INTEGRATED RURAL ELECTRIFICATION PLANNING IN TANZANIA

IN COLLABORATION WITH THE RURAL ENERGY AGENCY (REA) - TANZANIA

Context

by Cyril Perret - IED

The rate of access to electricity services in Tanzania remains very low today – under 12%, and it will still be a few years until the interconnected grid will reach all the isolated population. Urban and Rural electrification Access are particularly low, respectively around 39% and 2% (Sources IEA 2008) with 36.9 millions of people without electricity.

The government of Tanzania is engaged itself in the restructuring of its electricity sector (Electricity Act 2008) with the following overarching principles for Rural Electrification:

- Defining Rural Electrification Plan and Strategies focusing on Grid expansion and the development of off-grid electricity supply systems in rural areas including new and renewable energy systems.
- Establishing and maintaining a rural electrification database to assist in the monitoring of progress and establishment of the targets of rural electrification.
- Defining framework for adopting specific policies and imposes requirements, levies, relief and regulations for the promotion and development of rural electrification in accordance to the Rural Energy Act.
- Defining new financing mechanisms for rural electrification, including modalities of public-private partnerships.
- Promoting of new actors so as to ensure maximized distribution and therefore access to modern energy services to local communities.

In effect, the double myths of “the private sector will do it all” – or – “the public sector will do it all” is well past, and the importance of a clear, transparent and enticing regulatory framework clearly established.

In this context, there is an obvious need for planning for rural energy services, in conjunction with economic development of rural areas. Skill levels – both as regards technical skills and planning know how, still are limited in Tanzania. There is need to make practical and operational tools available as well as to develop skills in the key institutions to ensure their sustained use over time.

Despite these significant evolutions, the integration of the power sector with other social services / utilities and the establishment of effective synergies have still to be carried out. The process of planning for extending electricity services remains a rather isolated process, and the new actors (communities, private sector, state services in charge of the development of public infrastructure services and economic development...) are not given the opportunity to become involved in such developments.

Hence, the overarching objective of the present proposal is to provide relevant decision makers both at the national and regional levels, with operational tools which will provide development and energy sector planners to formulate informed policy approaches.

Integrated geospatial planning

Formulation of a relevant methodology for Rural Electrification planning through a set of modern and innovative tools and Validation of the planning methodology producing Rural Electrification investments plans for 6 regions.

Sustainability & capacity building

Training packages for technical training and institutional capacity building of national and regional stakeholders (REA, EWURA, TANESCO, MEM) in the planning process made available to facilitate replication...
The project was led by the Rural Energy Agency (REA) in close collaboration with the French consulting company Innovation Energie Développement (IED) and implemented over a 2 years period.

The overall objective of the project was to improve the rural electrification investments coordination in Tanzania. This goal could be achieved by maximizing the impact of rural electrification on sustainable development and poverty alleviation by establishing effective cross sectorial investment and planning capacities and instruments using Geographical Information Systems as the convening factor.

The ultimate objective is that the developed tools outputs provide the required tangible elements for the formulation of appropriate policies and instruments to reach this goal. Hence, the project will be totally in line with the Tanzania Governmental National Vision 2025 for poverty eradication and sustainable development.

In the short term, Tanzania is embarking on its Rural Electrification Plan and Strategies – grid extension with also an off grid component: there is an urgent need for the country to develop technical capacity and to be endowed with hands on tools to direct investments and decide between off grid and on grid options, renewable or fossil fuel based off grid production – and priority areas from the perspective of maximizing development impact of scarce resources.

In the medium term, the six regional plans helped to develop electrification projects integrated with Regional Development Plans, from which the local population will benefit. The main project outcome was to improve capacities for delivering energy services for poverty alleviation, both in terms of technical skills and tools: an operational planning approach for rural electrification investments and therefore the provision of sustainable energy services for poverty alleviation, at Regional and national levels. We anticipate that a more development-oriented integrated approach, involving national and local stakeholders from different sectors and demonstrating the social and economic impacts of rural electrification projects on poverty alleviation, will bring additional investments in the sector.

**Target group**

The key target groups were the Rural Development actors and more specifically rural Electrification Planning authorities including, REA in charge of promoting and facilitating rural energy development by working in partnership and collaboration with private sector, Non-Governmental Organizations, Community Based Organizations, and Government agencies. Alongside REA, the following partners were closely involved:

- **Ministry of Energy and Minerals (MEM)** which is responsible for policy directives in relation to rural electrification.
- **TANESCO** (Electricity and Renewable Energies sections particularly) the National power utility responsible for all the electricity in Tanzania.
- **The regulator EWURA**, which provides the regulation of the electricity supply and services industry covering licensing and issuing of permits, rights and obligations of licenses, tariffs and charges, monitoring, inspection, investigation and compliance, the planning, monitoring and regulation of rural electrification...
- **The Rural Energy Working Group (REWG)**, gathering key stakeholders from other Ministries: rural development, health, education, agriculture and natural resources, roads and rural industry which strives to maximize the socio economic impact of the methodology and proposed projects.
- **Private sector developers** of modern energy services, including community based groups, non-governmental organizations and financial intermediaries...
Geographic Information System
GIS stores territory information under thematic layers which can be linked each others geographically for advanced spatial analysis.

