricity utility and domestic and international contractors will have sufficient capabilities to meet the technical challenges of the programme.

This Prospectus presents the Government's current plans for the electricity access programme. The Government and sector stakeholders have worked hard to ensure that the programme is based on a thorough assessment of policy conditions, technical and economic planning, funding requirements and implementation capacity. This Prospectus addresses each of these critical components of the programme, and describes a role for development partners in supporting the access programme.

**Sector Policy Reforms and Government Initiatives**

The electricity sector in Rwanda has experienced a major transition over the last five years. In 2004 a drought period exposed the country to electricity shortages, highlighting the need for greater energy diversification and better power system planning. The Government of Rwanda responded to the electricity shortage as a high priority, and together with development partners has implemented major investments and planning initiatives that have helped to resolve supply constraints.

The Government has articulated a strategic vision for the next phase of energy sector development in its national energy policy and strategy, and has enacted a new legal framework to put the new energy sector policy into action. A major theme in the new legislation is that private sector investment and management will play a significant role in developing the sector, within a regulatory environment that protects consumers and enables investors to recover their costs. The emphasis on private sector involvement reflects the Government's commitment to move away from a Ministry-managed electricity sector towards a transmission and distribution network managed by an efficient utility, while allowing increasing levels of private sector investment in generation.

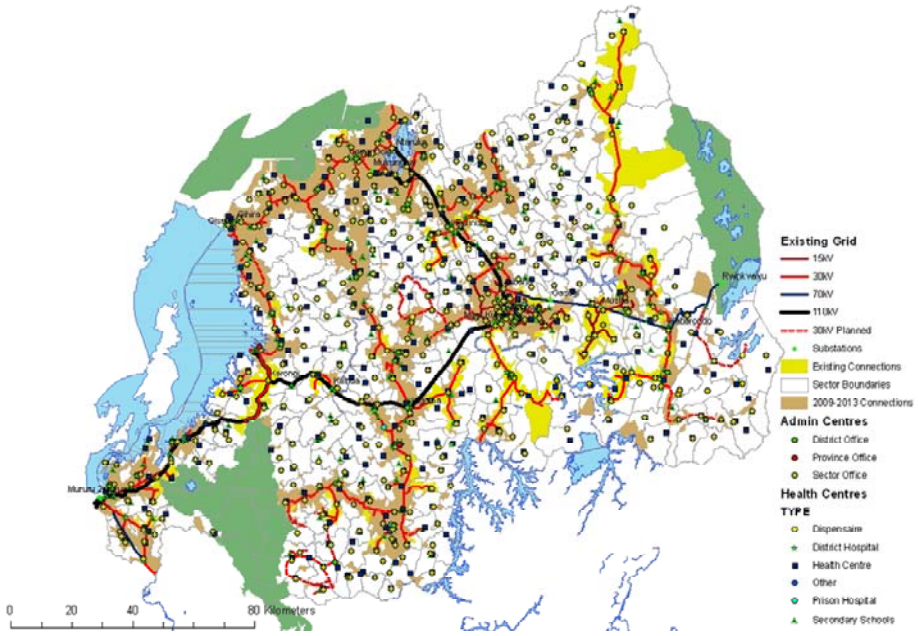
## Electrification Planning for the Access Programme

In a joint effort with the national electricity utility in Rwanda, the Government has begun planning the national electricity access programme. This planning work identifies the most sensible way for electricity to be extended over the next 20 years—with a particular focus on the next five years—based on the demographic, social and economic characteristics of different locations within the country and the supply and demand conditions for electricity in Rwanda. This planning exercise estimates the cost of the electricity access programme and highlights the most significant programme implementation challenges.

An overview of the results of the electrification planning exercise is provided in Figure A. Planning cells with existing connections are shaded yellow, and planning cells with new household connections that have been prioritised for the 2009–2013 period are shaded light brown. This prioritisation has been set to achieve some grid electricity supply to 100 percent of sectors by the end of 2013. All social institutions falling within the shaded planning cells are earmarked for grid connection. The remaining social institutions targeted for electricity supply are shown by distinct symbols in the figure below, and will be equipped with solar PV units.

The results show that the Government's ambition of ensuring that all administrative centres, schools and health facilities are electrified and extending access to around 16 percent of households by 2012 is consistent with a technically feasible and efficient access programme. These results can be achieved by progressively extending the medium voltage network, and concentrating initially on increasing the number of connections within the areas already reached by the MV network. Given the high population density in Rwanda, the plan shows that most areas of the country can expect to be connected to the national grid. However, in some areas, local mini-grids based on micro-hydro and solar PV systems will continue to be efficient for some time.

**Figure A: Results of Electricity Access Programme Planning**



A series of important conclusions on the priorities for the access programme can be drawn from this geospatial planning exercise:

- **Focus on communities close to the existing network**—Rwanda is fortunate to have a relatively well-developed MV transmission network, with more than 60 percent of the population within five kilometres of the grid. Over 95 percent of planned new connections to 2012 are within five kilometres of the existing grid
- **Focus initially on more densely populated areas**—New connections will initially be made in the urban area of Kigali and peri-urban areas in the northeast of the country. This will help to minimise programme costs and maximise economic opportunities
- **Connect social facilities with solar PV in remote areas**—To reach the Government's targets for supplying electricity to schools, health centres and administrative offices, social facilities falling outside the areas that will be reached by the grid will have solar PV units. This will help to ensure that the benefits of electricity are accessed by all Rwandans citizens.

**Estimated Cost of Access Programme**

The cost of each component within the access programme has been estimated by analysing the costs incurred in recent electrification projects in Rwanda, and discussing component costs with local and regional suppliers. Recent electrification projects in Rwanda have been expensive, and this Prospectus accounts for cost reductions that are expected to be achieved through the access programme's scale and by revising technical specifications.

**Table A: Capital Costs of Electricity Access Programme (2009–2013)**

| Programme Component | Investment (US$ million) | Technical Assistance (US$ million) | Total (US$ million) |
|---|---|---|---|
| MV Line Extensions | 104.3 | 0.9 | 105.2 |
| Expansion Connections | 70.8 | 0.8 | 71.6 |
| Micro Hydro Supply Systems | 54.3 | 0.5 | 54.8 |
| Infill Connections | 52.4 | 0.4 | 52.8 |
| MV Strengthening | 34.6 | 0.4 | 26.4 |
| Solar PV Units | 26.2 | 0.2 | 35.0 |
| RECO Strategic Plan and Training | 0 | 19.5 | 19.5 |
| Other Technical Assistance to MININFRA | 0 | 9.2 | 9.2 |
| Solar Hot Water | 4.7 | 0.3 | 5.0 |
| Compact Fluorescent Lightbulbs | 1.6 | 0 | 1.6 |
| **Total Cost of Roll-out Programme** | **348.9** | **28.7** | **377.6** |

Table A illustrates that the cost of new MV distribution line is a major component of the access programme. Distribution line costs have traditionally been very expensive in Rwanda,

and work is underway to reduce these costs for the access programme. The electricity utility has already identified ways to lower the cost of new MV extensions, such as revising the technical specifications used in recent electrification projects and developing local capacity to manufacture required materials. The scale of the access programme will also reduce costs by enabling private contractors to recover fixed costs over a larger quantity of new connections.

**Funding Plan**

A summary of per household capital costs for the access programme is provided in Table B. Costs are shown separately for the total access programme investment package and for required investments in MV/LV infrastructure.

Table B shows the capital costs of rolling out the transmission and distribution network to achieve the required number of new connections derived from the geospatial planning exercise, as well as the capital costs of off-grid solutions where those are more efficient. Connection costs start at around US$1,300 per household in 2009 and fall to around US$1,200 in the remaining years of the EDPRS as the programme achieves cost reductions. The cost savings are partially offset each year as the programme moves from connecting primarily urban and peri-urban customers to reaching more rural communities. The total costs of the programme fall in 2013 to less than US$900 per household as investments to achieve the Government's EDPRS targets are no longer required.

An indication of the additional costs incurred in the access programme by targeting remote communities and social institutions is also provided in the right hand columns of the table. These estimates only include MV/LV investments in the cost per household calculations (excluding costs incurred through solar and micro-hydro investments). Focusing only on the cost of MV/LV infrastructure reduces per household investment costs to less than US$1,000 in 2009 falling to around US$600 in 2013.

**Table B: Capital Costs of Electricity Access Programme per Household (US$)**

| Year | Households Connected | Total Investment (US$ million) | Cost per Household ($/HH) | MV/LV Investment (US$ million) | Cost per Household ($/HH) |
|---|---|---|---|---|---|
| 2009 | 36,969 | 56.1 | 1,323 | 35.5 | 959.7 |
| 2010 | 57,428 | 78.9 | 1,247 | 50.4 | 877.2 |
| 2011 | 65,983 | 84.2 | 1,194 | 47.1 | 713.5 |
| 2012 | 67,661 | 92.1 | 1,281 | 51.6 | 763.3 |
| 2013 | 71,645 | 66.3 | 882 | 43.0 | 599.6 |
| **Total** | **299,686** | **377.6** | **1,185** | **227.5** | **782.6** |

The programme to increase electricity access also needs to be fully integrated with the ongoing provision of services to existing customers, as well as efforts to improve the quality of the network and develop new, lower-cost sources of generation. For this reason, the access programme considers the funding needs for system expansion within the overall funding requirements for the sector.

There are three sources of funds for the electricity sector: customer payments, Government subsidies and contributions from development partners. For the power sector to be financially viable, the entire funding needs of the sector—which include both capital and operating costs—must be able to be covered from these three sources of funds.

The Government has prepared an initial analysis of how total sector funding needs over the next five years (2009–2013) will be met from the three major funding sources:

- **Funding needs**—The total funding needed to meet operating costs and achieve the Government's sector plans for new generation and transmission investment and the access programme is estimated to be US$875 million, an average of US$175 million per year
- **Funding sources**—In its new energy sector policy the Government has stated that, at a minimum, operating costs should be met through operating revenues. Additional funding will then be provided through Government contributions and development partners to meet the capital costs of the access programme and investments in generation and transmission capacity. The Government proposes a sustainable financing framework for the electricity sector that will see 10 percent of the capital costs of new grid extensions provided through connection charges, 10 percent of the capital costs of new grid extensions provided from the utility's financial resources (funded from surplus tariff revenues), and the remaining 80 percent funded by the Government and development partners.

The ability to fund operating costs through customer payments is greater in Rwanda than many other African nations due to Government decisions to raise tariffs in recent years. The current residential electricity tariff in Rwanda is around 20c/kWh (112 RWF/kWh), excluding value added tax. The Government recently completed a study to understand whether tariffs can be adjusted to account for the lower cost of new generation sources. This study found that the Government needs to be cautious before implementing any tariff cuts, as the true costs of serving different customer classes are not yet known. To achieve a balance between affordability and the need for customer funding, the financial balance for the sector has been calculated assuming that consumers are asked to contribute an average amount of US$100 (10 percent) towards the cost of connection.

The Government plans to complete a full tariff study this year to consider this issue further. At this time it is clear that given a plausible range of tariffs and connection charges that are affordable for Rwandan households, more than half of the total costs of the sector will need to come from the Government and the development partners. This contribution will have an important effect on accelerating growth and reducing poverty. As incomes rise over time, the power sector in Rwanda will become self-sustaining and electricity will become affordable for a greater proportion of Rwandan households.

### Programme Implementation

The Government recognises that the access programme will require a significant scaling-up of capacity to efficiently manage the programme and procure the required materials. The electricity utility in Rwanda, Electrogaz, has already increased the rate of making new connections through the use of external contractors to complete low voltage distribution network extensions. In 2008, Electrogaz made over 20,000 new connections compared to only 1,000 new connections five years ago. The utility will continue to expand its use of

external contractors, and will be more able to attract private sector interest in tenders through the increased scale of the access programme.

A number of organisational changes to Electrogaz have also been proposed to assist project implementation. These include:

- **Forming a dedicated electricity utility**—Electrogaz has traditionally been responsible for providing electricity and water utility services in Rwanda. The Government has recently passed laws to create separate utilities for electricity and water—the Rwanda Electricity Corporation (RECO) and the Rwanda Water and Sanitation Corporation (RWASCO). This change will allow the RECO management to focus on the efficiently providing electricity throughout Rwanda
- **Increasing the operational autonomy of the electricity utility**—The Government is committed to providing a sufficient level of operational autonomy to the electricity utility to implement the access programme. The utility will be empowered to determine the details of programme implementation and will be held accountable for programme outcomes
- **Establishing a dedicated function for the access programme**—A separate programme implementation unit will be established within the national electricity utility to implement the access programme. This will help to ensure that the programme remains a focus for the organisation and that the programme has sufficient resources to be managed effectively. The UERP provides valuable experience for establishing this unit.

To ensure the sustainability of the programme, the Government is committed to continuing closely monitoring and evaluating sector outcomes. In addition to achieving the targets set for new household and social infrastructure electricity connections, Government officials will monitor financial flows for the access programme to ensure that revenues from customer payments meet operating costs and make a contribution towards capital expenditures.

**Participation of Development Partners**

After accounting for customer connection charges and tariff payments, the electricity sector is projected to need further funding of around US$500 million from the Government and development partners to achieve the desired sector development targets to 2012. This includes capital developments in generation, new transmission facilities and the access programme. The access programme alone will require more than US$300 million from the Government and development partners (80 percent of the programme's projected capital cost). The Government will make a strong financial commitment to the access programme to underscore the importance of electricity access for the country's development.

Assuming a fiscal commitment of US$50 million from the Government, development partners are asked to contribute a further US$225 million to the access programme. This amount excludes components of the access programme that have already received funding commitments from development partners, which total over US$35 million. A notable example of early donor commitment to the access programme is the solar energy project that received grant funding of over US$10 million from members of the European Union. Under this programme rural schools, health centres and administrative offices will receive electricity supply using solar PV installations.

# 1 Purpose of Prospectus

The Government of Rwanda has set ambitious targets for extending electricity access under the Economic Development and Poverty Reduction Strategy (EDPRS). The Government's targets call for the total number of electricity connections to be increased from around 100,000 connections to 350,000 connections by 2012, with a special emphasis on connecting social infrastructure—health facilities, schools and administrative offices.

This Access Programme Investment Prospectus (the "Prospectus") presents a five year plan for extending electricity access that achieves Rwanda's EDPRS targets and integrates technical, financing and implementation planning components. The Prospectus seeks to raise US$250 million from development partners to fund access programme investments. The Prospectus aims to ease the analytical burden on development partners by providing credible information on Rwanda's electrification plans and presenting all relevant information and analysis on the access programme in one document.

This Prospectus focuses on the period from 2009–2013 although the electricity access programme will continue beyond 2013. The technical, financing and implementation plan presented in this Prospectus has been developed using a longer-term planning horizon to 2020. The results of this planning exercise indicate that the sector will become more financially self-sustaining after 2013, which will reduce the level of financial support needed from development partners.

The approach to achieving the Government's electrification targets is driven by building local implementation capacity from a low starting base and encouraging long-term financial sustainability in the electricity sector. This Prospectus offers development partners an opportunity to contribute to the access programme in Rwanda by providing grant finance for the programme.

The access programme in Rwanda is taking place within a sector-wide approach to energy investment, which facilitates cooperation between the Government and development partners on electricity sector expansion. The paradigm of the sector-wide approach lends itself naturally to broad funding approaches such as general budget support, earmarked budget support and sector-specific basket funding. However, other funding arrangements can also be used to implement the investments presented in this Prospectus, for example, targeted mechanisms such as project-specific support and technical assistance funds.

The contents of this Prospectus are as follows:

- **Section 2. Access Programme is a Critical Part of Electricity Sector Development**—provides essential background to the access programme. This section illustrates that the access programme is an important step to provide more Rwandans with modern forms of energy and greater economic opportunities. The Government's targets for electricity access are presented
- **Section 3. Sector Institutions Ready for Access Programme**—describes the measures the Government has put in place to prepare for the access programme. This section discusses how the programme takes place within a new paradigm of sector-side development, which relies on a coordinated and consistent approach to electrification. This section also presents an overview of current sector institutions, policy direction, and relevant laws and regulations

- **Section 4. Geospatial Roll-out of Electricity Access**—presents the physical plan for undertaking the electrification roll-out based on a critical assessment of technical and economic feasibility. This section presents geospatial information that illustrates the high-level plan for connecting new households and social infrastructure to the electricity network, based on a well-developed prioritisation methodology to select a development path that maximises programme benefits and minimises costs
- **Section 5. Funding for the Access Programme**—evaluates the availability of funding to meet projected costs. This section presents the results of a cash-flow model of expenditures on investments and operations, matched against financial inflows from customer payments and explicit Government contributions from 2009 to 2012. This enables a funding gap to be calculated that must be met through support from development partners for the access programme to succeed
- **Section 6. Implementing the Access Programme**—describes the approach that will be used to scale-up implementation capacity for the access programme. This section covers important programme issues, such as strategies to reduce costs through the efficient procurement of materials and approaches to recruit and retain staff with the skills required for the programme. The role of private sector industries in supplying materials for the access programme is also discussed
- **Section 7. Support from Development Partners**—summarizes the level of support required from Rwanda's development partners through financial contributions and technical assistance. The section sets out the key risks anticipated in carrying out the access programme, and discusses an ongoing monitoring and evaluation framework to ensure regular oversight and reporting on the outcomes of the programme.

# 2 Access Programme is a Critical Part of Electricity Sector Development

The access programme is an essential component of the Government's agenda to provide Rwandan citizens with modern forms of energy. This agenda is important for the Government in order to promote more economic opportunities and reduce poverty in both urban and rural areas of the country. The access programme comes at a critical time in the trajectory of energy sector development in Rwanda. In 2004, a drought period exposed the country to electricity shortages, highlighting the need for greater energy diversification and better power system planning. Since that time, the Government and energy sector participants have successfully managed the supply crisis and positioned the sector for a phase of sustainable and well-supported growth.

This Section describes how the transition from crisis management to system expansion has occurred, focusing on the investments that have been made to reinforce electricity supply in Rwanda. The proposed system expansion under the access programme is discussed by presenting the Government's targets for electricity access to 2012. This section also highlights how the programme fits within the strategic and macroeconomic direction of the country to enhance economic performance as a means to reducing poverty.

## 2.1 Solving Rwanda's Shortage of Electricity

The electricity sector in Rwanda has recently experienced shortages in generating capacity, resulting in blackouts and unmet demand for electricity. The Government of Rwanda quickly realised that responding to the electricity shortage was a high priority and has implemented major planning initiatives and capital investments that have helped to resolve supply constraints. These actions mean that supply from the electricity system can now meet demand.

Responding to the electricity supply crisis has been the main focus of investment activity from 2004 to 2008. A total of around US$45 million has been successfully invested under the Urgent Electricity Rehabilitation Programme (UERP), delivering 20MW of thermal generating capacity and rehabilitating segments of Rwanda's transmission and distribution network. Considerable effort has also been applied to build capacity in power system planning, with critical investments in bulk supply identified to enhance reliability and lower the costs of supply. A master planning exercise is currently underway to plan the long-term development of the electricity system in Rwanda.

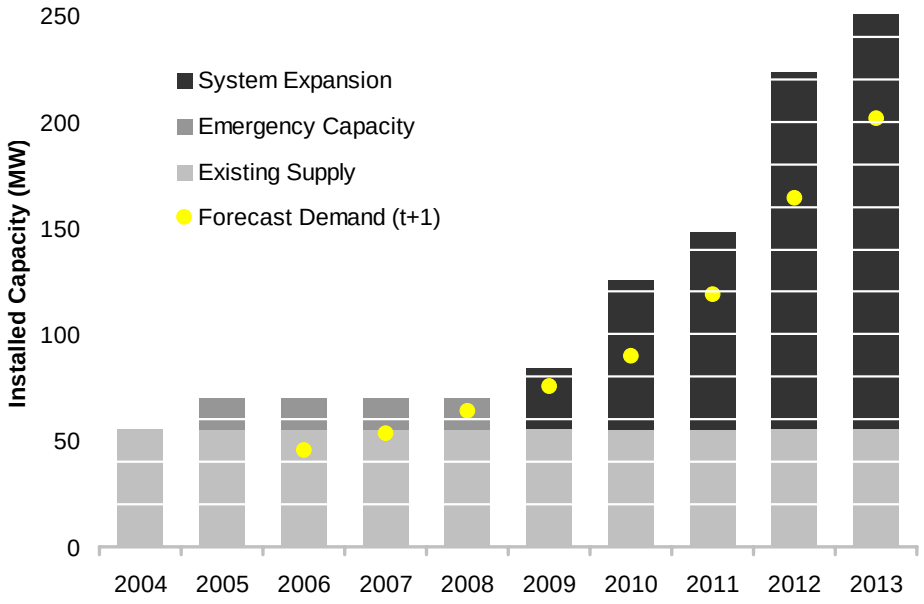
Figure 2.1 presents the installed generation capacity in Rwanda and the level of demand forecasted in the Master Plan for the following year (Fichtner, 2009).[1] This highlights that the transition from a shortage in generation capacity to system expansion has occurred in Rwanda through three phases:

- First, investments in rented emergency diesel capacity from 2005 resolved immediate supply shortages

[1] The demand forecast for the following year (t+1) is used to compare the generation capacity that will be available at the end of the proceeding year to meet demand. This approach is appropriate because in some cases new generation will be commissioned part way through the year.

- Secondly, commissioning of the UERP thermal plant towards the end of 2008 has allowed rented units to be displaced, lowering the overall cost of electricity supply while still meeting forecast demand in 2009
- Thirdly, planned investments in hydro, methane gas and micro-hydro generation will support system expansion to 2013. Figure 2.1 adds new generation capacity according to current expected commissioning dates provided by MININFRA. The 9.5MW hydro plant at Rukarara is projected to be available from the end of 2009 and the 27.5MW plant being built at Nyaborongo is expected to be commissioned at the start of 2013. A new 25MW methane gas plant at Lake Kivu is expected to be available from the start of 2011, and new micro-hydro plants are expected to be commissioned incrementally from 2009–2012.

**Figure 2.1: Generation Expansion—From Supply Shortage to System Expansion**




Source: Electrogaz Reports and Government Estimates

Figure 2.1 (above) indicates that planned new generation capacity will be sufficient to meet projected domestic demand, even under the high demand scenario in the Master Plan. As discussed later in this Prospectus, the Government expects that the additional generation capacity will both improve reliability and will be available for trade with other countries in the region as transmission interconnections are developed and the East Africa Power Pool progresses.

Table 2.1 (below) considers the impact of delays in commissioning new generation plants. This highlights that a 12-month delay in any of the planned new plants over 5MW would not threaten system reliability, with reserve margins maintained of available generation over demand of at least 20 percent.[2] This does not mean that there is no risk of supply shortages during the next five years. Given the large increase in demand forecast over this timeframe, power system operators and planners will need to work hard to ensure that existing and new

[2] In Section 4.4 we also present a high-level assessment of network capacity, which suggests that adequate capacity will be generally available to support the new connections during the initial years of the access programme.

supply capacity is available as expected. We also note that although planned supply appears sufficient to meet demand for the next five years, planning work needs to proceed for further new generation to meet demand to 2020. The Master Plan projects peak demand of almost 400MW in 2020 in the maximum demand scenario, while currently planned generation will raise available capacity to around 250MW.

**Table 2.1: Impact of Potential Delays on Available Generation Reserve Margin**

| Indicators | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| Base supply forecast reserve margin | 24% | 40% | 39% | 47% | 34% |
| Rukarara 12 month delay | 24% | 35% | 39% | 47% | 34% |
| Methane Phase I 12 month delay | 24% | 25% | 39% | 47% | 34% |
| Methane Phase II 12 month delay | 24% | 40% | 39% | 20% | 34% |
| Nyaborongo 12 month delay | 24% | 40% | 39% | 47% | 26% |

In addition to improving supply, the electricity sector has achieved significantly better financial performance in recent years. The national electricity and water utility, Electrogaz, has moved from recording annual operating losses of over US$9.1 million (RWF 5 billion) in 2004 to making a small operating profit in 2007 of US$4.6 million (RWF 2.5 billion). This turnaround in financial performance can be attributed to three factors:

- Increases in electricity tariffs from RWF 42/kWh in 2004 to current tariffs of RWF 112/kWh (before value added tax)
- Increases in Government support in the form of direct subsidies, fuel purchases and tax relief
- Increases in the number of electricity customers served by Electrogaz, from around 65,000 in 2004 to current connections of just over 100,000.

The financial management systems within Electrogaz have also been enhanced. An experienced Chief Financial Officer has recently joined the utility, and the process of auditing annual accounts has been brought up to date.