Activities

- **Phase 1: Data collection and compilation**: Data were collected at regional level and later compiled into a GIS dataset for further analysis. The GIS monitoring and follow-up database at the national level will be available, with national capacity to maintain and update it, as a key instrument for awareness building and cross sector mobilization in country, as well as mobilization of international donors.

- **Phase 2**: The Rural Electrification planning tool GEOSIM® and the GIS database was deployed among national institutions involved in the energy sector. A web interface was also developed in order to disseminate collected information to national stakeholders.

- **Phase 3**: Formulation of a relevant methodology for Rural Electrification planning through a set of modern and innovative tools. A whole method was developed, indicators, parameters and strategies discussed within the Working Group and approved. The planning software programme will be available for the Rural Electrification Agency in charge of rural electrification offering henceforth a clear, transparent and user friendly planning tool to implement this participative approach.

- **Phase 4**: Identification of renewable energy potentials for the targeted pilot region including field visits. (mini hydro and biomass potentials are mainly concerned)

- **Phase 5**: Energy surveys performed at villages and households level for each region using a statistically representative sample so as to build a customized load forecast model for each region.

- **Phase 6**: Validation of the planning methodology producing Rural Electrification investments plans for 6 regions. Results benefitted indirectly to the Ministry of Energy and Minerals, TANESCO and EWURA. It will therefore be possible to apply the planning approach to other parts of the country.

- **Phase 7**: Capacity building for REA staff and others stakeholders for one month duration through various specialized training sessions insuring the project sustainability and local take over. Training packages for technical training and institutional capacity building of national and regional stakeholders in the planning process will be made available to facilitate replication.

- **Phase 8**: National multisectorial coordination and international exchange of experience. The whole method of developing synergies with social services, public utilities and business development implemented within the framework of IREP, could also be applied to other countries in the region: the Club of National Agencies and Structures in charge of Rural Electrification (Club-ER) quite involved in this theme and was mobilized for regional dissemination activities across the region.
Maximising the impact of rural electrification on social and economic development

The main objective of the geospatial approach is to anticipate the impact of rural electrification projects on social and economic development, in order to maximise it at the planning stage. In other words, cost per kWh or number of connections achieved will no longer be the only criteria to identify promising projects, contrary to standard planning methods.

This novel approach is motivated by the following paradox: modern forms of energy such as electricity have in theory a significant potential for social and economic development and yet rural electrification projects until now have had very often a low impact on development according to many evaluation studies.

Definition of Impact

First of all, the concept of “impact” of rural electrification (on social and economic development) has to be defined. The concept used here is very different from the concept of direct results, which are for example the number of households and businesses benefiting from electricity, avoided costs in energy purchase etc.

Contrary to results, impact takes into account long lasting changes caused by electrification, possibly interacting with changes in other sectors (typically health, education and economy). For example, the impact of a rural electrification project on a target area where there are only households will be significantly lower than that of a project targeting villages with many productive activities, hospitals and schools, even if these factors are (supposedly) independent from the electrification project itself.

Taking into account impact in the planning process

The IREP approach suggests anticipating impact upstream of the planning process. The rationale behind this is the following reasoning: rural electrification is usually not profitable, therefore it requires public subsidies which are available in very limited quantities, and these limited resources should be allocated to places with the highest potential for development, even if they are not necessarily the most profitable, nor administratively the most important. Naturally, once these places are identified, the planning model strives to find the cheapest solution to electrify them and possibly nearby settlements, creating a mini-grid. Technical and economic aspects of electricity generation do not play a role in the choice of settlements to electrify first.

Those settlements with relatively more potential impact on the development of their surroundings (or hinterland) than other settlements of the area are called Development Poles (DP).

Spatial analysis will allow us to identify the most relevant places (settlements) to electrify and then rank (prioritize) them, according to their rated potential for development. More classical tools such as load forecasting and least-cost sizing of power plants will then be used to optimise the projects technically, economically and financially, which will provide power to these high ranked settlements.

An integrated approach of rural electrification maximizing socioeconomic impact on population

A broad and comprehensive strategy for rural electrification was developed, drawing from the experience of IED and discussions with REA. This strategy tackle technical, financial and organisational challenges and particularly strive to reach the GOT’s electrification targets as quickly as possible, using the least-cost options, while always targeting areas where impact of electrification on social and economic development is the highest, to make the most of private investment and possible subsidies.