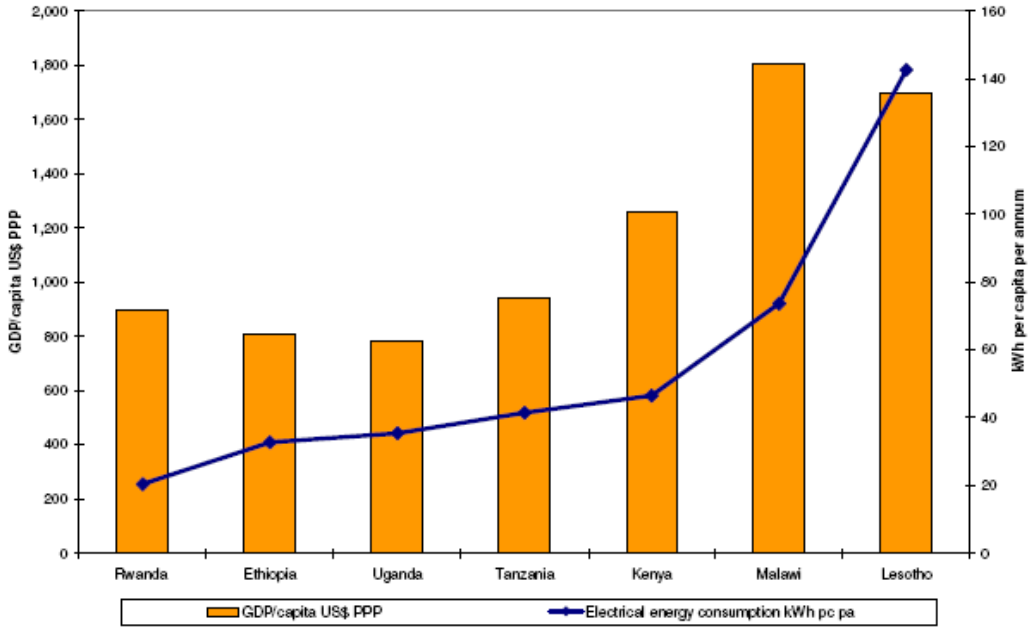
Measures implemented in the past four years have greatly enhanced the operational and financial grounding of the electricity sector in Rwanda. The access programme will take advantage of these recent sector achievements to rapidly increase access to the electricity in Rwanda. The time to expand access to electricity in Rwanda is now.

## 2.2 Government Goals for Expanding Access to Electricity

Expanding access to electricity in Rwanda is central to the Government's plan to improve economic growth as a means of providing employment opportunities and reducing poverty. The Government has established the "Vision 2020" framework for Rwanda's development, which contains a focus on improving the nation's energy, water and ICT infrastructure. The full benefits of these macroeconomic priorities will not be realised without enhancing access to electricity. The access programme is supportive of the focus of economic development in Rwanda, and forms part of a larger transition to use energy more efficiently and progressively displace the use of biomass with petroleum products and electricity.

Figure 2.2 shows that per capita income levels in African nations are closely correlated with the consumption of electricity. Rwanda has relatively low rates of electricity consumption and is relatively poorer than other African nations.

**Figure 2.2: Comparative Data from Africa on GDP and Electricity Consumption**




Source: Ministry of Infrastructure, Rwanda Energy Sector Strategy, 2008

The Government believes that electricity is an enabler of economic growth and better social performance—enabling improvements in education, better health services, more productive commercial investments and greater household efficiency. For example, access to electricity will improve the economics of tea and coffee production, enabling suppliers to expand their operations and spurring economic development throughout different regions of Rwanda.

The transition to modern energy sources is linked to Government targets that have been set under the EDPRS and are being actively monitored over time. The EDPRS sets the medium-term framework to 2012 for achieving the long-term aspirations embodied in "Vision 2020" and the "Millennium Development Goals", focusing on the flagship areas of growth for jobs and export, reducing poverty through increased productive capacity (*Umurenge*) and improved governance.

The energy sector is expected to make an important contribution to achieving these goals by increasing access to electricity for enterprises and households. The targets that have been set for expanding electricity access are shown in Table 2.2 (below). While the targets for expanding electricity access are ambitious, the Government is keen to pursue further initiatives to build implementation capacity and increase funding for the access programme to exceed the targets, if possible.

**Table 2.2: EDPRS Targets for Expanding Access to Electricity**

| Indicators | Current 2008 | Target 2012 |
|---|---|---|
| Connected households and enterprises | 100,000 | 350,000 |
| Health facilities have access to reliable energy for lighting, technology applications and refrigeration | 50% | 100% |
| Schools have access to reliable energy for lighting | 20% | 50% |
| Sector offices have access to reliable energy | 25% | 100% |

Source: Ministry of Infrastructure

The remainder of this Prospectus presents information on how these targets for electricity access will be achieved, highlighting the institutional, technical, financial, and implementation plans that underpin the access programme. The Government acknowledges that the targets are ambitious, however the planning presented in this Prospectus shows that the targets are achievable.

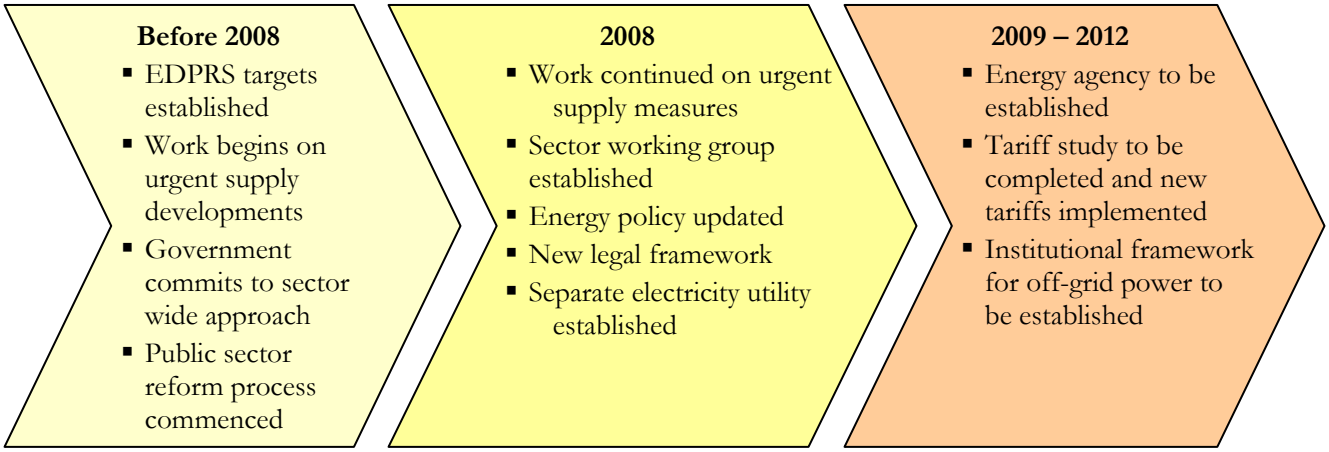
# 3 Sector Institutions Ready for Access Programme

When the Government articulated its strategic direction for Rwanda in Vision 2020 and the EDPRS, it understood that Government involvement in different sectors needed to adapt to the country's new path. Over the past few years the Government has worked hard to create institutional arrangements in the electricity sector that encourage more investment in electricity infrastructure and ensure high-quality service provision. In particular, the Government has led a movement away from focusing on individual electricity projects towards a coordinated sector-wide approach to achieving development goals. The Government has also passed new sector legislation, regulations and governance arrangements that put sector development aspirations into action. These responses ensure that the Government and sector players are ready to deliver on the high expectations established for the access programme.

This Section of the Prospectus presents an overview of policy and institutional initiatives that have been implemented to support the access programme. Section 3.1 discusses the policy rationale behind the access programme's sector-wide approach—to move away from implementing one-off energy projects towards a systematic and coherent approach to planning, financing, and making new electricity connections. Section 3.2 provides a brief summary of key sector players and Section 3.3 discusses the new focus of energy sector strategy and policy. Section 3.4 highlights how sector policy is being implemented through sector legislation and regulation.

Figure 3.1 (below) provides an overview of some of the actions taken to date, and future measures proposed by the Government to improve governance and investment in the electricity sector.

**Figure 3.1: Overview of Government Initiatives to Enhance the Electricity Sector**




## 3.1 Sector-Wide Approach for the Access Programme

The Sector-Wide Approach for energy adopted in Rwanda (the "Energy SWAP") is an important foundation for the access programme. The Energy SWAP embraces the idea that developing Rwanda's energy sector requires a constructive engagement between the Government and development partners. A high level of coordination is particularly

important for the access programme, where investments will often have direct technical and financial impacts on other sector developments.

The Energy SWAP is part of a broader movement in Rwanda towards greater coordination between the Government and development partners. Rwanda is a signatory to the Paris Declaration on Aid Effectiveness of March 2005, which commits the Government of Rwanda to exercising leadership and coordinating development actions, while development partners commit to harmonising support. The health, water, and education sectors in Rwanda are also promoting greater harmonisation. Other countries in East Africa have successfully implemented SWAPs, and the Ugandan water sector provides a prominent example of how sector-wide cooperation can maximise development impacts by improving investment coordination and realising programme synergies.[3]

The Energy SWAP was formally launched in July 2008 by a Memorandum of Understanding (MoU) signed by the Ministers of Finance and Energy and senior representatives from the development partners. Under the MoU, the Government has agreed to lead energy sector development by ensuring that sufficient resources are reflected in fiscal budgets and that public agencies at the central and local levels interact constructively. Development partners have agreed to focus their support on achieving the EDPRS objectives, and communicating openly with the Government on sector investment plans.

The Energy SWAP has some clear benefits for the electricity access programme. In particular, the Energy SWAP allows development partners to contribute towards a national programme for rolling out electricity access, rather than under piecemeal project developments. This increased donor coordination will result in more complimentary investments and reduce the likelihood of duplication and wasted resources. The Energy SWAP also reduces the administrative burden placed on both Government and development partners because investment requirements are identified at the sector level and developed under a consistent approach.

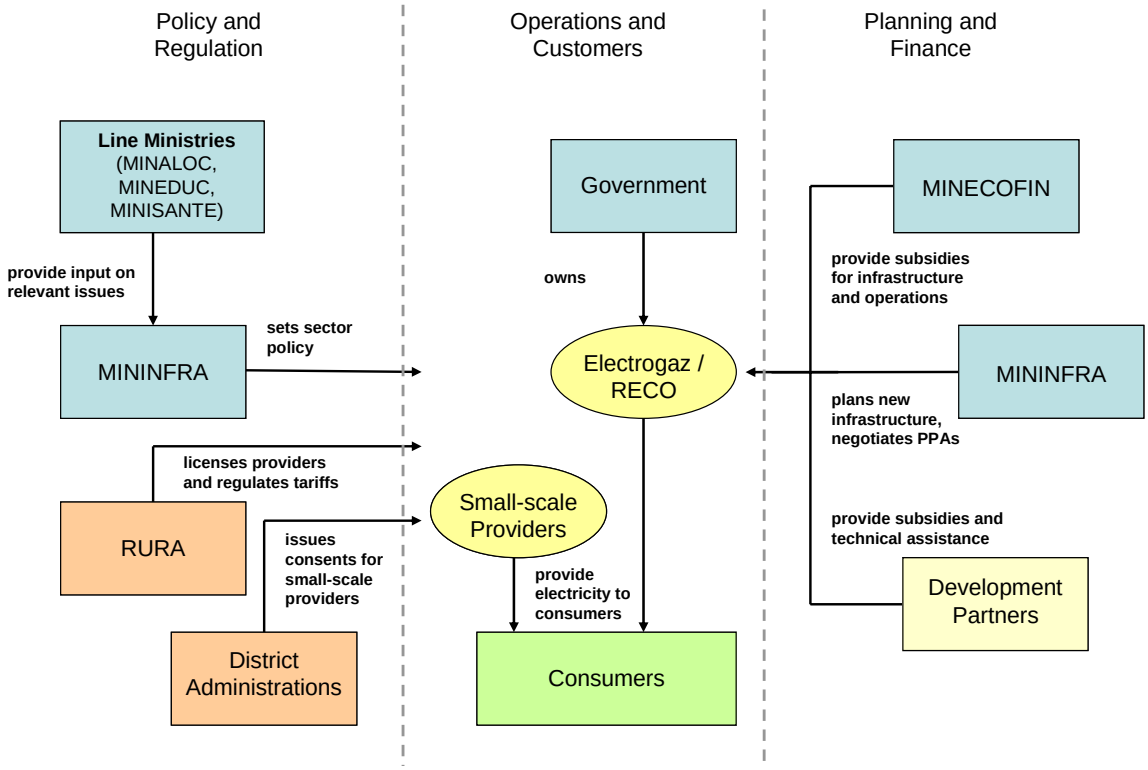
A sector working has been formed to implement the Energy SWAP and has met on several occasions in 2008. A Secretariat within the working group also actively coordinates interactions between Government officials and development partners to share information.

## 3.2 Overview of Sector Institutions

Figure 3.2 presents an overview of the key players in Rwanda's electricity sector. These are divided into entities responsible for policy and regulation, operations and customers, and planning and finance. A brief description of each of the institutions shown in Figure 3.2 follows below.

[3] Cong, Richard (2007) "WSS SWAP Overview: Uganda Case", Presentation to Water Week 2007, Washington, D.C.

**Figure 3.2: Electricity Sector Players in Rwanda**




## Electrogaz / RECO

Electrogaz has existed for thirty-two years as a vertically-integrated electricity and water utility. Electrogaz was formed as a Government owned and operated company in 1976,[4] and has traditionally been responsible for all electricity sector operations—electricity generation, transmission, distribution and customer connections and billing. In 2008, the Rwandan Parliament passed a new law establishing separate utilities for electricity (Rwanda Electricity Corporation (RECO)) and water (Rwanda Water and Sewerage Corporation (RWASCO)). The new law classifies RECO as "a public institution that performs commercial or industrial activities".[5]

The law gives RECO legal status with administrative and financial autonomy to operate electricity infrastructure, encourage the use of electricity, facilitate private investment, extend services, identify cheap power options and cooperate with similar regional institutions. The Board and Managing Director are appointed by the Prime Minister.[6] Daily management is entrusted to the Managing Director answerable to the Board.

[4] Decree n° 18/76-1976 (20 April 1976) granted a monopoly to Electrogaz over the production and distribution of water and electricity for 99 years. The monopoly was removed in August 1999 under Law n° 18/99. During the period from 2003 to 2005, Electrogaz was operated by Lahmayer International under a management contract. In 2005 the management of Electrogaz reverted to the Government of Rwanda.

[5] Law Establishing Rwanda Electricity Corporation and Determining its Responsibilities, Organisation, Functioning, Article 1.

[6] Law Establishing Rwanda Electricity Corporation and Determining its Responsibilities, Organisation, Functioning, Article 7.

### Central Government

The Government's role in the electricity sector is to set sector policy, monitor performance and implement sector rules and regulations. The Government also helps to plan and finance new electricity investments, bolstering capacity in Rwanda to prepare for future demand and engage private sector investors. As the owner of the national electricity utility, the Government also plays a role in providing electricity supply to consumers.

### MININFRA

The Ministry of Infrastructure (MININFRA) leads the Government's policy-making in the electricity sector. MININFRA's role is to advise on policy issues and reach a consensus on policy goals in the energy sector. In recent years, MININFRA has been involved in planning major electricity sector investments and obtaining funding for investments from the Ministry of Economy and Finance (MINECOFIN). MININFRA is also responsible for negotiating gas concessions and power purchase agreements (PPAs) with private investors.

A draft law has been prepared to set up the Rwanda Energy and Water Board within MININFRA. The objective of this initiative is to have an operational body attached to the Ministry with greater flexibility and ability to undertake quasi-commercial functions, such as resource development, licensing, fieldwork, data collation and publication of sector statistics.

### MINECOFIN

The Ministry of Finance and Economic Planning (MINECOFIN) is a lead partner in the sector. In recent years, the Government has provided funding for new thermal fuel, hydro and gas generation assets and has subsidized expenditures for fuel. MINECOFIN retains a significant interest in how the sector is run and resourced, as well as representing the Government as the owner of the electricity utility.

### Other Line Ministries

The key line ministries playing a significant in the electricity sector as consumers and collaborators include the Ministry of Local Government (MINALOC), Ministry of Education (MINEDUC) and Ministry of Health (MINASANTE). These line ministries are particularly interested in the targets in the access programme for connecting health facilities, schools and administrative centres.

### RURA

The Rwanda Utilities Regulatory Authority (RURA) was created in 2001 to independent regulate public utilities, including electricity and the extraction and distribution of natural gas.[7] RURA is required to "promote the interests of users and potential users who require goods and services provided by certain public utilities".[8] RURA is required to set tariffs and tariff methodologies that are non-discriminatory, facilitate competition, recover the economic costs of supply, allow the recovery of justified costs, and promote economic development and encourage efficiency.[9]

[7] Law 39-2001 of 13 September 2001 Establishing an Agency for the Regulation of Certain Public Utilities (the "RURA Law of 2001").

[8] RURA Law of 2001, Article 13.

[9] Electricity Law, Article 26.

**Development Partners**

A number of development partners from the international donor community provide technical and financial support in the Rwandan electricity sector. Active development partners in the sector include the African Development Bank (AfDB), European Commission, United Nations Industrial Development Organization (UNIDO), the World Bank, International Finance Corporation (IFC) and the Governments of Belgium and the Netherlands (through GTZ of Germany). Development partners support investments in renewable generation (such as micro-hydro plants and solar projects), regional energy projects and methane gas-power generation at Lake Kivu. The World Bank and Nordic Development Fund have also funded investments under the Urgent Electricity Rehabilitation Project (UERP) to help Rwanda increase its electricity generation capacity and improve reliability following supply shortages in 2004.

**Local Government**

The Government of Rwanda has embarked on a successful decentralisation policy. The Government views a policy of decentralised administration as an instrument for political empowerment, a platform for sustainable democratic development, as a way to mobilise resources, and as a means for social reconciliation. The country has two layers of government: Central and Local. Local administrative entities include provinces (*Intara*), districts (*Akarere*), sectors (*Umurenge*), cells (*Akagari*) and the village (*Umudugudu*).

Local government roles in the electricity sector include implementation, service delivery, participation and accountability. The decentralisation policy in Rwanda creates opportunities to seek local solutions to service delivery problems by coordinating with local communities. This is particularly important for development partners that support service delivery activities, particularly in small electricity systems based on peat and mini-hydro resources.

As the access programme moves into the implementation phase, local governments will act as important intermediaries between national authorities and local community organisations that are interested in mobilising resources to supply their region.

## 3.3 Energy Sector Strategy and Policy

The Government's strategic vision for developing the energy sector is articulated in a new national energy policy and strategy.[10]

- The **national energy policy** contains policy statements on issues such as energy pricing and subsidies, energy sector governance and regulation, and the financing of energy sector investments. The policy also contains a separate policy statement on the electricity sub-sector, which confirms the policy commitment to enhancing access to electricity, particularly in rural areas
- The **national energy strategy** sets out how the energy transition in Rwanda will be achieved given the macroeconomic impacts of consuming more petroleum products and electricity. The strategy highlights that the Government's priorities to develop a knowledge-based economy and exploit indigenous energy resources will help to ensure that modern energy consumption is consistent with sustainable increases in national income levels.

[10] Rwanda National Energy Policy and National Energy Strategy, November 2008.

## 3.4 Energy Sector Legislation and Regulation

The Government has recently enacted a suite of new legislation in the energy sector. The Electricity Law governs the supply and distribution of electricity, and the Gas Law administers the use of methane gas from Lake Kivu. New laws have also been drafted to create the new electricity utility RECO and establish a National Energy Development Agency (NEDA). These laws complement an existing regulatory framework for Rwandan utilities, and give additional powers and responsibilities to the independent regulator, RURA.

The Electricity Law reflects a commitment to moving away from Government managed electricity supply to a system that emphasizes an efficient utility managing transmission and distribution, while allowing increasing private sector investment in generation. The Electricity Law provides that the electricity transmission entity (currently Electrogaz) will have an exclusive right to transmit electricity, and will also be responsible for operating the system.

Although the current supply chain in Rwanda relies on a single-buyer, Electrogaz, purchasing power from private plants, the Electricity Law also preserves opportunities for further sector reform when the time is right.

The regulator is responsible for issuing licenses to electricity generators, transmission and distribution entities, and has powers to set tariffs based on the economic costs of serving each class of customer. The regulator may reallocate costs among customers, provided that the tariff-setting methodology is designed to enhance the efficiency of the sector. The Electricity Law requires also RURA to consult MININFRA to understand the level of proposed government subsidies before setting tariffs. The regulatory framework encourage tariffs that allow investors to recover a rate of return on that is comparable to the return obtained in similar investments.

RURA plans to build capacity to assume the additional regulatory responsibilities it has been granted under the Electricity Law. RURA is receiving technical assistance and training under the ICF-funded "Capacity Building and Transmission Support in the Rwandan Energy Sector Project". Specific areas of capacity building are licensing and concessions, tariff regulation, network access and regional interconnections, advice on power purchase agreements, and regulatory strategy.

# 4 Geospatial Roll-out of Electricity Access

In a joint effort with the national electricity utility in Rwanda, the Government has begun planning the access programme. This planning work underscores the fact that this Prospectus is not a hypothetical request for funds from development partners, but rather a concrete request to development partners to support a least-cost expansion that makes engineering and economic sense.

The technical plan identifies the best way for electricity to be extended over the next 20 years (with a particular focus on the next five years), based on the social and economic characteristics of different locations within the country, and the supply and demand conditions for electricity in Rwanda. The roll-out plan is conducted at a programme level, and further detailed design and planning work will be completed as the programme is implemented. The plan reflects the Government's focus on sustainability and the use of indigenous resources where possible, and contains significant investments in renewable energy, particularly for grid connected and isolated small hydropower systems.

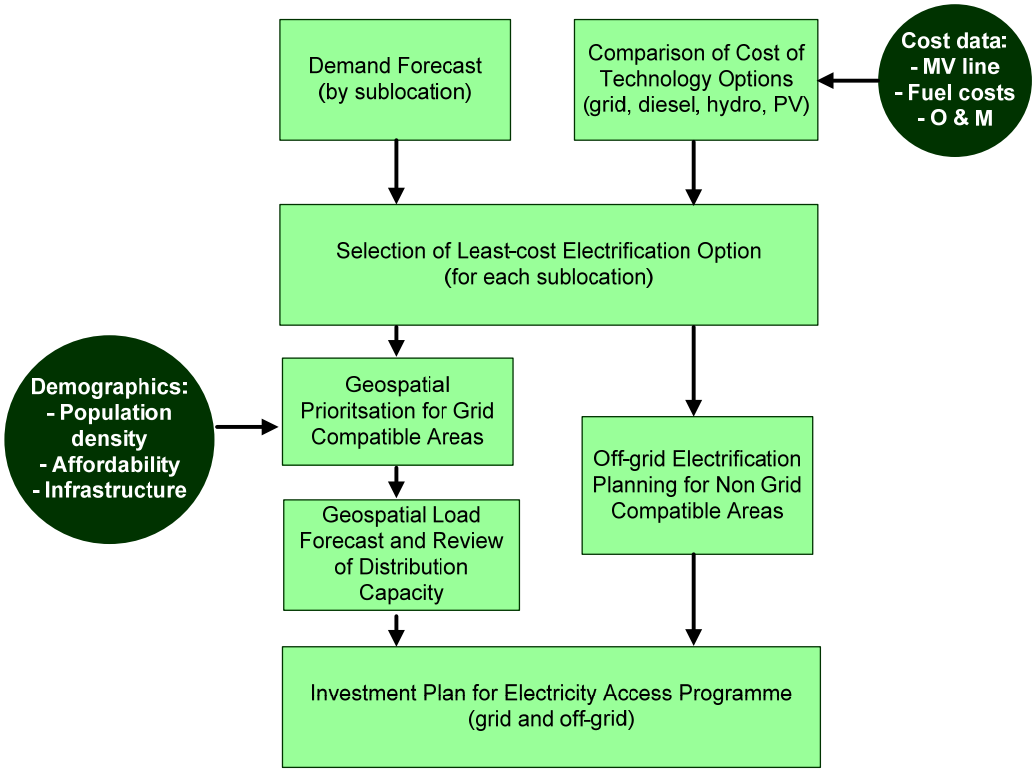
This Section first presents an overview of the planning process used to determine the reach of the access programme. The various components of the planning process and the planning results are then discussed. Section 4.2 presents a summary of the data collected on the social and economic characteristics of different areas within Rwanda. Section 4.3 discusses a model that has been used to select between available technologies for electricity supply. The process of prioritising new connections to the network is discussed in Section 4.4, and Section 4.5 presents the off-grid elements of the access programme. These components are then drawn together in Section 4.6.

The planning work presented in this Section enables the cost of the electricity access programme to be accurately estimated (Section 5), and allows programme implementation challenges to be identified (Section 6).

## 4.1 Approach to Electrification Planning

An overview of the approach to planning the electricity access programme is shown in Figure 4.1 (below).

**Figure 4.1: Overview of Approach to Electrification Planning**




A brief description of each stage in the planning process shown in Figure 4.1 follows below:

- **Demand forecast (by sublocation)**—The country has been divided into over 9,300 planning cells (sublocations) and a simple demand forecast is computed for each planning cell. The final demand in each cell is used for the purpose of appropriately sizing the technology options to be compared in the least cost technology model
- **Comparison of technology costs**—The capital and operating costs of different methods of providing electricity to meet demand in each planning cell are compared. This analysis includes the cost of grid connections and grid supply, diesel generator sets of different sizes, micro-hydro generators (where a suitable hydro resource is available) and solar PV panels (for domestic use). The costs of each option over a 10 year period are discounted into present value terms assuming a discount rate of 10 percent
- **Selection of least-cost electrification option**—The decentralised electrification options (diesel, micro-hydro and solar PV) are compared to select the best off-grid option. The cost of the best off-grid option is divided by the cost per kilometre of medium voltage (MV) line to estimate the maximum length of MV line that would be cost-effective to electrify each planning cell. If the centre of the planning cell is closer to the nearest adjacent cell than this level of cost effective expenditure on MV line, the cell is identified as grid compatible. Planning cells that are further away from the nearest adjacent cell are identified as being better suited to off-grid electrification

- **Geospatial prioritisation for grid compatible areas**—To prioritise new grid connections a weight is applied to grid compatible cells depending on demographic and cost factors, including proximity to the existing grid, inter-household distances, social infrastructure, access to road networks, and the ability of consumers in each planning cell to afford electricity. The objective of this prioritisation is to ensure that the programme maximises the benefits of electrification, while minimising programme costs. New connections are identified (by sublocation) to meet the by the EDPRS & Vision 2020 targets
- **Geospatial load forecast and review of distribution capacity**—A comprehensive geospatial load demand forecast is computed taking into account the location of the prioritised new connections over the planning horizon. A high-level review of existing MV lines and substations is conducted to ensure that the MV distribution network has the capacity to supply the new connections
- **Off-grid electrification planning**—A high-level plan is prepared for extending electricity to locations where off-grid electrification is identified as least-cost. The major component of this plan is to provide solar PV units for schools, health centres and administrative offices to meet the Government's targets for each of these important social institutions
- **Investment plan for electricity access programme**—The final stage in the planning process is to cost the investment plan based on the investment requirements identified. These costs provide the basis for the detailed funding plan described in Section 5.

The following sections of this Prospectus present further detail on the analysis completed to plan the access programme. The results and key conclusions from each stage in the planning process are also presented and discussed.

## 4.2 Review of Social, Economic and Network Characteristics

A necessary input into the planning process for Rwanda's electrification programme is an understanding of the social and economic characteristics in different parts of the country. The technical planning process then uses information on different settlement patterns, the location of social and economic infrastructure, and existing electrical infrastructure to provide a highest value assessment of how to expand access to electricity. The planning process for the access programme specifically considers:

- Administrative boundaries and population density
- The location and electrification status of social infrastructure
- Existing electricity infrastructure
- The affordability of electricity

The social and economic information collected for this Prospectus has been sourced from a range of Government and academic sources and combined into a single ArcGIS (version 9.2) geospatial database. Some datasets are used directly in the format provided, while other data are manipulated into a more useful format for the access programme. The information sourced for the planning exercise is summarised in Table 4.1 (below).

**Table 4.1: Variables Considered in Planning the Access Programme**

| Type of Characteristic | Variable | Source | Figure Reference |
|---|---|---|---|
| Demographic | Population data and growth[11] | National ID Survey | Figure 4.2 |
| Political | Country and administrative boundaries | National Institute of Statistics and MINALOC | Figure 4.2 |
| Political | Presidential priorities | Electrogaz | Not shown |
| Social | Administrative offices | MINALOC | Figure 4.3 |
| Social | Health centres | MINISANTE | Figure 4.3 |
| Social | Schools | MINEDUC | Not shown |
| Natural features | Roads, rivers, national parks etc | MININFRA and MINIRENA | Not shown |
| Electricity infrastructure | Location of power lines (HV, MV and LV) | Electrogaz | Figure 4.4 |
| Electricity infrastructure | Location of micro-hydro sites | BTC micro-hydro atlas | Figure 4.4 |
| Demographic | Income levels and poverty data | NIS EICV2 Survey | Figure 4.5 |

The quality of information available for this Prospectus varies, and initiatives to improve data availability and accuracy will be required to enhance planning capability in Rwanda. One general improvement would be for the Government or the GIS Centre at the National University of Rwanda to maintain a central registry for GIS data that contains official administrative boundaries and demographic data associated with each area. Swede Survey is currently completing an aerial photography survey in Rwanda, which will allow a more credible analysis of social and economic conditions.

Information on income levels and poverty data would also be improved by enabling users to access data at finer levels of resolution. Data from the EICV2 survey is currently available at the district level, and the data would be most valuable for the type of analysis presented in this Prospectus at the sector level.

The data available on social infrastructure could also be enhanced for planning purposes. The relevant attributes of each administrative office, health centre and school would help to plan infrastructure investments that would support these facilities. In this Prospectus, general assumptions have been made about the average energy consumption at each type of social institution. We understand that MININFRA is currently collecting data on the attributes at many social institutions throughout the country.

A significant amount of good work has been completed to capture the geographical coordinates of electricity infrastructure, with all HV and MV overhead line routes and substation/power station locations accessible in a GIS format. However, additional work is required to capture MV underground cable routes (mainly in Kigali). There is also an urgent

[11] Population growth is assumed at national level and densities at the sector level. Certain government policies (e.g. Habitat policy, *imidugudu*) may affect these parameters, and the impacts should be incorporated into the programme during implementation.

need to capture technical attributes associated with electricity infrastructure, including conductor/cable types and ratings, substation equipment specifications, and the nameplate data and unique identifiers for MV/LV transformers. Operational data on equipment loading and normal operating parameters would further enhance analysis.

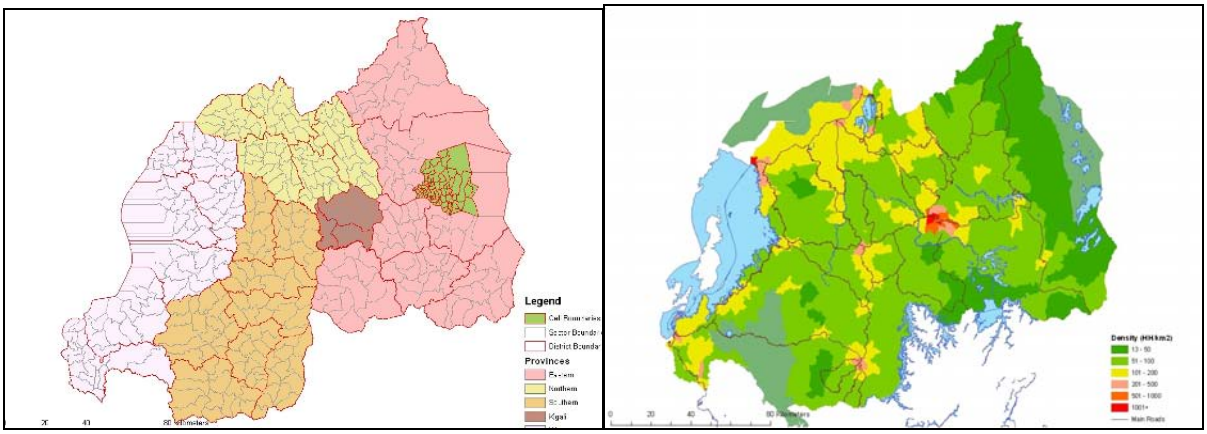
Geo-locations of all large (and 'other 'important') customers with a unique Customer Number that will link them with their network Point of Supply, as well as their "CRM/Billing System" databases. The identification of all smaller customers with their "Sector" (and hopefully "Cell" will make analysis easier.

**Administrative boundaries and population density**

The planning locations and sublocations for the technical planning of the access programme are based on the current political administrative boundaries. Rwanda's 5 Provinces, 30 Districts and 416 Sectors are shown in Figure 4.2 (left map below). A further level of planning detail has been achieved by using the boundaries for the census data collected in 2002 to create 9,311 planning cells.[12]

Data on the population in each sector was collected by the National Institute of Statistics (NIS) as part of the National ID Project conducted in 2008. This data is used to calculate population densities throughout the country, which are shown in Figure 4.2 (right map below). The map shows that the most densely populated areas of the country are around the capital, Kigali, and the northwest of the country on the border with the Democratic Republic of Congo.

**Figure 4.2: Administrative Boundaries (left) and Population Density (right)**



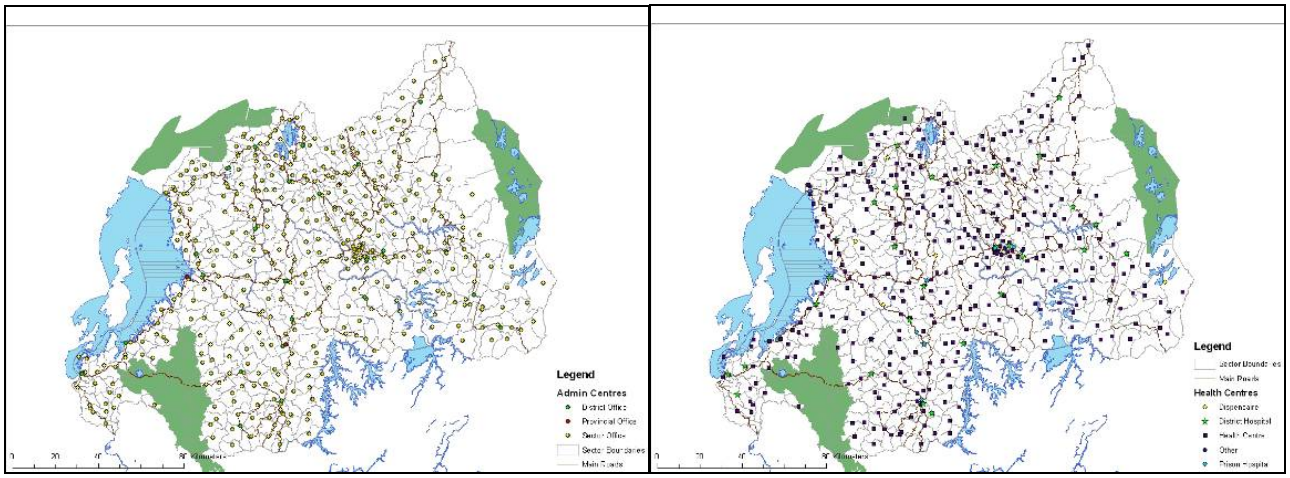

Source: NUR CGIS and National ID Survey

**The location and electrification status of social infrastructure**

The location of social infrastructure is important in planning the access programme. The Government has set specific targets for providing electricity to administrative offices, health centres and schools. The geographical location of each of these social facilities and its electrified status is captured in the GIS model, and used to influence the way that the access programme is prioritised. As expected, the geographic distribution of social infrastructure is relatively dispersed throughout the country.

[12] Current population data is available at a sector level for geospatial planning purposes. (Source: National ID Project, NIS)

**Figure 4.3: Location of Administrative Offices (left) and Health Centres (right)**




Notes: Although schools are not shown, the same process has been applied to secondary and primary schools

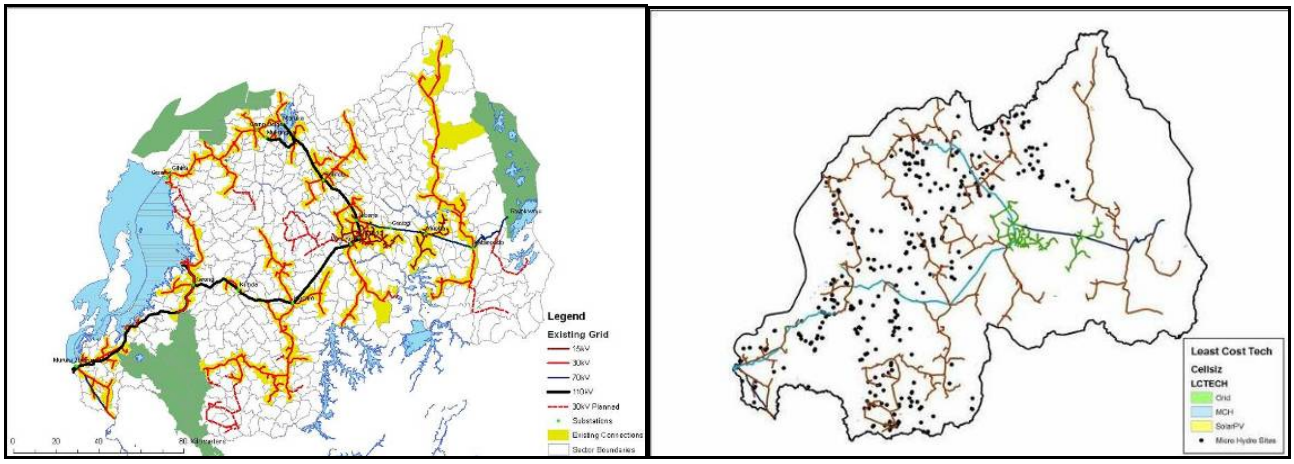
Source: NUR-CGIS, MINEDUC and MINISANTE

### Existing electricity infrastructure

Data on Rwanda's electricity network has also been captured in GIS form to plan the access programme. Rwanda currently has a very low level of access to electricity of around six percent nationwide. At the end of 2008, Electrogaz had around 110,000 customers connected to the national grid, with 80 percent of these connections in the Kigali area. However, the existing grid extends to a significant portion of the country. This feature is shown in Figure 4.4 (left map below), which depicts the location of high-voltage and medium-voltage lines in Rwanda and the sublocations where existing connections are situated. The dotted lines indicate 30kV distribution lines that are either currently under construction, or planned to connect new micro-hydro plants currently under construction, or to connect areas previously identified as Presidential priorities for electrification.

Rwanda has significant a hydro resource that has been taken into account in planning the access programme. Rwanda's hydro resources are particularly well suited for small-scale generation, either in stand-alone mini-grids or feeding into the national electricity grid. Over 300 micro-hydro sites have been evaluated by a comprehensive study completed in 2008, and the location of the most promising sites is shown in Figure 4.4 (right map below).

**Figure 4.4: Existing Electricity Network (left) and Potential Micro-hydro Sites (right)**



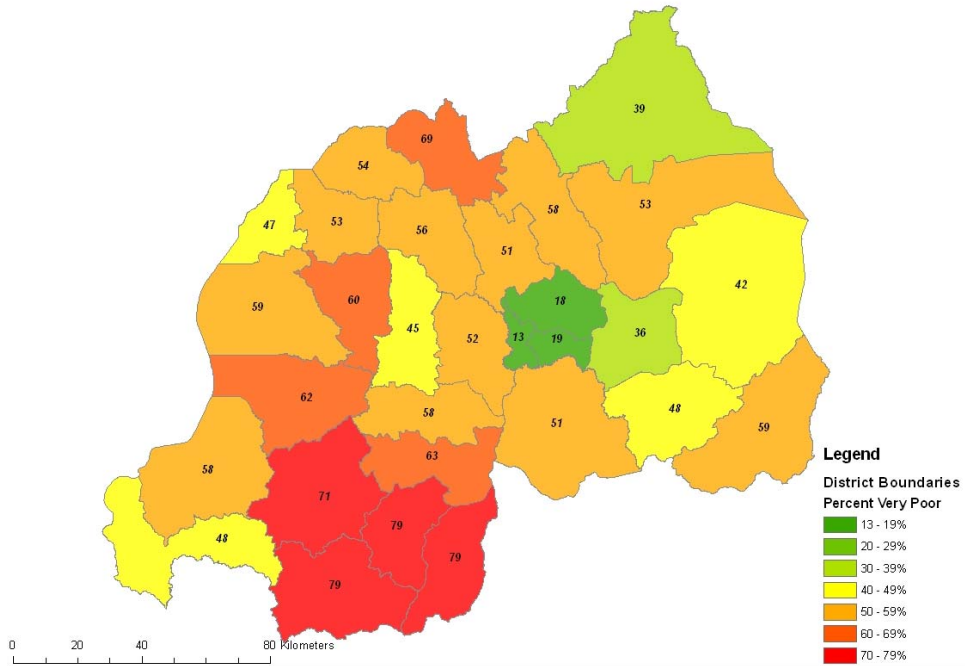

Notes: The potential micro-hydro sites shown are selected from the hydro atlas based on a potential installed capacity of ≤ 1,000 kVA

Source: NUR CGIS and Ministry of Infrastructure / BTC "Hydropower Atlas".

### The affordability of electricity

One of the major constraints on expanding access to electricity in Rwanda will be the limited ability of most households to pay for electricity. Figure 4.5 (below) shows the proportion of households that have daily expenditure levels of less than US$1.25 per day. In most areas of the country, between 50 and 80 percent of households spend less than $1.25 per day. This represents a barrier to significantly expanding the use of electricity.

**Figure 4.5: Proportion of Population in Rwanda Living on Less than $1.25 per Day**




Source: EICV2 Survey

In order to provide a realistic view of the number of new connections that can be obtained within a particular sublocation, an analysis of the affordability of electricity was carried out. The approach to account for the affordability of electricity in different parts of the country is described in Box 4.1 (below).

**Box 4.1: Evaluating the Affordability of Electricity in Rwanda**

The poverty map presented as Figure 4.5 suggests that careful consideration needs to be given to affordability in the planning the access programme. Although the Government and development partners want to extend access to electricity to help alleviate poverty, these objectives need to be balanced against the financial sustainability of the programme by considering the ability of households to pay for electricity.

There is currently no detailed information on ability to pay for electricity in Rwanda. This Prospectus uses data on household expenditures from the Household Living Conditions Study (EICV2) and studies on comparative expenditures on energy in the region (Kebede et al (2002) and Karekezi (2002)). The EICV2 survey collected data on 6,900 households and divides the country into 30 districts, which are then split into expenditure quintiles. A recent survey commissioned by the European Union has also been used to compare the results of the EICV2 survey with more recent data.

The data broadly shows that the average household in the highest quintile in each district spends 3 times the average household in the next highest spending quintile, and 13 times the average household in the lowest quintile. The data also shows that households in the Kigali area are able to spend relatively more than other parts of the country. Widespread poverty nevertheless remains in the Kigali area, with over 40 percent of survey respondents spending less than US$2.50 per week.

The survey responses have been used to estimate the proportion of households in each district able to afford an electricity connection, assuming that a household will be able to afford an electricity connection if:

*Total Expenditure * Energy Expenditure (%) > Current Tariff * Minimum Consumption (kWh)*

The minimum consumption level is assumed to be 20kWh per month. This is a very low level of consumption from 2–3 energy efficient light bulbs and a radio. The proportion of energy expenditure in each household will vary depending on the characteristics of each household and community, and on the cost of electricity substitutes (such as kerosene, batteries and candles). A

recent comparative study (Karekezi (2002)) found that urban household expenditures on energy in Africa ranged from 12.5 percent in Burkino Faso to almost 25 percent in Mauritania. Data from an earlier study of energy expenditures in Ethiopia (Kedebe (2002)) also support two important conclusions:

- Poorer households (typically in more rural communities) tend to spend a higher proportion of their expenditures on energy. This is because household expenditures in rural areas do not include food that is grown within the household.
- Average household expenditures on fuel and power are typically in the range of 5–6 percent in urban areas, and 10–12 percent in rural areas.

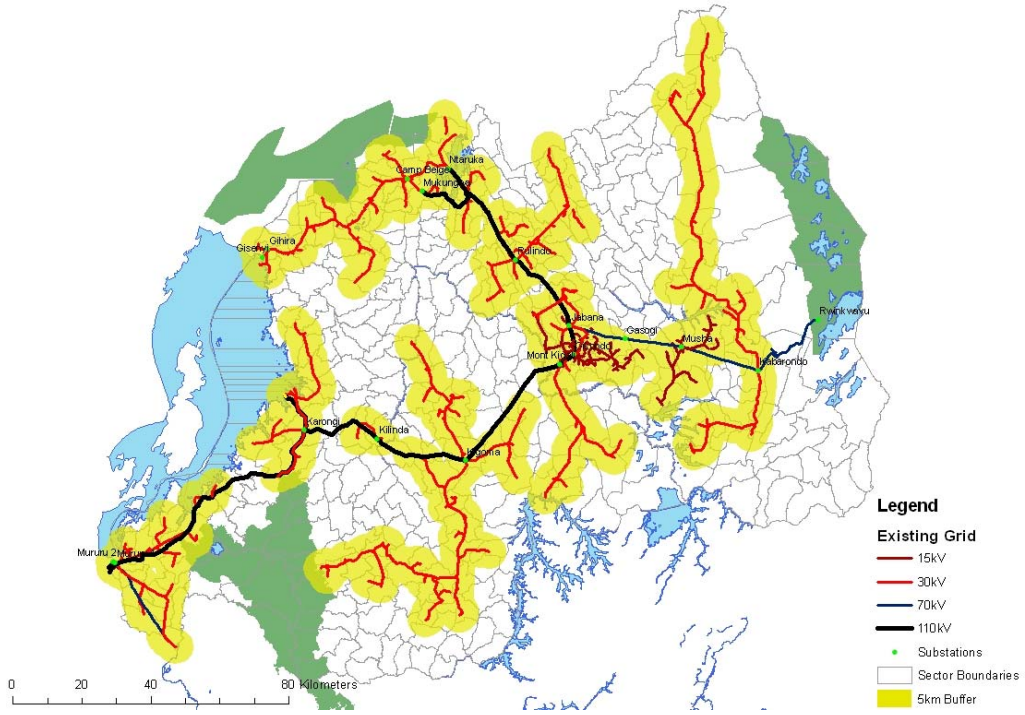
The following assumptions have been used on the maximum proportion of expenditures that would be spent on electricity in Rwanda, which provides the following approximate average expenditures on electricity:

| Area | Max. Energy Expenditures (%) | Expenditures on Min. Consumption (%) |
|---|---|---|
| Urban | 10 | 2–3 |
| Peri-urban | 15 | 4–5 |
| Rural | 20 | 8-10 |
| Deep rural | 25 | 10-14 |

A further assumption is economic growth in Rwanda translates into average growth in household incomes of five percent per annum over the next ten years. The overall effect of this income increase is an average increase in the proportion of households that can afford electricity of 1.5 percent.

Fortunately, there are other factors in Rwanda that assist the access programme. For example, the electricity grid already extends to a large part of the country and more than 65 percent of the population live within five kilometres of the distribution grid. The areas of the country that are within 5km of the existing network are shown in Figure 4.6 (below). This means that the cost of providing access to electricity can be achieved with relatively less expenditure on network expansion than other less densely populated countries.

**Figure 4.6: Areas within 5 kilometres of Existing Electricity Distribution Network**




## 4.3 Analysis of Least Cost Electrification Options

Using the data collected on social and economic characteristics, a spreadsheet-based model has been created to compare the costs of the different options for supplying electricity in each planning cell (the "technology selection model"). This model is integrated with the GIS-based database to extract spatially derived data to compare the following technology options within each planning cell:

- Mini-diesel generator (DG) mini-grid
- Solar photovoltaic (solar PV)
- Micro-hydro (MCH) mini-grid, and
- Grid extensions.

The planning approach compares the costs of the non-grid supply options—diesel generator sets of different sizes, installing household solar PV panels, and micro-hydro generators where a suitable hydro resource is available. The model then compares the best decentralised electrification option with the capital and operating costs of a "generalised grid" supply, initially disregarding the location of the existing electricity network. The detailed assumptions and results from the model are attached in the Technical Annex, Section 1.

The technology selection model first conducts a simple load forecast for each planning cell, using variables on population growth,[13] affordability and load growth for new connections (using an S-curve growth rate). Decentralised electrification options are then evaluated based on the capital costs of the optimal-sized generator to meet the final demand in each planning cell, and the costs of operating and maintaining the equipment. The costs of each decentralised option are discounted into present value terms over a 10-year period, assuming a discount rate of 10 percent.

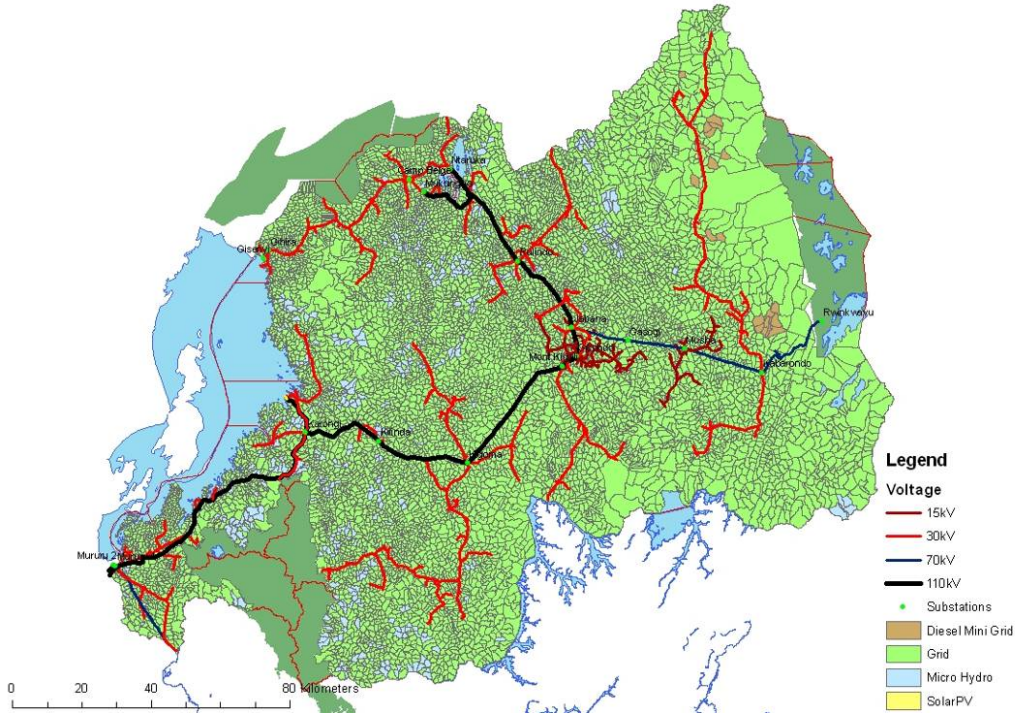
The cost of the least cost non-grid option is divided by the average cost per kilometre of medium voltage (MV) line to estimate the maximum length of MV line that would be cost-effective to extend to each planning cell (*MVmax*).[14] If the centre of the planning cell is closer to the nearest adjacent cell than *MVmax*, the cell is identified as grid compatible. Planning cells that are further away from the nearest adjacent cell are identified as being better suited to decentralised electrification.

The results of the technology selection model are then imported into the GIS database and viewed spatially relative to the existing grid. This allows a common-sense evaluation to be applied in determining where off-grid alternatives are best suited. The results of the technology selection model are shown in Figure 4.7 (below). This figure shows that the overwhelming majority of planning cells (95 percent) are identified as grid compatible, which is consistent with expectations in a densely populated country like Rwanda. Supply from off-grid micro-hydro systems is least cost in (4.5 percent) of planning cells, while diesel generator mini-grids and solar PV household systems are seldom a least cost option in Rwanda (less than one percent).

[13] National Institute of Statistics of Rwanda, EICV2 survey.

[14] This approach to comparing decentralised electrification options was applied in Columbia Earth Institute (2007) for electrification planning in Kenya. To ensure a like-for-like comparison between non-grid and grid options, the mini-grid cost for micro-hydro and diesel generators is not included and a long run marginal cost of electricity supply for grid generation of 10c/kWh has been assumed.

**Figure 4.7: Results of the Least Cost Technology Model**




The planning cells identified as suitable for micro-hydro systems may or may not be grid connected depending on proximity to the grid at the time the hydro resource is developed. However, the proximity of the cells identified as best suited to diesel generator mini-grid or solar PV household systems have been reviewed relative to the existing grid as a reality check. As can be seen from Figure 4.7 (above), the few cells identified for diesel mini-grid supply are relatively close to the existing grid. This result indicates that these cells will most likely become grid connected, although the level of demand in each cell does not justify prioritisation under the access programme.

## 4.4 Prioritisation of New Grid Connections

The areas identified for grid electrification in the technology selection model are prioritised according to attributes in each planning cell. The attributes used to prioritise cells for grid connection have been selected based on experience in similar electrification planning projects in Africa on the criteria that are the most accurate indicators of project costs and benefits. The attributes included in the grid prioritisation model are:

- Inter-household distances (based on population densities)
- Number of un-electrified households
- Number of un-electrified social facilities (administrative offices, health centres and schools)
- Proximity to roads (an indicator of access and economic activity)
- Proximity to the existing medium voltage network
- Economic development nodes indicated by the location of a market, and

- Presidential priorities for electrification.

Each attribute receives a weight according to its relative significance in determining the likely costs and benefits of electrification. The total score for each sublocation is then used to rank the planning cells relative to each other. Cells that receive the highest scores are prioritised for electrification in the access programme, according to a realistic assessment of the number of new connections that can be achieved in each year. As discussed in Box 4.2 (below), while a detailed economic assessment of the costs and benefits of extending coverage to different cells is not possible at this time, the prioritisation approach used to plan the access programme captures many of the elements that will form part of the more detailed project cost-benefit analysis.

**Box 4.2: Calculating the Economic Impact of Rwanda's Electrification Programme**

The methodology applied in this Prospectus to plan Rwanda's electricity access programme prioritises the extension of electricity to planning cells by allocating scores to a range of economic and technical characteristics. This approach captures many of the elements that would form part of a project cost-benefit analysis—higher population densities, proximity to the network and access to roads will all tend to lower the costs of the programme. Prioritising cells with more unelectrified households, social institutions, and economic activity will tend to increase the economic benefits of the programme.

In addition, a preliminary assessment of the overall economic costs and benefits of the programme has been completed. This analysis uses the estimated capital and operating costs of providing supply to new customers discussed in detail in Section 5 of this Prospectus. The economic benefits of the access programme are more difficult to quantify. This analysis of economic benefits considers direct benefits only, which are reflected in the willingness of customers to pay for electricity. This is a relatively conservative approach to cost-benefit analysis, and the true benefits of the access programme are expected to be broader by enabling other economic activity to take place, such as complementary improvements in other infrastructure sectors.

There is currently no study of willingness to pay for electricity in Rwanda, although previous estimates of willingness to pay in rural communities made by ESMAP[15] range from between US$0.50c/kWh and US$0.70c/kWh.[16] These willingness to pay studies are based on households receiving the following benefits:

- Less expensive and expanded use of lighting
- Less expensive and expanded use of radio and television
- Improved returns on education and wage income
- Time savings for household chores
- Improved productivity of home businesses.

These estimated economic benefits are expected to accrue to Rwandan households as a direct consequence of the access programme and are likely to be higher than long run marginal costs of supply in Rwanda. This means that the programme will have net economic benefits.

[15] ESMAP. "Rural electrification and development in the Philippines: Measuring the social and economic benefits." In Report 255/02, Washington, D.C. 2002.

[16] International Energy Group (IEG) "The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits" IEG Impact Evaluation, 2008. For conclusions see: http://web.worldbank.org/WBSITE/EXTERNAL/EXTOED/EXTRURELECT/0,,contentMDK:21604879~menuPK:4489096~pagePK:64829573~piPK:64829550~theSitePK:4489015~isCURL:Y,00.html

Using the range of estimates of willingness to pay for electricity US$0.50c/kWh and US$0.70c/kWh an initial estimate of the economic return of the access programme has been calculated. This economic cost benefit analysis is provided in the Technical Annex, Section 4. For new household connections, the analysis assumes benefits of US$0.70c/kWh for the first 20kWh consumed per month, and US$0.50c/kWh for any additional consumption. Social institutions and commercial enterprises are assumed to be willing to pay US$0.70c/kWh. These parameters provide the following economic indicators for Rwanda's access programme over a time period to 2020:

- Economic rate of return: 24 percent
- Net present value (assuming a discount rate of 10 percent): US$168 million
- Levelised economic benefits: US$0.26c/kWh

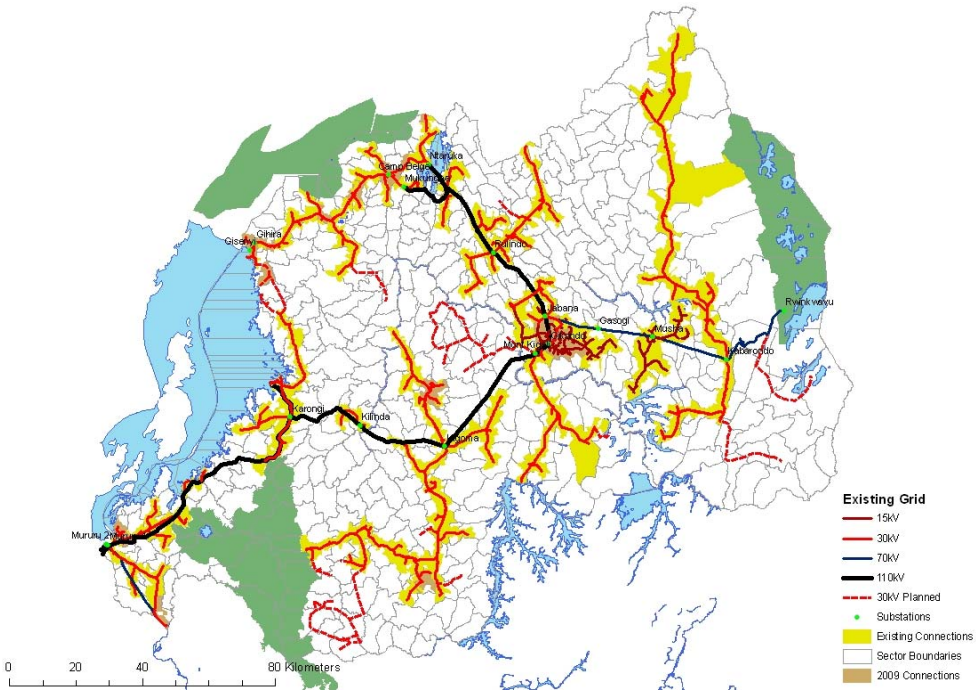
The economic rate of return for individual components within the overall access programme will be higher than the expected return for the programme as a whole.

The results of the least cost grid prioritisation approach for each of the next five years are shown in Figure 4.8 to Figure 4.12 (below). The grid prioritisation shows that the Government's targets can be achieved without requiring a massive extension of the medium voltage (MV) network. Rwanda is fortunate to have a relatively well-developed MV transmission network, with more than 60 percent of the population within five kilometres of the grid. Over 95 percent of planned new connections to 2012 are within five kilometres of the existing grid.

The planning also targets a considerable number of new connections in areas that already have some low voltage networks. These connections are commonly referred to as "infills", and the majority of these connections will initially be made in the urban area of Kigali and peri-urban areas in the northwest of the country. This part of the access programme will help to minimise costs and maximise economic opportunities for the urban poor.

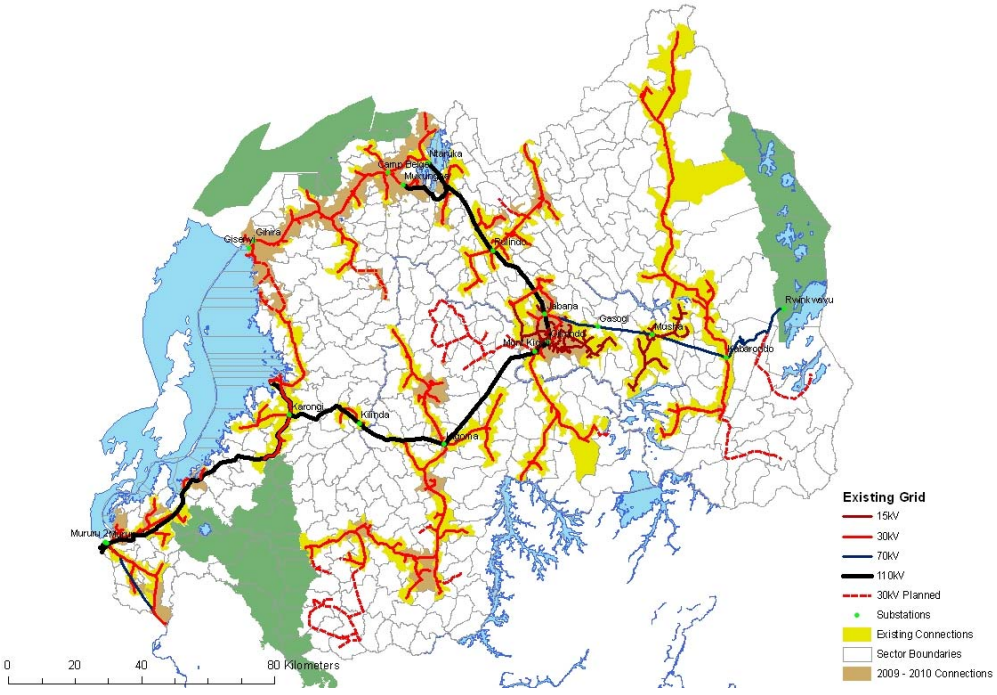
While all existing and planned distribution lines have been included to prioritise new grid connections, some networks do not receive any new connections under the prioritisation approach. This is because the prioritisation approach takes into account a range of social and economic indicators, rather than solely focusing on the existing grid. The final selection of areas targeted for new electricity connections will need to be reviewed according to prevailing social and political imperatives during the programme implementation phase.

## Figure 4.8: Least Cost Grid Prioritisation for 2009



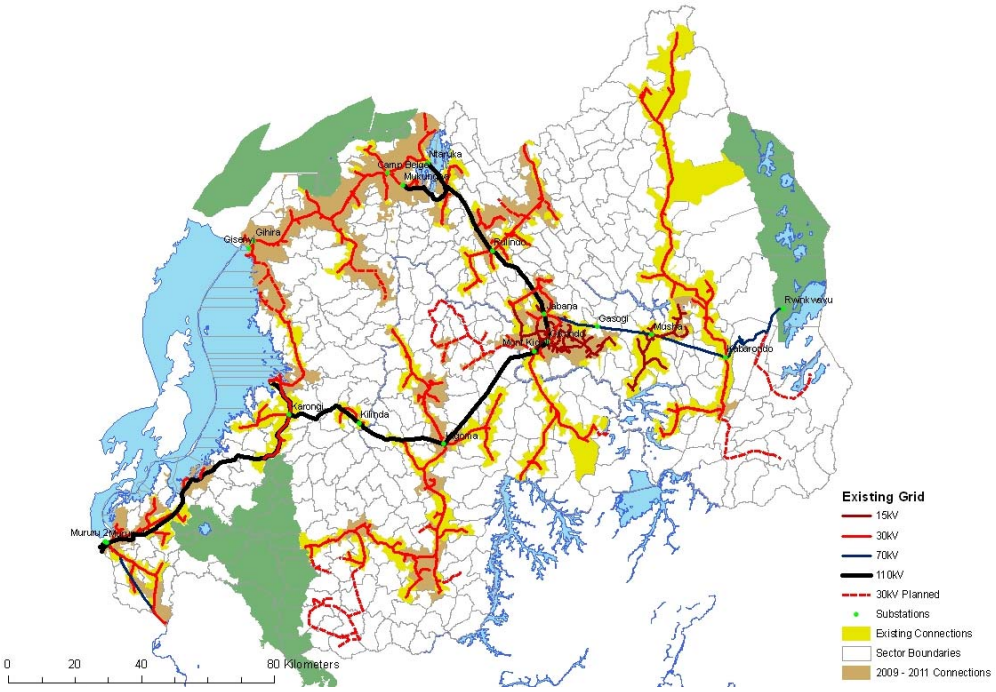

**37,000 new connections**

## Figure 4.9: Least Cost Grid Prioritisation for 2010



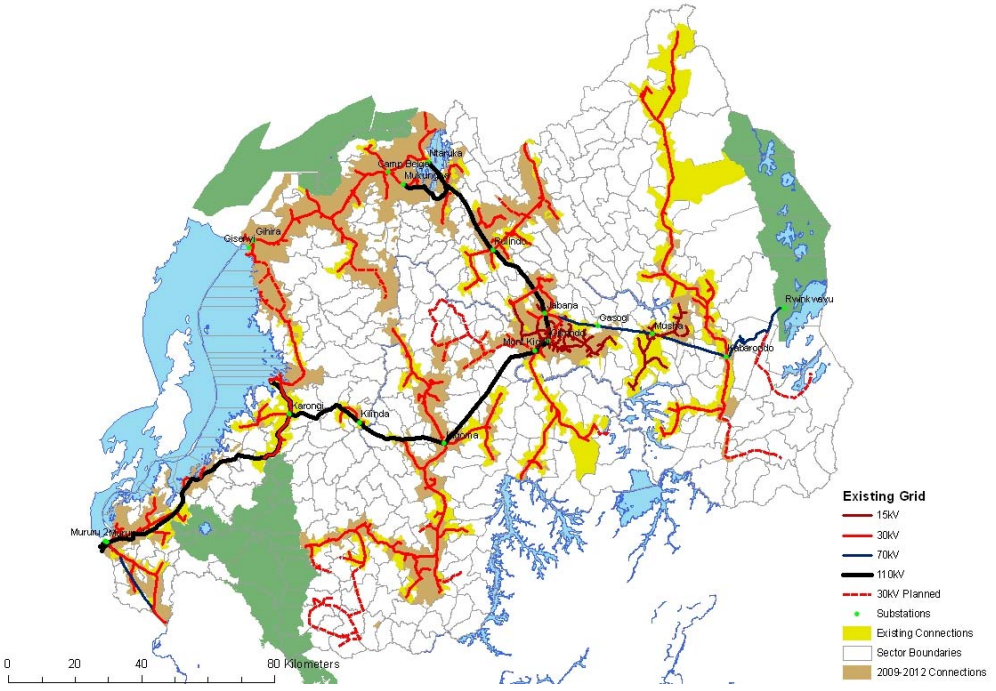

**57,000 new connections**

## Figure 4.10: Least Cost Grid Prioritisation for 2011



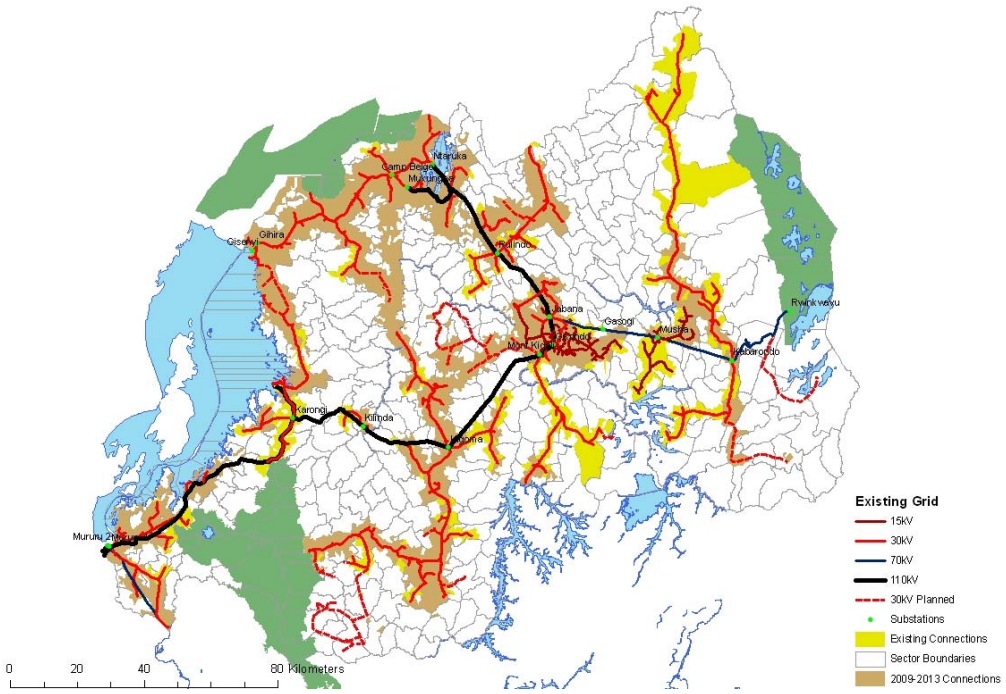

**66,000 new connections**

## Figure 4.11: Least Cost Grid Prioritisation for 2012




**68,000 new connections**

**Figure 4.12: Least Cost Grid Prioritisation for 2013**




**72,000 new connections**

By the end of 2013, the least-cost expansion plan shown in Figure 4.8 (above) increases sector coverage for grid connections from 59 percent of sectors to 69 percent. The Government has also considered an alternative development scenario that provides grid coverage in every sector by 2012. This scenario differs from a least-cost planning approach, and has been compiled to determine the incremental cost of reaching all sectors with the electricity network. This scenario is illustrated in Figure 4.13 (below).

The geospatial database calculates that an additional 500km of MV line would be required to reach all sectors within the grid by 2012. This cost is separately identified in the funding plan presented in Section 5, and also includes the increased costs per connection of making new connections in areas with lower household densities than the sublocations prioritised under the least-cost approach.

**Figure 4.13: Plan to Achieve 100 Percent Grid Coverage of Administrative Sectors**

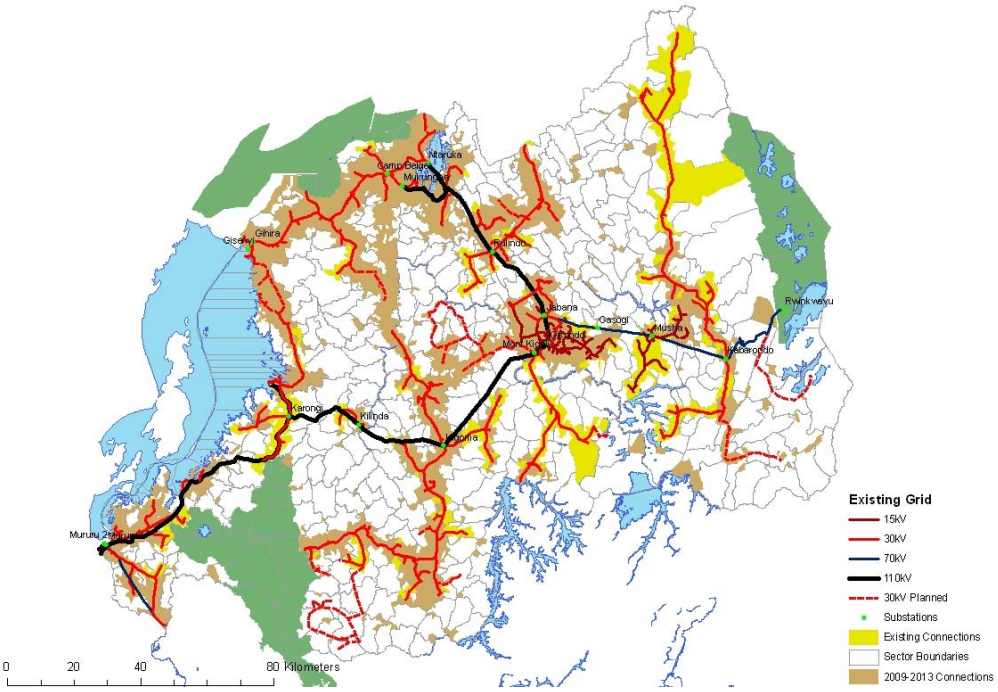
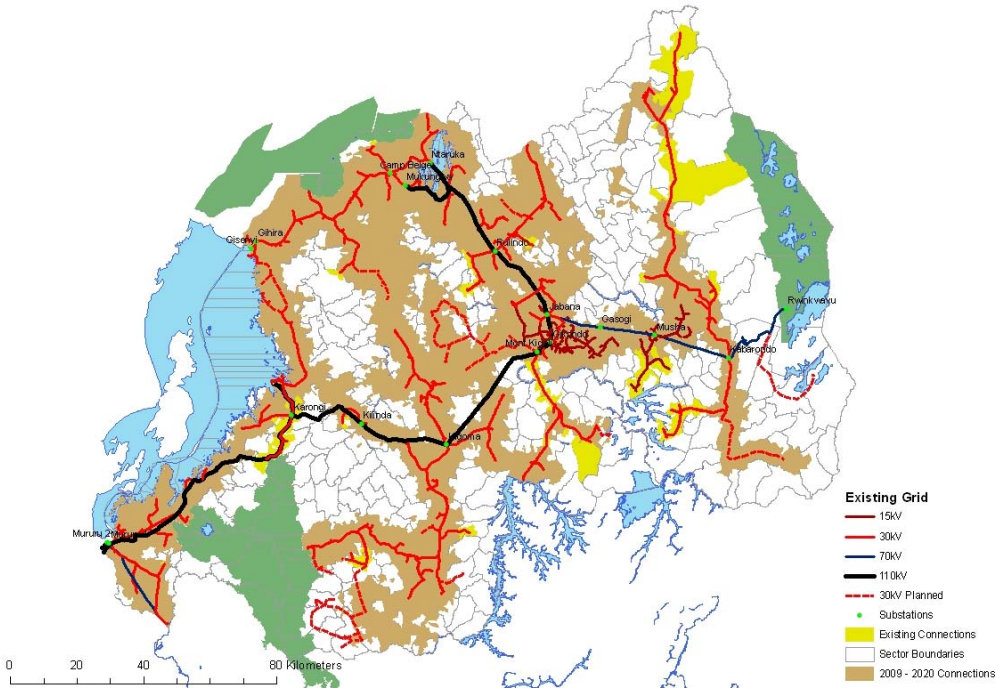



Figure 4.14 (below) shows the prioritisation of grid connections to 2020. This plan has been informed by the Government's target to reach 35 percent national electrification by 2020—as part of Rwanda's Vision 2020. While additional grid extensions are required to achieve the Vision 2020 target, the focus of the programme will remain in areas that are relatively close to existing electricity infrastructure.

**Figure 4.14: Least Cost Grid Prioritisation to 2020**




**2013–2020 – 394,000 new connections**

While the technical planning of the access programme indicates that the Government's access targets are achievable, large areas of the country will remain without access to grid electricity for many years to come. This is a reality given expectations on the ability of households to afford electricity, the availability of funding from external sources, and the rate that sector players can expand the electricity system.

However, social infrastructure in all sectors will be targeted for electricity access by 2012. All administrative offices, health centres and schools that are currently un-electrified (or non-grid electrified) and fall within the planning cells prioritised for grid electrification will receive grid supply by 2012. As discussed below in Section 4.5, the social facilities that fall outside these planning cells will also have access to electricity from dedicated solar PV systems. This will ensure that all Rwandan communities have some access to electricity for educational, health and social purposes.

**Table 4.2: Population within 5 Kilometres of Social Institutions with Electricity**

| Social Institution | 2008 | 2012 |
|---|---|---|
| Health Centres | 85% | 96% |
| Administrative Offices | 82% | 97% |
| Secondary Schools | 55% | 86% |

**Geospatial load forecast and distributional capacity review**

The grid prioritisation and phasing of new connections to meet the Government's targets have been used to compile a geospatial load forecast. This load forecast takes into account the growth rate of new electricity users from initially low levels of consumption (as low as 20kWh for some rural households) to higher levels of usage over a 10 year period. The spatial component of the load forecast allows loads to be aggregated within planning cells, using an electricity usage "coincidence" factor to account for different patterns of usage from different types of consumers. The geospatial forecast also enables the association of cells with the existing network, so that demand is linked to feeder zones to assess the capacity of the network.

Distribution network information on line and cable types for distribution feeders in Rwanda is currently very limited. The electricity utility has provided an indication of typical conductor sizes used at the different voltage levels in Rwanda, which is presented in Table 4.3 (below). These conductor sizes are considered relatively large compared to usual practice in Africa.

**Table 4.3: Typical Sizes of Conductors Used**

| kV | Conductor | Current (A) Normal | Capacity (MVA) |
|---|---|---|---|
| 110 | 240 / 40 | 610 | 117 |
| 70 | 132 / 24 | 420 | 51 |
| 30 | 120 / 20 | 410 | 22 |
| 15 | 70 / 12 | 300 | 8 |
| 6.6 | 35 | 190 | 3 |

These typical conductor sizes have been compared with network loading data received from the National Dispatch Centre. An initial high-level assessment of current loading indicates that adequate capacity will be generally available to support the new connections during the initial years of the access programme. However, detailed network modelling and load flow analysis will be necessary in the implementation stage of the access programme to identify potential capacity constraints in specific areas. Any bottlenecks can then be remedied through appropriate network strengthening investments. Additional network strengthening will also be required due to normal load growth and the rapid increase in the number of connections.

The costs of network strengthening investments have been estimated for this access programme Prospectus. In the absence of more detailed information these costs have been calculated depending on the additional demand added to the electricity network each year.

## 4.5 Off-Grid Electrification Planning

Off-grid power supplies are an important complement to the new electricity connections that will be made on the national grid. Rwanda is fortunate to have excellent water resources and hilly terrain that provides good run-off to harness hydro resources for energy. Solar PV electrification is also a viable option for electrification in parts of the country that cannot be economically reached by the national grid in the next five years.

### Off-grid micro hydro systems

The comprehensive Hydropower Atlas developed for Rwanda identifies over 300 existing and potential future hydro sites.[17] The Hydropower Atlas has been used in this Prospectus to identify the micro-hydro sites that should be targeted for development as part of the access programme. Further technical and financial assessments would be required to confirm the viability of developing these sites.

To prioritise the most viable potential micro-hydro sites, this Prospectus uses the following three-step approach:

- Potential sites in the Hydropower Atlas with a capacity of zero or greater than 750kW are excluded from the analysis
- GIS data on the supply area served by each potential site are used to prioritise micro-hydro developments. Demand for each site is estimated using an average ADMD of 0.3kVA and a power factor of 0.99. Sites with higher expected net present values are prioritised ahead of less financially viable sites
- Micro-hydro sites that are not capacity-constrained within a ten year time horizon are given priority. This eliminates small sites that would be fully utilised within a short timeframe from the analysis.

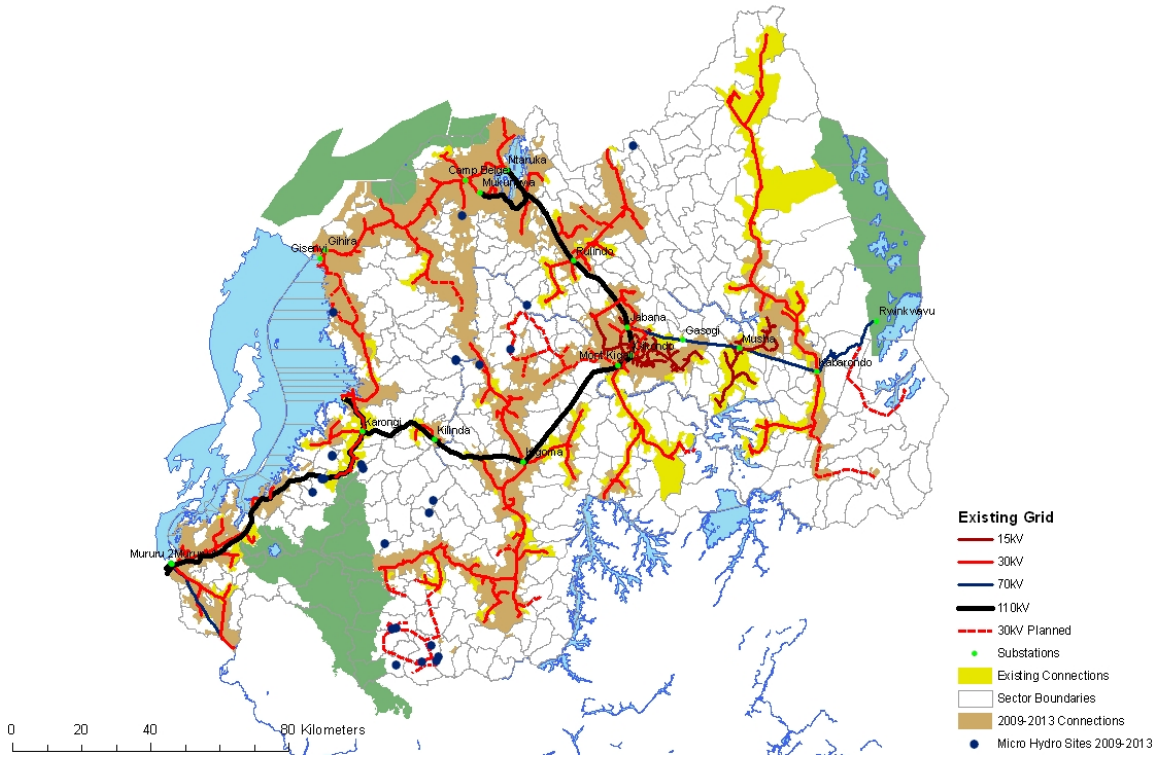
The 25 sites with the highest priority are selected for development within the next five years. The cost of supply from each site is then compared to an estimated long-run marginal supply cost on the grid of 12c/kWh. Where the cost of developing a micro-hydro site and the transmission to connect the site to the network results in lower-cost power than grid supply the site would be best developed as a grid connected system.

A listing of the sites by district and sector is provided in the Technical Annex, Section 2.2.[18]

[17] Ministry of Infrastructure and Belgian Technical Cooperation "Hydropower Atlas" (2007).

[18] Further information on each site, including geo-coordinates, can be found in the Ministry of Infrastructure and Belgian Technical Cooperation "Hydropower Atlas" (2007).

**Figure 4.15: Location of Prioritised Micro-hydro Sites**




### Solar PV for social institutions

The electrification of social institutions is an important component of the access programme. The location and electrification status of all administrative centres, health centres, and most primary and secondary schools has been used in the planning process. These characteristics appear in both the prioritisation process and for determining the funding requirements for grid and off-grid supply to these institutions. Social institutions that fall outside the areas identified for grid electrification have been prioritised for electricity supply by 2012 through the installation of solar PV units.

Different types of social institutions will have different electricity supply needs. Health centres will generally have greater demand for electricity than schools and administrative offices, and demand will vary depending on the population served by the institution and the level of service provided. At this stage of the planning process standard solar PV sizes have been used to estimate total solar PV costs. Through discussions with local stakeholders currently involved in solar electrification, solar PV units of 3kW have been assumed for health centres, 1.5kW for schools and 1kW for administrative offices.

A summary of the number of social institutions in each Province targeted for grid and off-grid supply is shown in Table 4.4 (below). The cost of these off-grid institutional systems is identified separately in Section 5.

**Table 4.4: Social Institutions Electrification Status at end of 2012**

| | Health Centres | | Administrative Offices | | Secondary Schools | | Primary Schools | |
|---|---|---|---|---|---|---|---|---|
| Total Number | 426 | | 451 | | 401 | | 2,439 | |
| Electrified (2008) | 205 | | 255 | | 2,250 | | | |
| | Grid | Off Grid | Grid | Off Grid | Grid | Off Grid | Grid | Off Grid |
| Northern | 44 | 37 | 59 | 35 | 49 | 18 | 212 | 12 |
| Southern | 52 | 59 | 46 | 64 | 74 | 27 | 209 | 14 |
| Eastern | 35 | 62 | 43 | 61 | 40 | 14 | 142 | 12 |
| Western | 66 | 38 | 66 | 38 | 83 | 30 | 309 | 15 |
| Kigali | 30 | 3 | 34 | 5 | 49 | 18 | 94 | 14 |
| Coverage | 53% | 47% | 55% | 45% | 74% | 26% | 40% | 3% |
| Total | 100% | | 100% | | 50% | | | |

Figure 4.16 (below) indicates the location of all health centres and their planned connection status (grid or off-grid) and the location of prioritised micro-hydro sites supply by the end of 2012. The number of health centres in Rwanda is assumed to grow at the same rate as the total population of the country. Under the access programme, all health centres will have electricity access by 2012. More than half of the health centres will have grid supply (53 percent), while the remaining health centres (47 percent) will receive solar PV systems.

**Figure 4.16: Health Centre Access to Electricity by 2012**

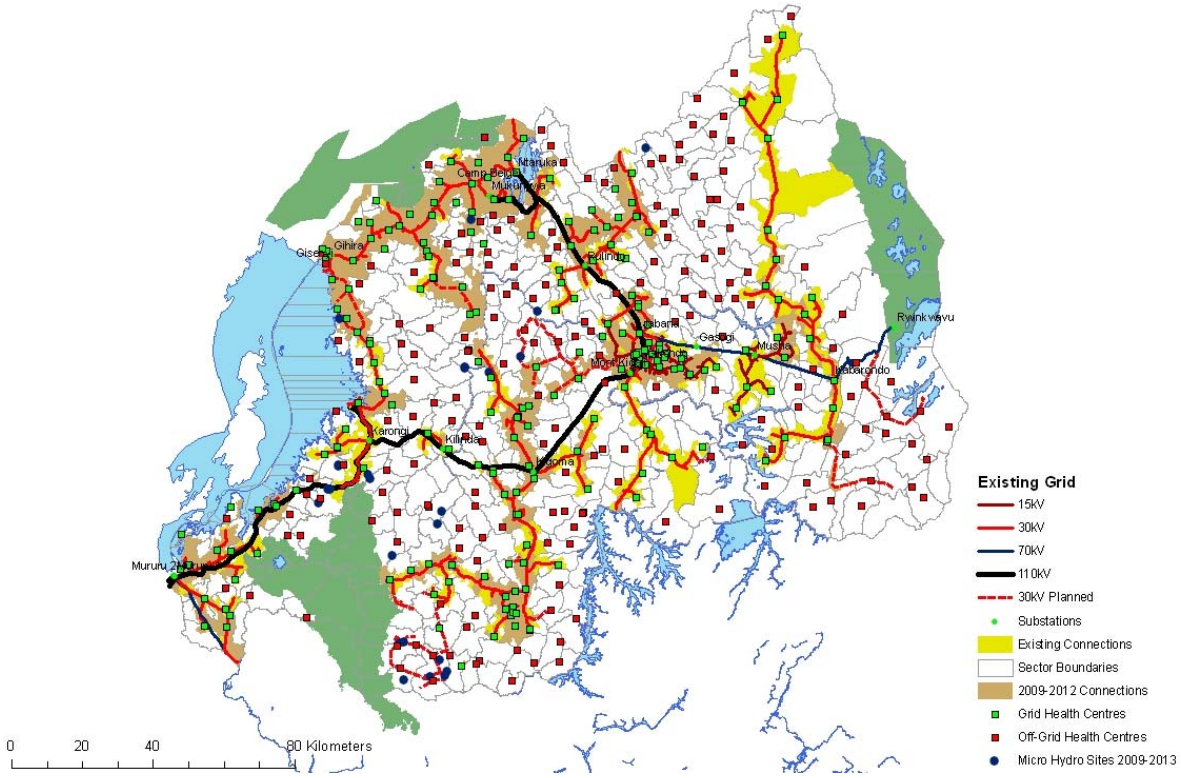
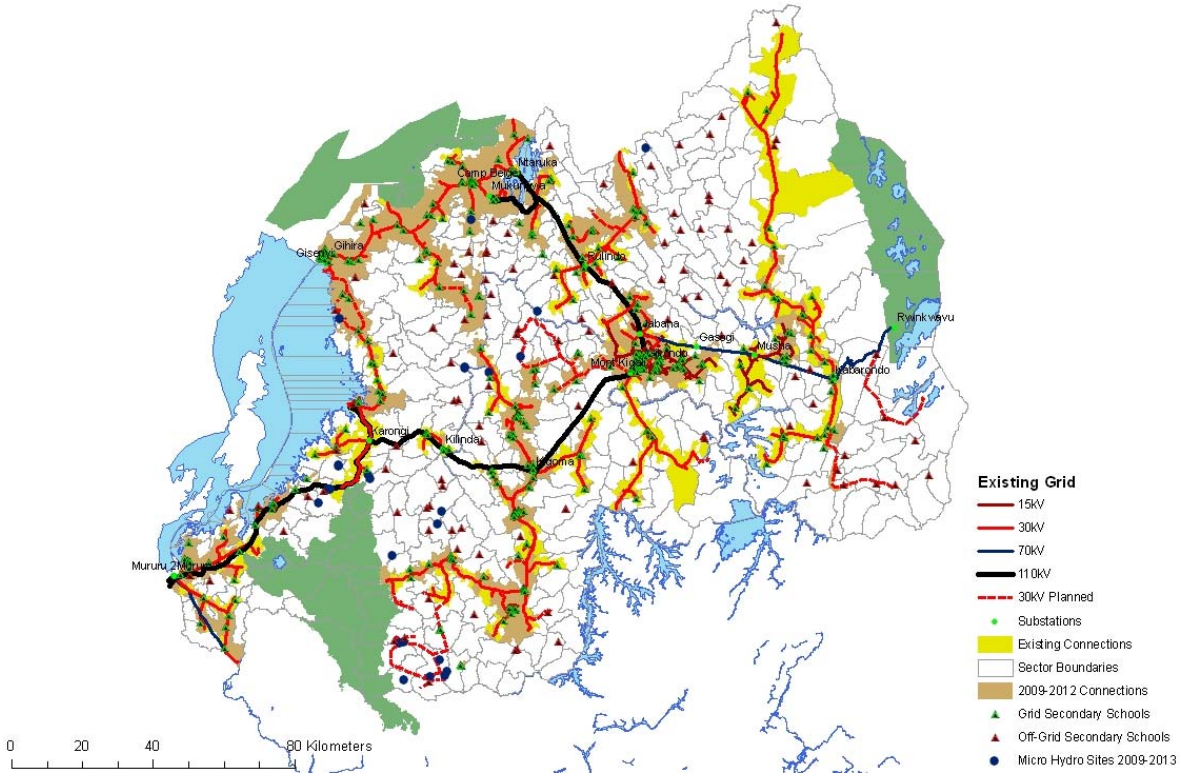


Figure 4.17 (below) indicates the location of all secondary schools and their connection status (grid or off-grid) and the location of prioritised micro-hydro sites supply by the end of 2012. Although primary schools are not indicated on the map (to avoid the map becoming unreadable), the same approach is applied to primary schools. The number of schools in Rwanda is assumed to grow at the same rate as the total population of the country. Under the access programme, 50 percent of schools will have electricity access by 2012. Most electrified secondary schools will have 24-hour grid supply (74 percent), while other secondary schools (26 percent) will receive solar PV systems.

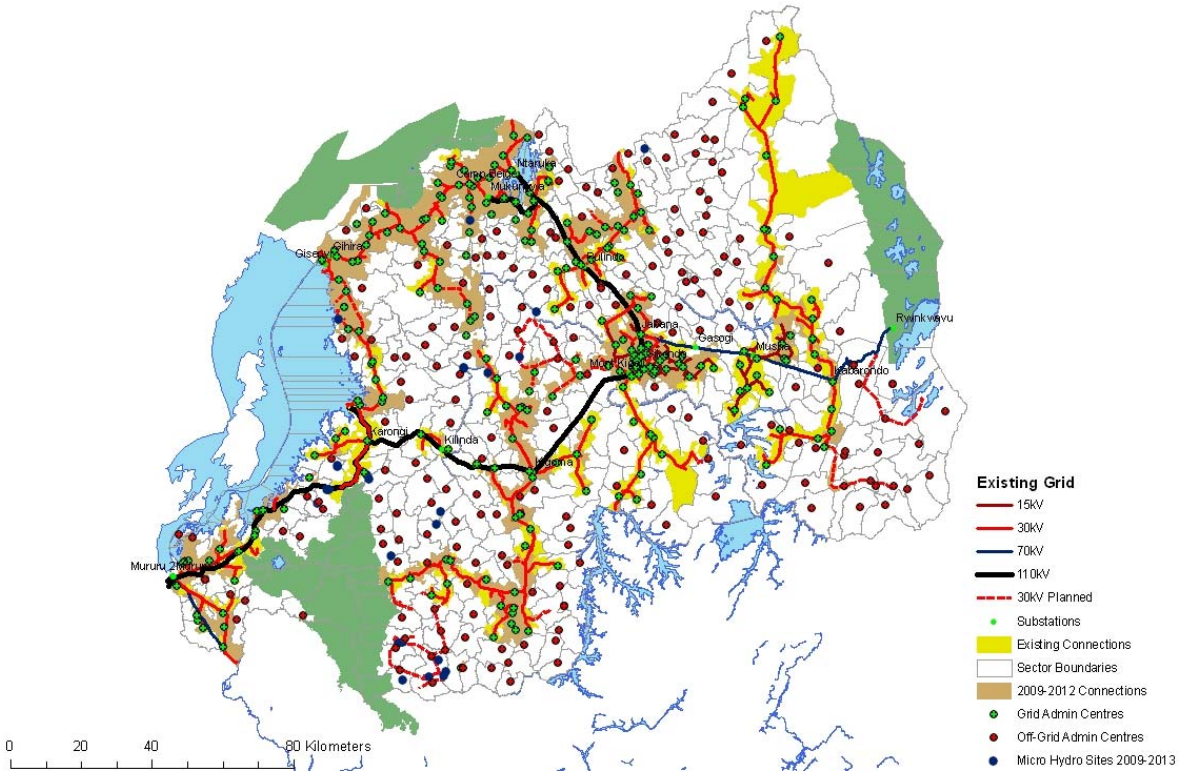
**Figure 4.17: School Access to Electricity by 2012**




Note: Only secondary schools are shown in the figure to avoid the map becoming unreadable. However, the planning approach is also applied to primary schools.

Figure 4.18 (below) indicates the location of all administrative offices and their connection status (grid or off-grid) and the location of prioritised micro-hydro sites supply by the end of 2012. Under the access programme, all administrative offices will have electricity access by 2012. Most administrative offices will have 24-hour grid supply (55 percent), while the remaining administrative offices (45 percent) will receive solar PV systems.

**Figure 4.18: Administrative Centre Access to Electricity by 2012**

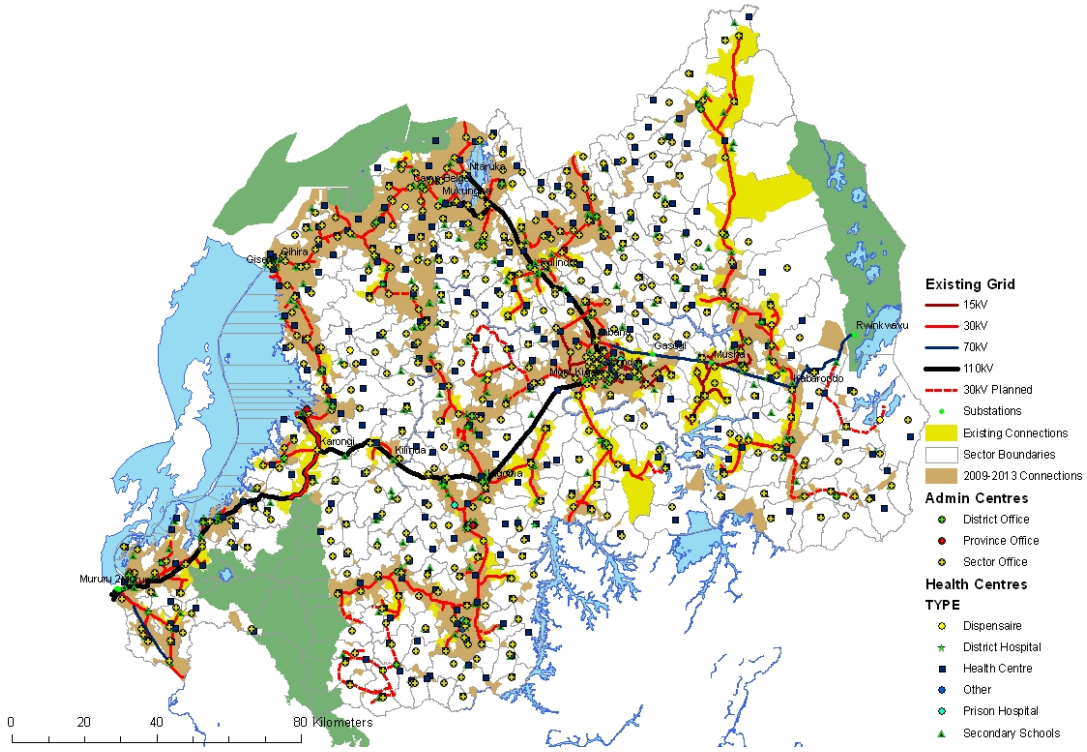



The installation of solar PV systems at social facilities that will not be connected to the grid by 2012 helps to ensure that the benefits of electricity will be accessible for all Rwandans. Due to the limits on the number of new household connections that are feasible, the solar PV programme will provide an important parallel to the main grid and micro-hydro components that can connect a large number of households. By providing electricity to remote social facilities, citizens that do not have household access by 2012 will at least be able to unlock the benefits of improved health, education and civic services. As discussed in Section 7, the solar energy programme funded by members of the European Union is a notable example of early donor commitment to the access programme. Investments that have already received some funding have been taken into account in estimating the additional funding required.

## 4.6 Summary of the Technical Plan for the Access Programme

Figure 4.19 (below) combines the grid and off-grid elements of the access programme to 2012 into a single geospatial plan.

**Figure 4.19: Overall Electrification Access Programme to 2013**




Three important conclusions can be drawn on the programme's priorities:

- **Focus on communities close to the existing network**—Rwanda is fortunate to have a relatively well-developed MV transmission network, with more than 60 percent of the population within five kilometres of the grid. Over 95 percent of planned new connections to 2012 are within five kilometres of the existing grid
- **Focus initially on more densely populated areas**—New connections will initially be made in the urban area of Kigali and peri-urban areas in the northeast of the country. This will help to minimise programme costs and maximise economic opportunities
- **Connect social facilities with solar PV in remote areas**—To reach the Government's targets for supplying electricity to schools, health centres and administrative offices, social facilities falling outside the areas that will be reached by the grid will have solar PV units.

The number of new household connections planned for the electricity network in each District is shown in Table 4.5, based on the least-cost planning approach. The three Districts in Kigali are presented first because new connections will initially focus in the urban area of Kigali. The remaining districts are presented in alphabetical order.

The table does not present the new connections that will be made to achieve complete grid coverage of all administrative sectors (shown in Figure 4.13 above). This means that districts with few connections will receive additional benefits to those highlighted in Table 4.5 as the programme is implemented. The connections made by off-grid systems (micro-hydro and

solar institutions) are also not shown in Table 4.5. This will further boost connections in under-served areas because more remote areas are targeted for off-grid supply under the least-cost plan. A full listing of new grid connections by sector, divided into infills and expansion connections, is provided in Table 2.6 of the Technical Annex.

**Table 4.5: Summary of New Grid Connections by District (2009–2013)**

| District | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| Gasabo | 5,630 | 2,696 | 3,377 | 2,562 | 1,825 |
| Kicukiro | 6,834 | 2,749 | 2,459 | 1,148 | 1,679 |
| Nyarugenge | 7,576 | 2,178 | 1,725 | 2,489 | 1,107 |
| Bugesera | - | - | - | 244 | 770 |
| Burera | 921 | 4,204 | 2,360 | 2,594 | 2,731 |
| Gakenke | - | 1,317 | 2,203 | 3,121 | 5,526 |
| Gatsibo | - | - | - | 1,271 | 2,248 |
| Gicumbi | - | 1,449 | 4,276 | 1,761 | 2,264 |
| Gisagara | - | 169 | 369 | 175 | 342 |
| Huye | 1,198 | 2,021 | 1,220 | 3,594 | 3,062 |
| Kamonyi | - | 295 | 2,043 | 3,000 | 3,723 |
| Karongi | - | 493 | 2,116 | 1,748 | 1,867 |
| Kayonza | - | - | 65 | 2,062 | 2,189 |
| Kirehe | - | - | - | 265 | 586 |
| Muhanga | 2,204 | 2,049 | 1,392 | 2,624 | 3,072 |
| Musanze | 3,315 | 8,319 | 4,869 | 3,515 | 2,932 |
| Ngoma | - | 85 | 454 | 986 | 998 |
| Ngororero | - | 1,546 | 3,743 | 3,327 | 2,719 |
| Nyabihu | 801 | 5,563 | 5,560 | 3,430 | 3,943 |
| Nyagatare | - | - | - | - | - |
| Nyamagabe | - | 482 | 386 | 1,186 | 1,825 |
| Nyamasheke | - | 2,304 | 2,550 | 3,352 | 3,817 |
| Nyanza | 76 | 2,033 | 286 | 2,401 | 2,450 |
| Nyaruguru | - | - | - | 85 | 54 |
| Rubavu | 3,707 | 8,949 | 4,294 | 5,136 | 3,126 |
| Ruhango | - | 605 | 2,197 | 2,301 | 1,415 |
| Rulindo | - | 1,127 | 5,827 | 3,086 | 3,277 |
| Rusizi | 3,254 | 3,412 | 2,529 | 4,286 | 2,856 |
| Rutsiro | 1,464 | 3,095 | 1,968 | 1,649 | 2,479 |
| Rwamagana | - | 264 | 2,458 | 2,607 | 1,535 |

# 5 Funding for the Access Programme

This Section presents the funding plan for the access programme. The funding plan shows that the access programme is not only technically viable, but also financially feasible, sustainable and stable. The funding requirements for the access programme and the sector as a whole have been projected on a cash-flow basis, and commitments for procurement packages have also been considered. This ensures that funding will be available as needed to support programme investments, eliminating interruptions that would frustrate progress and undermine the ability for sector players to achieve programme objectives.

This section demonstrates that the access programme can be fully-funded, provided a sufficient level of external support is contributed by development partners. The programme fits well with existing funding allocated to new grid connections, micro-hydro developments and solar PV installations. The access programme is also founded on a principle of improved sector financial sustainability—that at a minimum the sector must be able to cover operating costs from customer payments and make a 10 percent contribution towards the capital costs of the access programme.

This section first identifies the financial resources required to meet sector costs and achieve the objective of improved financial sustainability. Section 5.1 presents cost estimates for the access programme, divided into the core components of network extensions, network strengthening, new household connections, and off-grid connections. In Section 5.2 the cost of the access programme is considered alongside other funding needs (operating costs and capital investments in new generation and high-voltage transmission) to provide a complete picture of sector financial flows. Section 5.3 considers how financial commitments will need to align with the procurement of materials for the programme. Section 5.4 then discusses how an appropriate level of Government support for the access programme will balance the Government's support for the access programme against other Government priorities and fiscal constraints.

The financial analysis presented in this Prospectus is based on detailed financial modelling of sector cash inflows and outflows. Although the accuracy of these forecasts cannot be guaranteed, effort has been made to ensure that the cost estimates and expected revenues are based on realistic assumptions. A detailed breakdown of the assumptions of the cash flow model and the financial projections contained in the model can be found in Section 4 of the Technical Annex.

## 5.1 Estimated Cost of Access Programme

The cost of the physical plans for extending access to electricity presented in Section 4 have been estimated to calculate the total funding required for the access programme. The cost of each component in the programme has been estimated, together with the level of funding required for technical assistance. Table 5.1 (below) provides a summary of the total estimated capital costs of the access programme. The largest cost components of the programme are the extensions to the MV network, new connections through infills and in expanded distribution areas, development of micro hydro generators, and solar PV units for health centres, schools and administrative offices.

**Table 5.1: Total Capital Costs of Access Programme (2009-2013)**

| Programme Component | Investment (US$ million) | Technical Assistance (US$ million) | Total (US$ million) |
|---|---|---|---|
| MV Line Extensions | 104.3 | 0.9 | 105.2 |
| Expansion Connections | 70.8 | 0.8 | 71.6 |
| Micro Hydro Supply Systems | 54.3 | 0.5 | 54.8 |
| Infill Connections | 52.4 | 0.4 | 52.8 |
| MV Strengthening | 34.6 | 0.4 | 26.4 |
| Solar PV Units | 26.2 | 0.2 | 35.0 |
| RECO Strategic Plan and Training | 0 | 19.5 | 19.5 |
| Other Technical Assistance to MININFRA | 0 | 9.2 | 9.2 |
| Solar Hot Water | 4.7 | 0.3 | 5.0 |
| Compact Fluorescent Lightbulbs | 1.6 | 0 | 1.6 |
| **Total Cost of Roll-out Programme** | **348.9** | **28.7** | **377.6** |

The cost of each component within the programme has been estimated by analysing the costs incurred in recent electrification projects in Rwanda, and discussing component costs with local and regional suppliers. Consistent and up-to-date information was difficult to obtain directly from equipment suppliers, and Electrogaz does not currently maintain records of project costs in a format that allows component costs to be identified. However, cost information was available from a recent pilot project undertaken in the northeast of the country by the Tunisian electricity utility (the "STEG pilot") and data on other electrification projects in the region has been used in this Prospectus.

Recent electrification projects in Rwanda have been expensive. The high costs found in Rwanda are a result of the small scale of previous contracts for new connections, and other national factors such as high transportation costs. Through discussions with the electricity utility in Rwanda, three opportunities have been identified to achieve cost reductions for the access programme:

- Increase the size of the contracts bid out to private contractors to enable fixed costs to be recovered over a larger quantity of new connections
- Develop local capacity to manufacture required materials, such as power poles and electrical equipment
- Modify the technical specifications used for electrification projects to take advantage of lower cost supply options.

The first two opportunities for reducing costs will follow from the scale of the access programme. While current electrification projects in Rwanda are typically around 2,000 connections per contract, the access programme will contain much larger connection contracts to achieve total annual new connections of between 35,000 and 80,000 each year.

The average contract size is expected to be more than double the size of current contracts. This scale will enable existing local contractors to increase their capacity and will also attract international contractors to Rwanda to compete for connection contracts. Similarly, the capacity to supply other required materials will be enhanced by the scale of the access programme. The Government will work with private investors to ensure that local suppliers are able to compete for contracts under the access programme. However, some materials (such as power poles), will initially be imported until the Rwandan market develops.

Significant opportunities also exist to reduce costs by changing the technical specifications used in electrification projects. Some possible changes are discussed in Box 5.1 (below). The national electricity utility has established a working group to investigate opportunities to reduce costs by changing technical specifications.

**Box 5.1: Reducing Programme Costs by Changing Technical Specifications**

A major cost component of the access programme is the per kilometre cost of new medium voltage (MV) distribution line. Distribution line costs have traditionally been very expensive in Rwanda,[19] and work is underway to reduce these costs for the access programme.

One way to lower the cost of new MV power lines is to revise the technical specifications applied in recent electrification projects to use steel lattice-framed towers for new MV lines. Comparable investments throughout Africa use wooden poles, which are much cheaper and provide similar levels of performance. Concrete poles are also feasible for new MV lines, can be sourced at a significantly lower cost than steel lattice-framed towers, and can be manufactured locally (given sufficient volumes). The following pictures illustrate the traditional technical specification used in Rwanda (left), and a comparable wooden pole option used in other parts of Africa

[19] A recent electrification project in Rwanda undertaken by the Tunisian utility (STEG) cost $48,000 per kilometre of MV line for studies, equipment, transport and insurance. This was for a project of 4,000 connections.

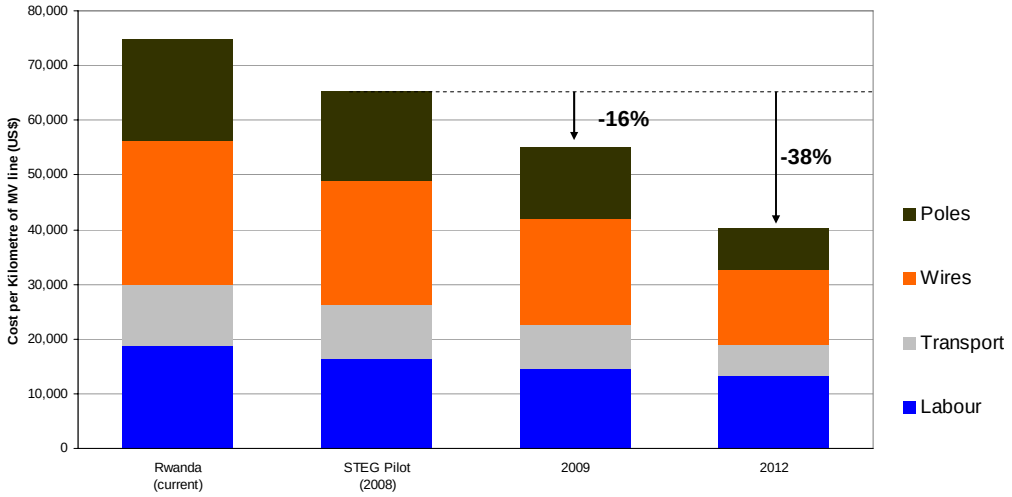
Opportunities also exist for the programme to lower the costs of low voltage (LV) reticulation. The electricity utility from Tunisia (STEG) has begun to provide technical assistance to Electrogaz on low-cost options for LV reticulation, such as the use of single phase and single-wire earth return (SWER) technology. It is expected that this approach can be cost-effectively applied throughout parts of Rwanda.

A component cost breakdown for MV line, MV/LV transformer substations, LV lines and service connections is provided in the Technical Annex, Section 3. The main components of these capital works are materials (poles and wires), transport and labour.

Typical component costs have been assessed based on recent local experience, together with the current pilot project being undertaken in the northeast of the country (the STEG pilot). A review of experience with other electrification projects has also been completed to provide comparative benchmarks for the projected component targets.[20]

Figure 5.1 (below) illustrates how the components of MV line extensions are projected to fall over the EDPRS period. Initial savings of around 16 percent are expected to come from the economies of scale provided by the access programme, and the larger size of project contracts and material procurement lots. Components such as poles will continue to be imported until local manufacturing facilities can be established, which is reflected in the initially lower cost savings on poles and transport costs. By 2012, cost reductions of around 40 percent for MV and LV lines are factored into programme funding requirements. These savings will result from the planned review of technical specifications, together with continued improvements in procurement practices. Projected costs also account for a reduction in transport costs by 2012 due to the development of local industry and the consequent reduction in import costs. Additional detail on modelled cost reductions is provided in the Technical Annex, Section 3.

**Figure 5.1: Projected Costs pre kilometre of MV Line Compared to Recent Projects**




[20] ESMAP. "Technical and economic assessment of off-grid, mini-grid and grid electrification options." World Bank, Washington, D.C. 2007.

Estimates of the capital cost of the major components of the access programme are shown in Table 5.2. This table shows the capital costs of rolling out the distribution network to achieve the required connections derived from the geospatial planning exercise, as well as the capital costs of off-grid solutions where those are more efficient.

The cost per kilometre of new MV line is initially estimated to be around US$55,000, after accounting for available cost reductions. These costs are expected to fall to US$35,000 per kilometre by 2013 as new material suppliers are established in Rwanda and as the programme gains procurement experience. The costs of connecting low voltage customers have been divided into "infill connections" (where low voltage networks already exist), and "expansion connections" (which will require additional medium voltage infrastructure within the supply area). A breakdown of the projected cost per connection in the access programme and expected cost reductions is provided in the Technical Annex, Sections 3 and 4.

**Table 5.2: Capital Cost Components of Electricity Access Programme (US$ million)**

| Programme Component | Unit Cost | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| Network extensions [1] | $55,000/km<br>$35,000/km | 23.5 | 24.1 | 20.6 | 22.7 | 13.3 |
| Low voltage connections | | | | | | |
| – Infill connections [2] | $350/conn. | 10.4 | 10.0 | 9.9 | 11.1 | 11.0 |
| – Expansion connections | $440/conn. | 1.5 | 16.3 | 16.6 | 17.8 | 18.6 |
| – CFLs | $1.82/CFL | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 |
| Network strengthening [3] | US$65/MWh | 1.5 | 4.1 | 7.1 | 10.2 | 11.8 |
| Off-grid connections | | | | | | |
| – Micro-hydro schemes [4] | $3,000/kW | 4.1 | 9.2 | 16.7 | 16.9 | 7.3 |
| – Solar PV electrification [5] | $20,000/kW | 6.4 | 6.4 | 6.4 | 6.4 | 0.7 |
| Solar Hot Water | $1,250/unit | 1.3 | 1.3 | 1.3 | 1.3 | 0.0 |
| Technical Assistance | Various | 7.3 | 7.3 | 5.4 | 5.4 | 3.2 |
| **Total** | | **56.1** | **78.9** | **84.2** | **92.1** | **66.3** |

Notes: [1] Initial MV line costs are estimated to be US$55,000/km. Costs are expected to fall by US5,000/km in each year of the programme, reaching $US35,000/km in 2013
[2] The connection costs quoted in the table are an average of per household connection costs for 2009–2012. These costs increase during the access programme as more remote communities are targeted for grid electrification
[3] The network is assumed to require further strengthening (for example, upgrading line capacities and conductor sizes) as additional load (MWh) is added under the access programme
[4] Average cost of micro-hydro generator and mini-grid distribution infrastructure. Actual costs vary depending on size of micro-hydro generator and the population density in the service area
[5] Includes the capital cost of solar PV units only (i.e. excludes operations and maintenance of PV units)

To put the costs of the access programme into context, Table 5.3 (below) summarises the per household capital costs of the access programme. Connection costs start at around

US$1,300 per household in 2009 and fall to around 1,200 in the remaining years of the EDPRS as the programme achieves cost reductions. The cost savings are partially offset each year as the programme moves from connecting primarily urban and peri-urban customers to reaching more rural communities. The total costs of the programme fall in 2013 to less than US$900 per household as investments to achieve the Government's EDPRS targets are no longer required. When the programme achieves efficient cost levels for the region, per household investment costs are project to fall to around US$850.

An indication of the additional costs incurred in the access programme by targeting remote communities and social institutions is also provided in the right hand columns of Table 5.3. These estimates only include MV/LV investments in the cost per household calculations (i.e. the costs incurred through solar and micro-hydro investments are excluded). Focusing only on the cost of MV/LV infrastructure reduces per household investment costs to less than US$1,000 in 2009 falling to around US$600 in 2013.

**Table 5.3: Summary of Costs of Access Programme per Household (2009 – 2013)**

| Year | Households Connected | Total Investment (US$ million) | Cost per Household ($/HH) | MV/LV Investment (US$ million) | Cost per Household ($/HH) |
|---|---|---|---|---|---|
| 2009 | 36,969 | 56.1 | 1,323 | 35.5 | 959.7 |
| 2010 | 57,428 | 78.9 | 1,247 | 50.4 | 877.2 |
| 2011 | 65,983 | 84.2 | 1,194 | 47.1 | 713.5 |
| 2012 | 67,661 | 92.1 | 1,281 | 51.6 | 763.3 |
| 2013 | 71,645 | 66.3 | 882 | 43.0 | 599.6 |
| **Total** | **299,686** | **377.6** | **1,185** | **227.5** | **782.6** |

## 5.2 Sector Funding Needs and Funding Sources

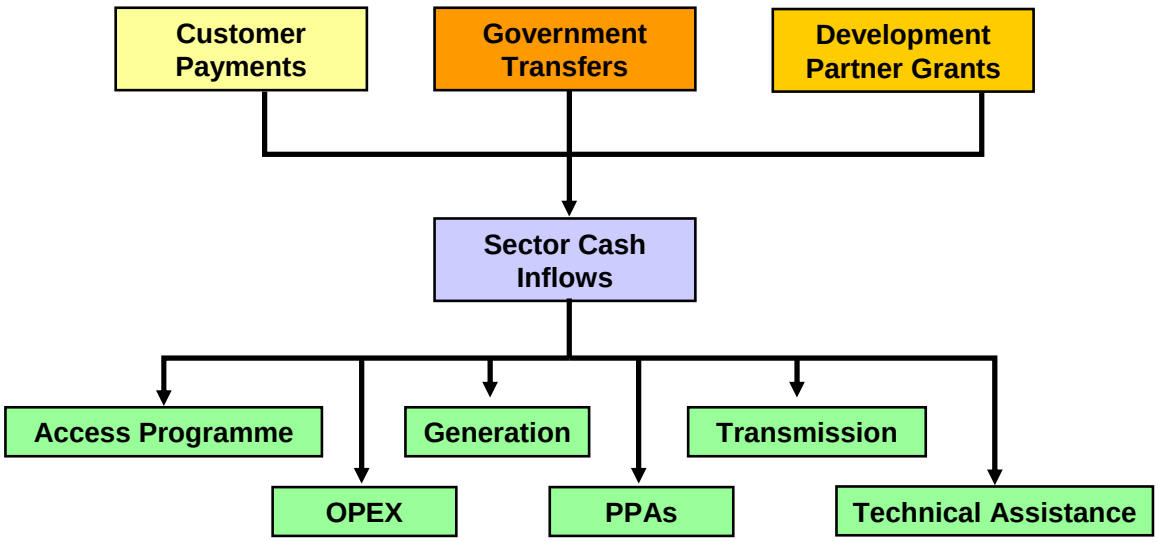
The cost of increasing access to electricity needs to be fully integrated with other sector initiatives to understand the total sector funding needs. Other expenses that must be met include the on-going provision of services to existing customers, as well as efforts to improve the quality of the electrical network and reduce the costs of generation.

Figure 5.2 (below) provides an overview of sector financial flows. At the bottom of Figure 5.2 are the financial outflows in the electricity sector—operating expenses (OPEX), costs for purchasing power under contract from independent generators (PPAs), capital costs for new generation and transmission facilities and the costs of the access programme. The figure shows that these costs must be met from three sources of funds: customer payments (primarily tariffs and connection charges), Government transfers and grants from development partners.

For the electricity sector to be financially viable, the entire funding needs of the sector, including both capital and operating costs, must be able to be covered from the three sources of funds. In simple terms, over any period of time, the cash needs of the sector—

based on how much is needed to meet operating costs and fund investments in generation, transmission and distribution access—must be fully met by cash payments from the customers, the Government and donors.[21]

**Figure 5.2: Overview of Sector Financial Flows**




The financial flows shown in Figure 5.2 are interdependent. As one funding source or funding need changes, other financial parameters will be affected. For example, reducing customer payments by lowering tariffs or cutting connection charges will reduce the costs of the access programme. This is because a greater proportion of households within each community will be able to afford an electricity connection, and the access programme will therefore become more geographically concentrated. However, this offsetting effect is likely to be small, and therefore lower customer payments will also mean that additional external funding is required from the Government and/or development partners.

The following subsections explore some of the sector funding needs and funding sources in more detail.

**Funding needs—operating expenses and power purchases**

Operating expenses in the electricity sector include the costs of generating electricity and purchasing power from independent producers,[22] operating and maintaining the transmission and distribution network, paying staff wages, administrative expenses and interest on loans. Off-grid operating costs include the cost of operating and maintaining decentralised micro-

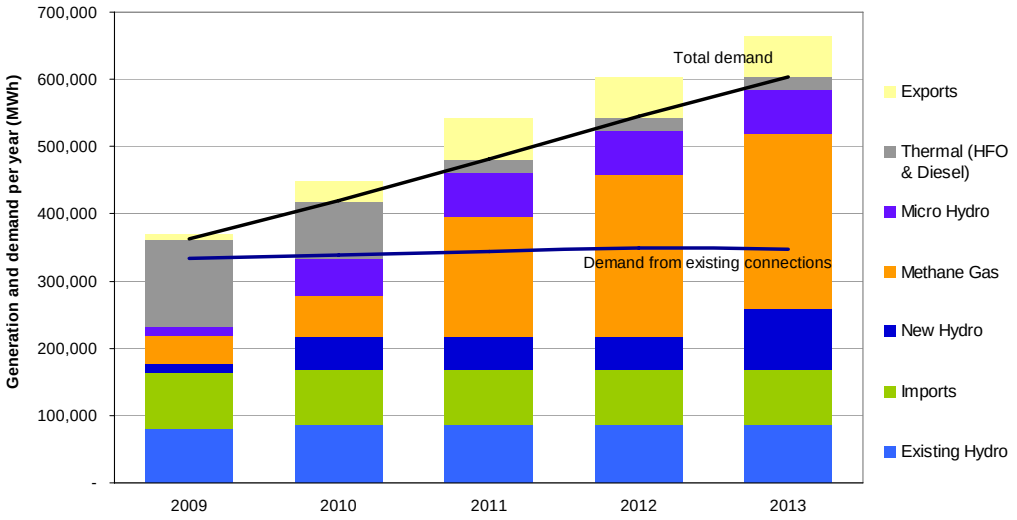
[21] Although funds can be accessed from other sources, such as private finance or loans to sector participants, these are sources of finance (not funding), and need to be paid back over time from customer payments, government transfers or development partner contributions.

[22] The Government recently concluded negotiations for a power purchase agreement (PPA) with a US-based company (Contour Global) to build and operate a methane gas generation plant at Lake Kivu. The plant will have an initial installed capacity of 25MW commissioned in 2010, and a further 75MW expected in 2012 (see East Africa Business Week, 7 March 2009). Other planned plants are also treated in this Prospectus as supplying electricity under power purchase agreements, specifically Rukarara, Mukungwa II, Nyaborongo, the methane gas pilot plants at Lake Kivu, and planned new micro-hydro plants being developed by development partners (GtZ, BTC and UNIDO).

hydro and solar PV units, while grid connections include the cost of purchasing the additional energy needed to meet the demands of the new customers.[23] The operating costs for new connections also include the incremental costs of maintaining additional network and servicing new customers. A detailed breakdown of projected sector operating expenses is provided in Section 4.2 of the Technical Annex.

The largest operating cost in the sector comes from generating electricity and purchasing power. An overview of how available generation sources should be operated over the next five years to meet demand at the lowest cost is provided in Figure 5.3 (below). These projections show that initially the new heavy fuel oil capacity commissioned in 2008 will need to operate as a baseload generator to meet demand, and will change to a peaking role as commercial methane gas generation capacity with lower operating costs is commissioned. Detailed projections of demand and generation are also provided in the Technical Annex, Section 4.2.

**Figure 5.3: Overview of Least-cost Generation Dispatch (2009-2013)**




The following approach has been used to determine the operating parameters shown in Figure 5.3 (above):

- **Demand** is depicted by the lines running across the chart. The lower blue line shows demand from existing customers, which is assumed to grow at a constant, relatively low rate (around 3 percent each year). Demand from new connections is shown by the area between the two lines, which grows over time as new connections are added and as newly-connected customers increase their consumption of electricity. Demand from each new connection is assumed to increase over time according to engineering curves (known as S-curves) derived from empirical experience in Africa on electricity consumption from different types of consumers and households. The demand projections used in this Prospectus are consistent with the demand forecasts presented in the Master Plan,

[23] In this context, it is important to note that the price per kWh for energy purchased from independent suppliers includes a component to cover the capital cost of developing additional generation.

which estimate 370GWh of domestic electricity demand in 2010 and 965GWh in 2015[24]

- **Generation** is shown by the vertical coloured bars in the chart, ordered from plants with the lowest operating cost (existing hydro stations) to highest operating cost (thermal plants). Lowest-cost available generation is used first to meet demand, assuming different availability and utilisation of different plants.[25] The analysis in this Prospectus assumes that available generation is dispatched first to meet existing demand, and is then dispatched to meet demand from new connections made under the access programme. This approach uses the marginal cost of generation to determine the cost of the access programme, rather than using average generation costs which are considerably lower
- **New generation plants** are scheduled to come on-line according to current expected commissioning dates. The "new hydro" generation shown in Figure 5.3 refers to the 9.5MW plant at Rukarara (available from the end of 2009) and the 27.5MW plant being built at Nyaborongo (expected to be commissioned in 2013). The new 25MW methane gas plant is assumed to be available in the first quarter of 2011, and new micro-hydro plants are expected to be commissioned incrementally from 2009–2012
- The **marginal generation plant** is assumed to be the recently commissioned heavy fuel oil (HFO) plant developed under the UERP. Oil prices are assumed to increase to US$100 per barrel by the end of 2009, and remain at that price (in real 2009 dollars).[26] This plant, together with the existing Jabana diesel plant, will be operated where necessary to meet demand. The analysis in this Prospectus suggests that the HFO plant will initially need to be operated as a baseload generator, but will shift to a peaking and exporting role as new, lower-cost generation sources are commissioned. This Prospectus assumes that when new sources of generation are available the HFO plant generates electricity during peak periods.[27] Where sufficient surplus capacity is available from the HFO plant, energy is assumed to be exported at a price 25 percent higher than the cost of generation.

The total estimated costs of operating the electricity system in Rwanda are presented in Table 5.4 (below), including operations and maintenance expenses, staffing and administrative costs. An operating contingency has also been factored in to account for the efficiencies that are expected to be achieved over the next four years. This contingency starts at 10 percent of other operating costs and falls to five percent by 2012.

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[24] See Fichtner. "Rapport Final de la Phase I. Volume 1: Rassemblement des donnees economiques et prevision de la demande" 2009, Tableau 7-21.

[25] Availability assumptions are particularly important for hydro generation plants, which rely on water availability to generate electricity. In recent years, hydro plants in Rwanda have been constrained due to lower than average rainfall. The assumptions used in this Prospectus are from Vernstrom (2008).

[26] Sensitivity analysis suggests that changes in the oil price will not have a major impact on sector operating costs, unless oil price changes are combined with a significant delay in the commissioning of the planned 25MW methane gas generation plant at Lake Kivu. This is because the commissioning of methane gas generation will reduce the need for generation from the HFO plant.

[27] The peak period in Rwanda is assumed to last for four hours during weekday evenings.

**Table 5.4: Estimated System Operating Costs (2009–2013) (USD million)**

| Programme Component | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| Current connections | | | | | |
| – Generation | 24.7 | 29.5 | 24.8 | 25.3 | 25.2 |
| – Transmission and Distribution | 4.3 | 4.0 | 3.6 | 3.3 | 3.0 |
| – Other (staff, administration, interest)[1] | 5.1 | 5.3 | 5.5 | 5.7 | 5.8 |
| New grid connections | | | | | |
| – Generation | 2.0 | 8.0 | 12.8 | 18.1 | 24.3 |
| – Transmission and Distribution | 0.3 | 0.9 | 1.8 | 2.6 | 3.7 |
| – Other (staff and administration) | 0.7 | 1.8 | 2.8 | 3.7 | 4.7 |
| Off-grid connections | 0.7 | 1.5 | 2.8 | 4.8 | 1.4 |
| Operating contingencies | 4.5 | 5.1 | 4.3 | 3.8 | 3.4 |
| **Total** | **42.3** | **56.1** | **58.4** | **67.4** | **71.5** |

The average cost of supplying existing customers in Rwanda is projected to be around 8–10c/kWh, while new connections made under the access programme have a higher average supply cost of between 10–13c/kWh. This is because new connections are assumed to be supplied by higher-cost plants. The overall average supply cost is projected to be around 9c/kWh. These estimated per unit supply costs are lower than those recently incurred in Rwanda because expensive rental units have been used in the past four years. For comparison, the average cost of supply in 2007 is estimated to be 17c/kWh.[28]

**Funding needs—capital investments**

The Government, development partners and private investors have proposed a number of capital investments in new generation and transmission that must be funded, in addition to the access programme. It is important to account for these investments in planning the access programme because the Government and development partners have constraints on the amount of funding that can be committed to the energy sector.

Estimates of the capital costs accounted for in this Prospectus are shown in Table 5.5 (below). Because most new generation capacity is treated as being repaid under power purchase agreements, the capital costs of constructing most new generation plants are not shown in Table 5.5 (instead payments under power purchase agreements are assumed to be sufficient to cover operating expenses and repay capital costs). The capital cost for new generation shown in Table 5.5 is for rehabilitating existing micro-hydro sites and conducting further hydro studies.

[28] Electrogaz Annual Report, 2007.

**Table 5.5: Capital Cost of Sector Investment Plans (excluding generation under PPAs)**

| Capital Investments | 2009 | 2010 | 2011 | 2012 | 2013 | Total |
|---|---|---|---|---|---|---|
| Generation | 22.3 | 12.7 | 17.5 | 17.6 | 4.4 | **74.5** |
| HV Transmission [1] | 25.7 | 19.9 | 11.1 | 11.8 | 11.8 | **80.3** |
| Distribution Rehabilitation | 0.2 | 0.2 | 0.2 | 0.2 | 0.7 | **1.5** |
| Access programme | 56.1 | 78.9 | 84.2 | 92.1 | 66.3 | **377.7** |
| **Total** | **104.3** | **111.7** | **113.0** | **121.7** | **83.2** | **534.0** |

Notes: [1]Transmission expenditures also include allocations for the rehabilitation of existing transmission and distribution networks, including the rehabilitation at Gikondo under the UERP.

The Medium Term Expenditure framework highlights that the Government has committed to provide considerable funds to the energy sector, in addition to its commitments to the access programme (Vernstrom, 2008). The Government will provide most of the US$80 million highlighted in Table 5.5 for new transmission facilities, with support from development partners such as the African Development Bank, on regional transmission links.

Private investors are also contributing an increasing amount in the energy sector. Most notably, the US-based company Contour Global signed a US$325 million deal to develop 100MW of methane gas fired generation at Lake Kivu.[29] In addition, development partners are working with private entrepreneurs on several micro-hydro sites.

**Funding needs—technical assistance**

Technical assistance will be an important component of the proposed expansion plan for Rwanda's electricity system. The electricity utility will need to enhance its capacity to plan and develop as a company, and a strategic plan has been prepared for the new electricity utility that estimates the cost of the technical support required (Hampton, 2009). Different aspects of the access programme will also require technical support. An initial estimate of these costs is provided in Table 5.6 (below).

[29] See Contour Global http://www.contourglobal.com/# (Accessed March 16, 2009).

**Table 5.6: Technical Assistance Required for Access Programme**

| Technical Assistance | 2009 | 2010 | 2011 | 2012 | Total EDPRS |
|---|---|---|---|---|---|
| **Grid-based component** | | | | | |
| Electrogaz Strategic Planning | 1.7 | 1.7 | 1.7 | 1.7 | 6.9 |
| Programme implementation unit | 1.1 | 1.1 | 0.6 | 0.6 | 3.8 |
| Further design and planning | 0.8 | 0.8 | 0.8 | 0.8 | 2.5 |
| Support to private sector | 0.2 | 0.2 | - | - | 0.5 |
| Lowering Programme Costs | 0.2 | 0.2 | - | - | 0.4 |
| Training for programme | 0.5 | 0.5 | 0.5 | 0.5 | 2 |
| Total Grid Based Technical Assistance | 5.3 | 5.3 | 3.7 | 3.7 | 17.9 |
| | | | | | |
| **Support to MININFRA/NEDA** | | | | | |
| SWG Secretariat | 0.8 | 0.8 | 0.8 | 0.8 | 3.2 |
| Reporting | 0.7 | 0.7 | 0.7 | 0.7 | 3 |
| Micro hydro sustainability framework | 0.2 | 0.2 | - | - | 0.5 |
| Solar PV installation | 0.1 | 0.1 | 0.1 | 0.1 | 0.4 |
| Solar hot water systems | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 |
| Total Technical Assistance to MININFRA / NEDA | 2 | 2 | 1.7 | 1.7 | 7.4 |
| **Total Technical Assistance** | **7.2** | **7.2** | **5.4** | **5.4** | **25.3** |

**Funding sources—customer payments (tariffs and connection charges)**

Financially sustainable power systems rely solely on customer payments to meet both operating and capital costs. However, very few developing countries have been able to achieve financial sustainability due to the relatively high costs associated with system expansion and the relatively limited ability for customers to pay cost-reflective tariffs.

The ability to at least fund operating costs through customer payments is greater in Rwanda than many other African nations as a result of recent Government decisions to raise tariff levels. The current residential electricity tariff in Rwanda is 112 RWF/kWh (approximately 20c/kWh) before value added tax.

Revenue collection rates are also relatively high in Rwanda due to the extensive use of prepayment meters. Electrogaz reports that in 2007, the utility was able to collect payment

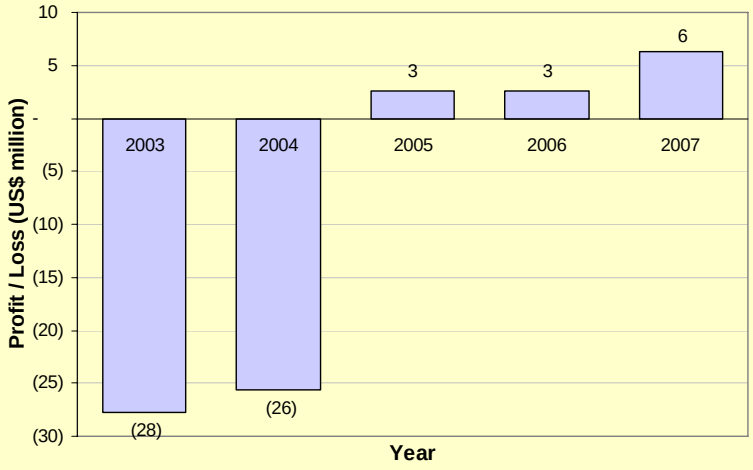
on approximately 75 percent of residential and institutional bills, and over 80 percent of bills issued to larger customers.[30]

Additional tariff revenues, combined with increasing support from the Government, have helped to improve the financial health of the Rwandan electricity utility over the past five years. As discussed in Box 5.2 below, the national utility has historically struggled to meet its operating costs from available funding sources, but has covered its costs from available revenues since 2005.

**Box 5.2: Historical Financial Performance of Electrogaz**

The financial health of the electricity utility in Rwanda is an important success factor for the access programme. Electrogaz will have primary responsibility for implementing the access programme, and it is therefore crucial that financial support provided to extend electricity access is not put at risk by poor utility financial performance.

The graph below provides an overview of Electrogaz's financial performance from 2003–2007 by focusing on bottom-line profits and losses. These profit and loss figures have been obtained from trial balances provided by Electrogaz for the past three financial years to obtain a reasonable view of the financial position of the company before the release of audited financial statements for this period.[31]




Higher revenues, combined with lower interest payments, have enabled Electrogaz to make a small profit from 2005–2007. These results are a significant improvement on the large financial losses made by Electrogaz in 2003 and 2004.

The Government recently commissioned an external consultant to help understand whether tariffs can be adjusted to account for the lower cost of new generation sources.[32] The Government also plans to complete a full tariff study this year to fully understand the costs of serving different customers with electricity. The initial tariff study found that the

[30] Electrogaz Annual Report, 2007.

[31] An accounting firm from Mauritius is currently completing an audit of the financial accounts of Electrogaz from 2003–2007. The results of this audit are expected in coming months.

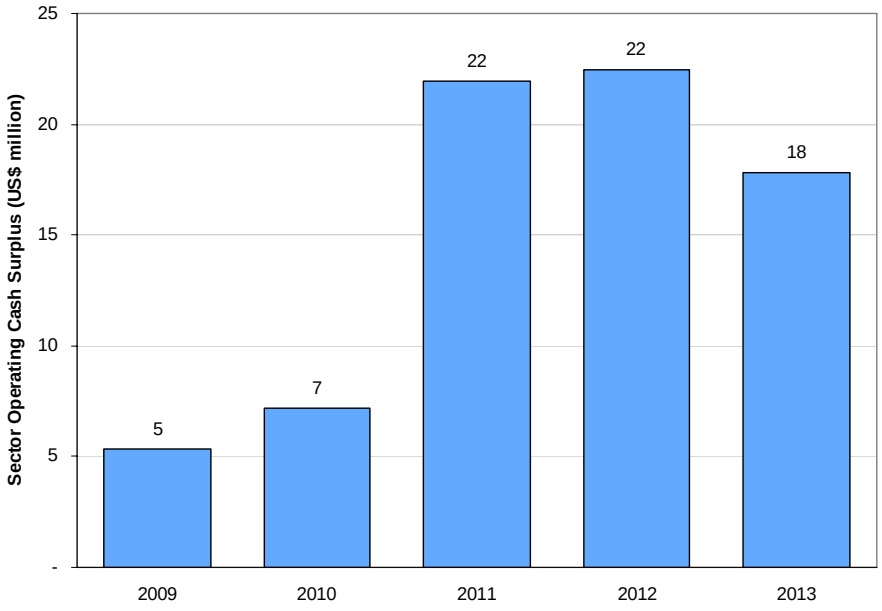
[32] Vernstrom. "Tariffs, taxes and subsidies in the electricity sector: An assessment and guide for public policy." Report commissioned by the Ministry of Infrastructure, Rwanda. 2008.

Government should be cautious about promising any tariff cuts as a result of the development of lower-cost generation sources. The Government intends to ensure that, at the very least, customer payments cover the entire system operating costs.

However, for the success of the access programme it will be important to make the initial connection cost affordable to customers. New customers are currently charged close to the full cost of connection, which can exceed US$500 and is not affordable to the vast majority of Rwandan households. The financial projections in this Prospectus have been calculated assuming that grid-based electricity consumers are asked to contribute 10 percent of the cost of their connection—an average of US$100 per connection.

Assuming that tariffs remain at current levels and a US$100 connection charge applies, the sector is projected to generate around US$75 million (42 billion RWF) in surplus cash flows (that is, after meeting operating costs). These surplus customer payments will be used to fund a small proportion of investments in new generation, transmission and the access programme—offsetting funding requirements from the Government and development partners. Figure 5.4 (below) presents projections of surplus cash flows to 2013, and a detailed breakdown of cash flows from operations is provided in the Technical Annex, Section 4.2.

**Figure 5.4: Projected Electricity Sector Net Operating Cash Flows (2009–2013)**




Projected surplus cash flows are projected to increase significantly when the planned 25MW methane generation plant is commissioned in 2011. This will reduce operating costs by displacing higher-cost generation from heavy-fuel oil.

### Summary of funding needs and funding sources

An initial analysis has been prepared of how total sector funding needs over the next four years (2009–2013) will be met while adhering to the following two funding principles:

- At a minimum, sector operating costs will be met through operating revenues

- The capital costs of the access programme will be funded in the following proportions: 10 percent from connection charges, 10 percent from the utility's financial resources and the remaining 80 percent from Government transfers and grants from development partners.

Figure 5.5 (below) illustrates that the first principle is expected to be achieved in each quarter of the EDPRS period. The graph shows that operating costs are projected to decrease in 2011 after a commercial scale methane gas plant is commissioned. At the same time operating cash flows increase as more power is available for sale.[33] Total system operating costs over the next four years are projected to be in the order of US$220 million, while cash flows from customer tariffs amount to over US$260 million.

**Figure 5.5: Forecast Sector Cash Flows (2009–2012) (RWF million)**

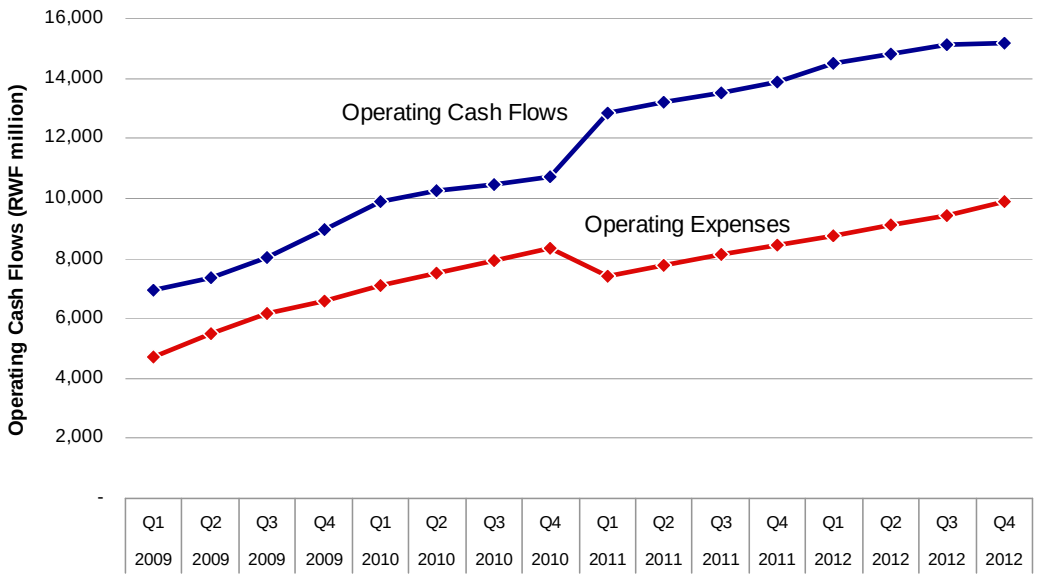


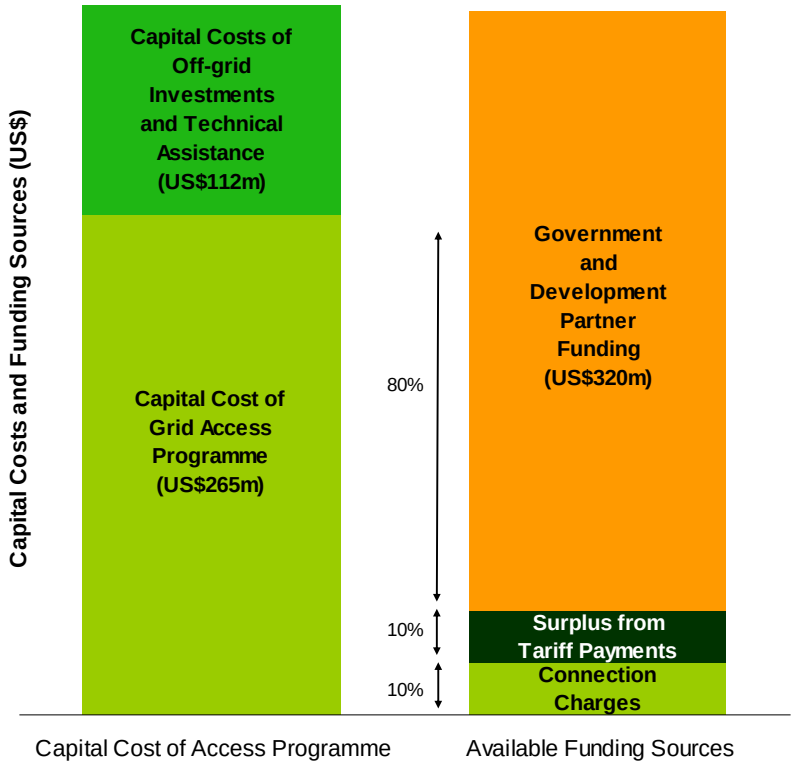

Figure 5.6 (below) shows the funding sources available to meet the capital costs of the access programme:

- **Connection charges** averaging US$100 per connection are required to provide 10 percent of the programme costs directly from new customers. These charges could be differentiated based on customers' ability to pay. This could be achieved by reducing the connection charge over time, ensuring that customers that are willing to pay relatively higher connection charges receive electricity connections first
- **Utility self-financing** totalling 10 percent of programme costs will come from operating cash surpluses. This contribution needs to be provided through operating surpluses because Electrogaz is not in a position to borrow for capital projects

[33] The financial projections made in this Prospectus assume that a proportion of surplus power is exported. The surplus power might alternatively be used for industrial or commercial developments within Rwanda.

- **Government and development partner funding** will need to be in the order of US$320 million to meet the remaining costs projected to 2012. This contribution will have an important effect on accelerating growth and reducing poverty, and as incomes rise, over time the power sector in Rwanda will become self-sustaining.

**Figure 5.6: Funding Sources for Capital Costs of Access Programme**




## 5.3 Financial Commitments for an Initial Procurement Package

The capital costs of the access programme have been projected on a quarterly basis to 2012 to ensure that cash expenditure requirements are able to be met from available sources of cash (see Technical Annex, Section 4.2). In addition, an initial procurement package has been estimated, recognising that promptly procuring required materials in bulk will achieve early cost reductions. An initial procurement of materials will also ensure that the programme is not delayed due to shortages in available materials.

Although payments to suppliers under procurement contracts will generally be made upon delivery of materials, this projection helps to understand the funding commitments that will need to be made by development partners to enter into large-scale agreements with suppliers.

The procurement packages presented in Table 5.7 is based on the projected costs of two initial procurement components:

- Grid connections in the first 18 months of the access programme (approximately 65,000 connections)

- EPC contracts for half of the new grid connections during the second 18 months of the programme (approximately 47,000 connections).

This suggests that financial commitments of approximately US$96 million will be needed to fund an initial procurement package and enable timely programme implementation.

**Table 5.7: Estimated Cost of Initial Procurement Packages**

| | Grid connections in 1st 18 months | | EPC contracts for grid connections in 2nd 18 months | | |
|---|---|---|---|---|---|
| **Programme component** | **Units required 2009–2010** | **Cost (US$ million)** | **Units required 2010–2010** | **Cost (US$ million)** | **Major components** |
| MV line extensions | 669 km | 35.7 | 350 km | 15.0 | Poles, MV cable, isolators, accessories |
| Infill connections | 47,541 connections | 15.4 | 20,309 connections | 7.5 | Meters and service cable |
| Expansion connections | 18,141 connections | 9.7 | 24,405 connections | 12.5 | Poles, MV cable, LV cable, transformers, meters and service cable |

The initial procurement of materials will likely be followed by a regular flow of supply contracts on an annual basis as the access programme becomes more established.

## 5.4 Government Funding for Access Programme

The Government is currently deciding on the level of fiscal contributions that will be budgeted for the energy sector in the Medium Term Expenditure Framework to 2012. Although the exact level of fiscal contribution is not yet known, the Government will continue to make a strong financial commitment to the energy sector. Significant Government resources have been committed to developing new hydroelectric plants at Rukarara and Nyaborongo, progressing methane gas generation at Lake Kivu, supporting investments in micro-hydro plants and commissioning new transmission facilities. In addition, the Government plans to make a strong financial commitment to the access programme to underscore the importance of electricity access.

As a developing country, Rwanda has a number of important priority expenditures for economic development, and has limited fiscal room for extensive Government programmes. In addition, Rwanda reached the completion point under the Highly Indebted Poor Country (HIPC) Initiative in April 2005, which provided for debt relief for the country of US$1.4 billion. Under the HIPC Initiative, the Government also agreed to limits on possible external borrowing to ensure that the country remains in a sustainable debt situation.

Notwithstanding these restrictions, the Government is committed to the access programme. The Government is expected to be able to commit $50 million to the access programme over the next five years, and will extend additional support to other sector investments in generation and transmission as required. This leaves around US$270 million required from development partners. This funding requirement is discussed in further detail later (in Section 7).

# 6 Implementing the Access Programme

Although Electrogaz has significantly increased its customer base—from about 30,000 customers in 2004 to over 110,000 customers—the capability required to meet the targets in the access programme will require further rapid improvements. The programme must be based on efficient implementation in order to achieve the Government's access targets and ensure continued support for the electrification programme beyond 2012. Some implementation issues have already been discussed in this Prospectus, such as the need to reduce the costs of the programme through efficient procurement. This Section discusses implementation and procurement capacity further, and highlights the need to enhance private sector capacity in Rwanda as an efficient way to implement the programme. Implementation capacity will be critical across several areas—human resources, materials, funding and management capabilities.

This section provides details of how the access programme will be implemented. Section 6.1 considers the role of the national electricity utility in implementing the programme. The establishment of separate electricity and water utilities has provided a clear management focus on the efficiently providing electricity throughout Rwanda. Section 6.2 discusses the programme implementation unit that will be established and embedded within the electricity utility to run the access programme. Finally, Section 6.3 discusses the role for other sector players in implementing the access programme. Private contractors will be an important resource for the programme, as will leadership at the local level.

## 6.1 Rwanda's National Electricity Utility—"RECO"

In Rwanda, electricity has historically been supplied by the combined water and electricity utility, Electrogaz. Electrogaz is the largest company in Rwanda and currently employs over 1,500 staff. Established in 1976 as a parastatal, the utility remained essentially unchanged until a series of recent reforms passed by the Government. To further focus the mission of the utility, the Government has recently passed a law to create separate utilities for electricity and water—the Rwanda Electricity Corporation (RECO) and the Rwanda Water and Sanitation Corporation (RWASCO). This change will allow the management of the electricity utility to focus on efficiently providing electricity throughout Rwanda and managing the customer growth expected under the access programme.

The law that establishes RECO also signals a change in the governance arrangements for the utility, from being a Government managed entity to a more regular commercial operation. This change takes place as part of a series of public service reforms initiated by the Government in 2005 and led by the Ministry of Public Service and Labour (MIFOTRA). These reforms are designed to help make Government departments and corporate entities more effective and accountable for results. Under the new legislation, the Ministry and the Board of Directors of RECO will agree upon a three-year performance contract with the Managing Director.[34]

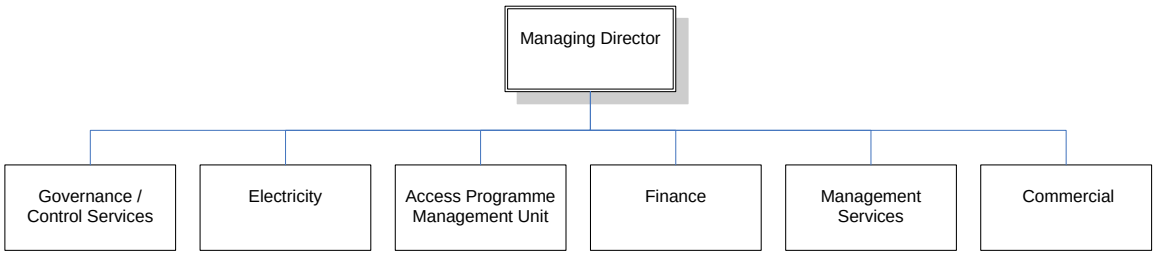
The management performance contract will define the powers, rights and responsibilities of each party in achieving the company's objectives, including the targets under the access programme and other sector initiatives. The contract will specify clear outputs that are expected, and will also identify the resources required to achieve these outputs. The

[34] See Article 4, Law Creating RECO and RWASCO.

Managing Director of RECO will then agree similar contracts with the senior management team of the utility to maintain accountability throughout the organisation.

An overview of the proposed organisational structure of RECO is also shown in Figure 6.1. The utility will be organised along functional divisions, with the access programme having a separate department and representative on the senior management team. Other departments in RECO will also need to add resources as the access programme is implemented. For example, the commercial department will have a significant role in marketing new connections and providing customer support to new customers.

**Figure 6.1: Organisation Chart for the Rwanda Electricity Corporation**




In transforming the electricity utility into a commercial enterprise the Government recognises that it needs to explicitly account for any public service obligations imposed on RECO, including aspects of the access programme that are not financially viable. The Government intends to address social concerns by separate mechanisms to deliver subsidies tied to measurable outputs. Through the process of setting the management performance contract, the utility will identify requirements that are not consistent with strict commercial incentives, and the Government will need to provide funding to support these initiatives. This means that the Government can still hold the utility's management accountable for delivering sound financial performance, and the Government is also made aware of the cost of policy decisions.

The Government recognises that holding management accountable for results also means that managers in the utility must have the ability to make commercial decisions and respond to sector opportunities. The Government is committed to providing a sufficient level of operational autonomy to the electricity utility to implement important sector developments. Therefore, the utility will be empowered to decide on the details of how to implement the access programme, including how staff will be remunerated and how materials will be procured. The Government will then closely monitor the utility's performance against milestones, and understand areas where further resources or technical assistance are required.

The issue of salary levels for public sector officials (including employees of Government-owned companies) is an area of concern for recruiting and retaining highly qualified staff for the national electricity utility. Electrogaz is fortunate to have dedicated and capable staff in the electricity unit, however significant additional skills and experience will be required as the company embarks on a period of growth. A number of options are currently available to RECO to find suitable staff, such as:

- Long-term secondments from international companies (such as the Tunisian utility, STEG) that are paid according to their home base salary and conditions, with a location related uplift
- Hiring people with the required skills on fixed-term contracts that meet market expectations, and
- Hiring local or international specialists and supplementing public sector packages with additional compensation from third party sources, such as development partners.

## 6.2 Capacity in the Access Programme Directorate

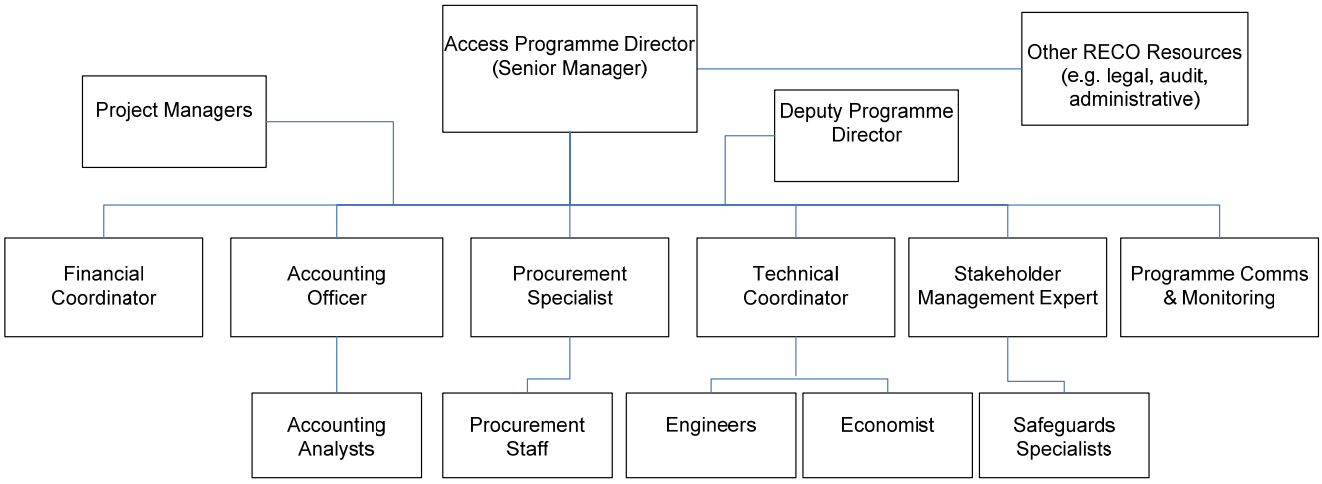
A separate programme directorate (the "directorate") will be established within the national electricity utility to implement the access programme. This will help to ensure that the programme remains a focus for the organisation and has sufficient resources to manage the programme effectively.

The Government and managers at Electrogaz have thought carefully about the core capacities that the unit will need to effectively manage and implement the access programme. These capacities will come from a combination of staff hired directly into the directorate (either from Electrogaz or externally) and technical assistance:

- **Planning capability**—The directorate will need to progressively take on the network planning and system development, currently undertaken with the assistance of contractors and development partners. The directorate will need the capability to engage in a systematic planning process, based on inputs such as this Prospectus and the Electricity Master Plan. This planning process will need to generate accurate load forecasts and turn the priorities identified in the technical planning for this Prospectus into coherent work schedules
- **Procurement skills**—The directorate will need to procure supplies and contractors on time and in the correct sequence to meet planning targets and maintain the reliability of the electrical network. The directorate will also need to understand the work required to maintain new facilities and service new customers, although other staff within the utility will be directly responsible for these functions
- **Finance and stakeholder management**—The directorate will need skills in finance and accounting to interface with development partners and finance experts to ensure that donor requirements are met, future funding for this programme is secured and any bridging finance required is available to ensure that cash inflows match procurement needs
- **Technical skills**—The directorate will need to build capacity in both the short-term and long-term for wiring and metering technicians through partnerships with local institutions, such as the Kigali Institute of Science and Technology (KIST).

An overview of the initial staffing requirements for the directorate is shown in Figure 6.2. It is expected that the directorate will start with around 20–30 full time staff, which will grow as the programme increases its scope. The directorate leader will be on the senior management team of the utility, ensuring that the access programme has visibility at the highest level of the company. The directorate will also be able to leverage other resources within the utility, such as legal, audit and administrative resources employed in other teams.

**Figure 6.2: Overview of Programme Management Unit**




Electrogaz has existing staff responsible for planning and implementing new connection projects that will be transferred into the programme directorate. The directorate will supplement these existing capabilities with critical new skills in procurement, stakeholder management and programme communications.

- **Procurement**—The directorate's procurement specialist will have a track-record at planning and sourcing required programme materials, ideally within the electricity sector. The procurement specialist is particularly important given the need to bring down programme costs. As discussed in Box 5.1 above, Electrogaz is already reviewing technical specifications for new investments, and the procurement specialist will need to continue this process and ensure that least-cost supply options are used
- **Stakeholder management**—The stakeholder management expert and safeguard specialists will undertake necessary studies on the environmental impacts of the programme and any compensation required for affected parties
- **Communications and monitoring**—The team member responsible for communicating programme goals and outcomes will have a proven ability to communicate with a range of knowledgeable stakeholders.

As the programme implements new connection projects, it will be important that local dynamics in different parts of Rwanda are understood. In particular, some communities may be prepared to contribute resources to the programme in order to accelerate electricity connections. Rather than maintain a pure, engineering-driven approach to electrification, the directorate will respond to local initiatives and maintain some flexibility while striving to meet the Government's targets. The stakeholder management expert and other directorate team members will work to investigate possible roles for community leaders and local organisations in the electrification process.

The directorate will also provide support to off-grid connection projects, where required. This will help to ensure that the grid and off-grid components of the programme are well

integrated, and that off-grid connections have access to the technical expertise inside the utility. The utility may also be able to earn additional revenue by providing maintenance or engineering capabilities on a fee for service basis.

To ensure that implementation improves over time, the directorate will collect statistics on important metrics for the programme. For example, the unit will collect information on the take-up rates for new connections in different parts of the country, and consumption levels for different customers. Electrogaz has already begun to implement a SCADA system to better record electricity usage and monitor network performance.

Rwanda has recent experience administering a dedicated programme in the electricity sector from the Urgent Electricity Rehabilitation Project (UERP). The implementation of the UERP is described further in Box 6.1.

**Box 6.1: Rwanda's Experience with the Urgent Electricity Rehabilitation Project**

The UERP is a special purpose organisation set up in 2005 to help address the power shortages caused by extended drought periods in 2003 and 2004. The UERP has focused on reinforcing the power system in Rwanda, adding a further 20MW of generation through the installation of a heavy-fuel oil plant at Jabana and rehabilitating significant parts of the transmission and distribution network.

Funding for the UERP comes from development partners. The UERP is governed by a standing committee with representatives from beneficiaries of the programme, including Government ministries, KIST, Electrogaz and the private sector. The UERP functions day-to-day as part of the electricity utility, although it is a separate organisation. The project director of the UERP works under contract from the Chairman of the Steering Committee, and attends all meetings of the Electrogaz Management Committee.

The following specific lessons apply from Rwanda's experience with the UERP:

- The mandate of the unit needs to be clearly defined—The UERP has been able to succeed where areas of responsibility have been clearly defined and understood. The need for additional generation capacity in Rwanda has been particularly pressing, and the UERP has responded to this challenge well
- A close working relationship with other parts of the electricity utility will be critical—The close working relationship between Electrogaz and the UERP has enabled the project to deliver support to Electrogaz officials, while the UERP has been able to effectively discharge its mandate by leveraging skills and knowledge within the utility
- Project preparation needs to be thorough—The detailed work required for preparing projects within the UERP has been significant and time-consuming. Adequate resources needs to be applied to ensure that projects within an overarching programme and well prepared, so that contracting needs and specifications for procurement are clear and consistent.

## 6.3 Private Sector Development in Rwanda

The access programme also needs to build external implementation capacity to succeed over the long-term. The construction and maintenance capacity of the private sector in Rwanda is currently relatively limited, and will need to be enhanced in order to meet connection targets and drive down the costs of the programme.

The electricity utility is well-placed to make use of private sector contractors, which have been used to increase new connections from 1,000 a year in 2004 to almost 20,000 new connections in 2008. The access programme provides a particularly attractive opportunity for private sector investors in Rwanda because the programme is based on predictable supply requirements. The programme will also run over an extended period until all economically viable connections have been made, which could be 20 years or more. These features of the programme enable investors to commit capital to building capacity on the basis of stable work orders and contracts.

The utility plans to carefully assess the optimal combination of full time technical staff and contractors. Contractors provide benefits in terms of flexibility, although the implementation capacity of local contractors is likely to be insufficient at present to meet the targets for electrification. In contrast, expanding full-time staff will help to strengthen the utility, but recruitment is constrained by a shortage of skilled people.

The access programme will initially need to source required materials and contracts from international suppliers. However, over time the programme will build on the implementation capacity of local suppliers, and will work with potential investors, to build a business case for Rwandan entrepreneurs that wish to play a role in supply materials for the access programme. While private investors will be expected to invest capital in developing the local businesses, support through technical assistance of US$1.75 million has be included in the access programme to help mitigate investment risks and enhance local capacity to supply materials.

# 7 Support from Development Partners

Expanding electricity access at the rate envisaged in Rwanda will not be possible without strong commitment from development partners. Capital grant contributions of around US$270 million will be required for the programme over the next 5 years. Several donor agencies are active in Rwanda's energy sector, and some of the off-grid investments presented in this Prospectus have already received funding from development partners.

This Section reviews the funding required from development partners for the access programme. Section 7.1 discusses the funding requirement and support that has already been committed to the access programme. An assessment of key programme risks is then presented in Section 7.2. Finally, Section 7.3 provides an overview of how funding allocations will be treated under the programmatic approach to electricity access investments and how funding flows will be monitored.

## 7.1 Funding Requirements from Development Partners

As set out in Section 5 of this Prospectus, the funding available from customer payments and the fiscal commitment from the Government leaves around $270 million of the costs of the access programme that development partners are being asked to contribute.

Certain off-grid components of the access programme have already received funding commitments from development partners. These commitments reduce the total amount that needs to be raised from development partners to achieve the new connections planned in this Prospectus.

Table 7.1 presents off-grid components in the access programme that have already received some funding commitments. Although, most funding relates to planned projects that have been factored into this Prospectus, some funding does not yet relate to specific investments.

**Table 7.1: Existing Donor Support for Access Programme Components (US$ million)**

| | Wold Bank | Netherlands | EU | GtZ | BTC | Existing Support |
|---|---|---|---|---|---|---|
| Micro Hydro [1] | | 0.3 | 5.2 | 2.0 | 18.8 | 26.3 |
| Solar | | | 6.3 | | 1.9 | 8.2 |
| CFLs | 1.2 | | | | | 1.2 |
| **Total** | **1.2** | **0.3** | **11.5** | **2.0** | **20.7** | **35.7** |

Source: MININFRA, Rwanda Public Procurement Authority (2008)

Notes: [1] Support for the access programme under current micro-hydro projects has been calculated as a proportion of total investment costs assuming an ADMD of 0.3kVA and an average connection cost of US$1,200 (excluding new transmission facilities for new grid connected micro-hydro sites).

The total cost of micro-hydro schemes already under development in Rwanda is over US$70 million—including the costs of developing the generation source and the cost of providing connections for households and social institutions. Existing micro-hydro investments are administered by GtZ (US$3.5 million), BTC (US$49.5 million, including US$13 million co-funding from the EU), and the Government/UNIDO (US$16.9 million).

To account for funds committed to these micro-hydro plants in this Prospectus, the cost of new connections made by these schemes has been removed from the amount to be raised from development partners.

Another notable example of early donor commitment to the access programme is the solar energy project funded by members of the European Commission. Under this programme rural schools, health centres and administrative offices will receive electricity supply using solar PV installations. An international tender is already underway for the supply and installation of photovoltaic equipment for health centres, applying funding received from PEPFAR.[35] These initiatives have also been taken into account in calculating the total support that still needs to be raised from development partners, and indicate that sufficient funding already exists to achieve the target of electrifying all health centres by 2012.

In addition, the African Development Bank proposes to fund regional transmission interconnections. Although these investments do not strictly fall within Rwanda's access programme, greater regional power trading would help to support system reliability following the addition of the new connections made in Rwanda, and would also enable more power exports from Rwanda in the event that surplus generating capacity becomes available.

Accounting for the funds already committed by donors, approximately US$225 million remains to be funded. Table 7.2 presents the calculation of the amount that needs to be raised to support the access programme presented in this Prospectus, starting with the total capital cost of the programme and subtracting existing sources of funding from Electrogaz (through surplus operating cash flows), connections charges, Government contributions and existing donor commitments.

**Table 7.2: Summary of Access Programme Support Required (US$ million)**

| | |
|---|---|
| Capital costs of access programme | 377.6 |
| Less: Self financing from Electrogaz | 39.5 |
| Less: Revenue from connection charges | 27.9 |
| Less: Government contributions | 50.0 |
| Less: Existing donor commitments | 35.7 |
| **Support Required** | **224.5** |

## 7.2 Programme Risk Mitigation

The major risks facing the access programme are listed in Table 7.3 (below), together with a brief description of the mitigation measure in place to minimise the impact of each risk. A high-level sensitivity test for each risk has also been conducted to evaluate the potential impact of each risk on programme costs and objectives. Unless stated otherwise, the impact on new connections is estimated using an average total cost per connection of US$1,200.

[35] Rwanda Public Procurement Authority (RPPA). "International tender notice: Supply and installation of photovoltaic equipments for health centres in Rwanda." 2008.

**Table 7.3: Summary of Key Programme Risks, Mitigation Measures and Sensitivities**

| **Risk** | **Change in level of political support** | |
|---|---|---|
| **Mitigation** | The access programme currently has broad-based political support. The electricity sector has recently received an increasing level of government support and the targets for electricity access are stipulated in the Governments EDPRS. Government contributions have been estimated accounting for fiscal limitations and the need to fund other Government expenditures. | |
| **Sensitivity test** | Considers the effect of no Government contribution to the access programme, with contributions from customer payments and development partners remaining the same. | |
| | **Impact on funding requirements** | **Impact on new connections** |
| | +US$40 million | -33,000 connections |

| **Risk** | **Inadequate supporting legal and regulatory framework** | |
|---|---|---|
| **Mitigation** | The access programme does not rely on fundamental changes to the existing legislative or regulatory framework. Regulatory capacity is currently being enhanced under a grant from the Investment Climate Facility for Africa (ICF), which will help to ensure credible and consistent regulatory decisions on electricity tariffs and service standards. | |
| **Sensitivity test** | Considers the impact of a 20 percent reduction in tariffs, lowering tariff levels to 90 RWF/kWh. As discussed in Section 5.2, a recent report on tariffs and subsidies in Rwanda recommends caution in this area (Vernstrom, 2008). This action would reduce available funding from customer payments by US$25 million, which would need to be raised from other sources. In addition, the programme could no longer be considered financially viable because operating cash flows would not cover operating expenses. This might in turn reduce the level of support for the programme. | |
| | **Impact on funding requirements** | **Impact on new connections** |
| | +US$25 million | -21,000 connections |

| **Risk** | **Insufficient demand for new connections** |
|---|---|
| **Mitigation** | Demand for new connections has been analysed on the basis of recent expenditure survey evidence and Government proposals to lower connection charge to a nominal level of US$100. A proposed tariff study will also complete a detailed analysis of the willingness to pay for electricity. The programme implementation unit will collect data on connection acceptance rates as the access programme moves into the implementation phase and plans will be updated as further evidence on affordability and willingness to pay becomes available. |
| **Sensitivity test** | Considers the impact of continuing to make new connections at the current rate of 25,000 new connections each year to 2012, while keeping other sector investments the same. Lowering the rate of new connections will reduce the total cost of the programme, but also directly comprises the primary objective of the programme to extend electricity access. Under this scenario, the average cost per connection would rise to over US$2,000. |

| | Impact on funding requirements | Impact on new connections |
|---|---|---|
| | -US$11.6 million | -128,000 connections |

| Risk | Insufficient supply from new generation sources |
|---|---|
| **Mitigation** | The access programme relies on sufficient supply of electricity from new hydro and methane gas sources. Construction has already begun at two new hydro plants with a combined installed capacity of over 35MW. A pilot plant is also operating at Lake Kivu and a deal has been finalised to deliver 100MW of new methane gas generation capacity. The ICF is also providing technical support to these developments. |
| **Sensitivity test** | Considers the impact of a delay in commissioning the 25MW methane gas plant at Lake Kivu until 2013. This scenario would increase generation costs because the HFO plant would need to operate more. A delay in methane gas generation would also reduce operating cash flows as no energy would be available for export. |

| Impact on funding requirements | Impact on new connections |
|---|---|
| +US$15.4 million | 12,800 connections |

| Risk | Inability to mobilise funding from customer payments due to non-payment |
|---|---|
| **Mitigation** | Collection rates from customers are relatively high in Rwanda due to prepayment metering, and theft of electricity is relatively low. Programme evaluation in this Prospectus accounts for historic rates of delinquency and default. The Government will monitor the payment of invoices by public sector institutions. |
| **Sensitivity test** | Considers the impact of reducing customer collections by 10 percentage points each year. Residential collections are assumed to fall from 75 percent in 2007 to 65 percent in 2009. Larger customer collection rates are assumed to fall from 80 percent in 2007 to 70 percent in 2009. |

| Impact on funding requirements | Impact on new connections |
|---|---|
| +US$24.0 million | -20,000 connections |

| Risk | Failure to achieve capital cost reductions |
|---|---|
| **Mitigation** | The access programme relies on achieving significant reductions in the capital cost of certain components based on the larger scale of the programme and changes to technical specifications. The modelled cost reductions are conservative, and the installed costs of programme components is projected to remain higher than comparable projects in the region, due to the smaller demand in Rwanda and additional transportation costs. |
| **Sensitivity test** | Considers the impact of MV line costs that are the same as the STEG pilot project (US$65,000/km). |

| Impact on funding requirements | Impact on new connections |
|---|---|
| + US$38.7 million | -33,000 |

| Risk | Failure to achieve operating efficiencies | |
|---|---|---|
| **Mitigation** | Operating efficiencies are factored in to the costs of the access programme in the form of gradual reductions in technical losses and operating expenses (per unit of electricity supplied), and gradual improvements in collection efficiencies. Projected improvements are conservative and are consistent with widely accepted incentive-based regulation of natural monopolies | |
| **Sensitivity test** | Considers the impact of failing to reduce network losses (set constant at 23 percent) and failing to reduce operating expenses | |
| | **Impact on funding requirements** | **Impact on new connections** |
| | + US$11.7 million | -10,000 connections |

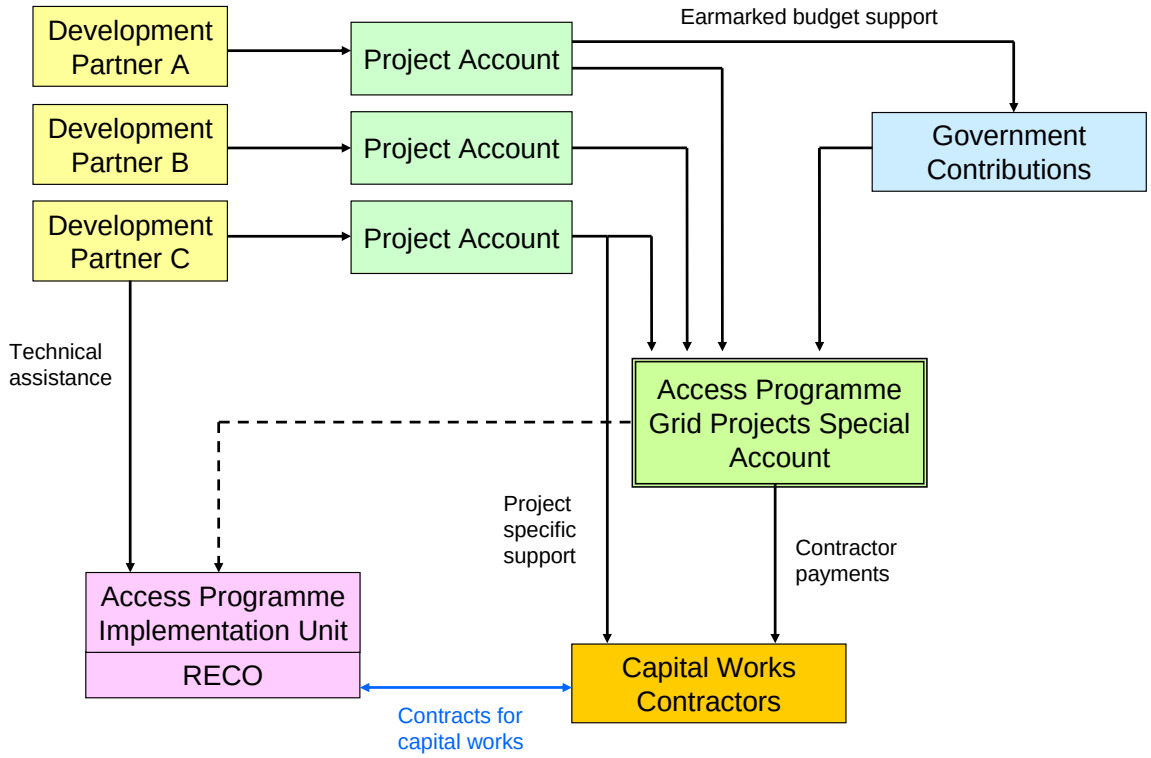
| Risk | Inadequate implementation capacity | |
|---|---|---|
| **Mitigation** | The programme faces significant challenges in rapidly acquiring or contracting the technical and programme management skills required for successful implementation. These risks remain high, despite recent experience through the UERP and the allocation of considerable planning and management focus to the programme. | |
| **Sensitivity test** | Considers the impact of continuing to make new connections at the current rate of 25,000 new connections each year to 2012, while keeping other sector investments the same. Lowering the rate of new connections will reduce the total cost of the programme, but also directly comprises the primary objective of the programme to extend electricity access. Under this scenario, the average cost per connection would rise to over US$2,000. | |
| | **Impact on funding requirements** | **Impact on new connections** |
| | -US$11.6 million | -128,000 connections |

## 7.3 Management of Development Partner Support

To ensure the sustainability of the programme, the Government is committed to continuing to closely monitoring and evaluating sector outcomes and reporting against stated programme objectives. In addition to achieving the targets set for new household and social infrastructure electricity connections, the national electricity utility and Government officials will have strict auditing and reporting responsibilities to development partners on financial parameters in the electricity sector.

Figure 7.1 (below) provides an overview of external funding flows into the access programme. While the access programme lends itself well to funding approaches such as sector-specific basket funding, earmarked budget support, other funding arrangements can also be used by development partners, for example, targeted mechanisms such as project-specific support and technical assistance funds. Financial flows will be monitored to ensure that donor contributions are ring-fenced (if required) and allocated to appropriate programme components, and financial flows from operations will be reported to transparently evaluate the ability of the sector to meet operating costs from customer payments. Similar funding arrangements will apply to the off-grid components of the investment programme.

**Figure 7.1: Funding Flows for the Access Programme**




Transactions processed through the access programme special account will be subject to an internal review by the audit department of the electricity utility and the Energy Sector Working Group. Contributing development partners will also have access to the financial records of the programme, and will receive quarterly reports, operational reports, and financial reports. The access programme will also be subject to an external audit by an

independent auditing firm that is acceptable to development partners. The audit will include an opinion on the programme's financial statements and a management letter on the internal control structure.

Procurement arrangements will also established for the access programme to accord with Government process requirements and development partner practices. The procurement specialist within the programme implementation unit will develop procurement guidelines for the programme in consultation with participating development partners. These guidelines will need to strike a balance between establishing procurement processes that promote probity in the use of funds, while retaining sufficient flexibility to respond to programme investment needs as they arise.

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T: +1 (202) 466-6790
F: +1 (202) 466-6797
1700 K Street NW Suite 450
WASHINGTON DC 20006
United States of America

T: +61 (2) 9231 6862
F: +61 (2) 9231 3847
Level 10, 1 Castlereagh Street
SYDNEY NSW 2000
Australia

T: +64 (4) 913 2800
F: +64 (4) 913 2808
Level 2, 88 The Terrace
PO Box 10-225
WELLINGTON 6143
New Zealand

T: +33 (1) 45 27 24 55
F: +33 (1) 45 20 17 69
7 Rue Claude Chahu
PARIS 75116
France

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