This strategy is supported by a concrete 10-years plan, identifying the most relevant projects from a socio-economic development point of view, using the available least-cost technologies (either mini hydro, biomass, diesel or National grid expansion). The plan was drafted with the use of a dedicated GIS-based tool named GEOSIM®.

The planning process is dealing with 4 main steps:

1. Spatial Analysis (selection and ranking of areas where social and economic impact of electrification is the highest)

During this first step, data on health, education and economic facilities are gathered for each locality and entered in the GIS database. These data were then processed through an analytical matrix approved by the REWG, similar to the Human Development Index, measuring the potential of each locality for the development of their respective surrounding areas (hinterlands).

Potential benefits of electrification on these localities and their hinterlands are assessed, and the ones with the highest potential are considered “Development Poles” (the number of Development Poles to select will depend directly on the electrification targets set for the 5-year plan). These Development Poles will be given a higher priority in the rural electrification plan and will be ranked according to this rated potential.

2. Load forecasting

Load forecasting is undertaken for each individual locality using an aggregated approach (“bottom-up”). Main characteristics of demand are thus forecasted over the planning period using average load profiles of different types of end-users (different categories of households, businesses, small industries, public facilities etc.). Socio-economic surveys were conducted to estimate...
these profiles. Population patterns have been defined and population divided in 3 classes related to their revenues.

This approach is based on surveys and previous studies and offers a unique flexibility so as to differentiate consumption behaviours from one region to another one.

Due to its heterogeneous geography features, energy consumption revealed important specification: Tanzania is mountainous in the northeast, where Mount Kilimanjaro, Africa’s highest peak, is situated. Three of Africa’s Great Lakes are partly within Tanzania. To the north and west lie Lake Victoria, Africa’s largest lake, and Lake Tanganyika, the continent’s deepest lake. To the southwest lies Lake Nyasa. Central Tanzania is a large plateau, with plains and arable land. The eastern shore is hot and humid, with the Zanzibar Archipelago just offshore.

Significant demands located outside villages and characterized during the surveys (medium and large agro-industries, large social infrastructures, markets…) were included in the study.

Using some proved assumptions; the model can therefore built load curves at village level useful for the next planning phase identifying least coast options.

3. Least-cost options

This third step consists in studying different technical supply options for the identified Development Poles:

- Isolated diesel or diesel-based mini-grids
- Mini and micro hydro
- Biomass-based projects
- PV hybrid system
- Wind hybrid system
- Grid expansion

Each option were sized so that its kWh levelized cost is the lowest, taking into account many different technical, economic and financial parameters, adjusted to each regional context. The least-cost option will be selected for each identified Development Pole.

Based on discussions and exchanges with REA and TANESCO, three different planning scenarios were considered:

- **Scenario 1** - Baseline scenario which focuses both on evaluating existing planned grid extension projects (GRID EXTENSION phase) with 33 kV lines on calculating the electrification cost of villages nearby the existing MV grid network (DENSIFICATION phase).

  ➔ Outputs: projected grid network likely to exist in 2013 (projected grid extension projects), total length of MV lines required, approximate cost for the total investment for each phase, impacted population...

- **Scenario 2** - Extension scenario: From the baseline scenario, we will consider the full electrification of the region if only performed by a regular grid extension (33 kV lines) or using SWER technology

  ➔ Outputs: projected grid network likely to exist if the region is fully electrified by grid, total length of MV lines required, approximate cost for the total investment...

- **Scenario 3** - Integrated scenario: From the baseline scenario, we will consider decentralised options for the off grid area using renewable energy supply (biomass, hydro, hybrid PV/Wind/diesel). All development poles are electrified with decentralized options.

  ➔ Outputs: Economic analysis for potential decentralized options, localities to be electrified, access rate....

4. Pre-electrification

In areas where conventional electrification options will not be provided at the end of the 10-year plan, provisional solutions are suggested. The solutions may include:

- PV kits for community health and education facilities
- Community motive power (engines) for income generating activities and battery charging stations

Eligibility criteria could take into account the remoteness of the locality, its population, etc.

GEOSIM© determines then the total investment and equipment needs if such program had to be implemented in the future to accelerate the energy access to modern services among the remote population or focusing on social infrastructures.

GEOSIM©

GIS based rural electrification planning software for decision makers and planners developed by IED and widely used in Africa and Asia for the past 5 years.

WEBSITE

www.geosim.fr
Renewable energies projects

Forstering the rural electrification pace in Tanzania remains a national challenge which must be addressed by REA in the next few years as part of the national Vision 2025 to offer universal energy access to Tanzania.

Rural electrification was, so far, traditionally done by grid extension through the national state-owned utility TANESCO.

The new institutional framework set in 2008 thanks to the Electricity Act is favorable to IPP and to renewable energies with the creation of FIT tariffs adjusted by EWURA for on-grid and off-grid injection. IPP regime is set with standard procedures, PPA and annual licenses (>1MW). IPPs can get investment support but not for operation.

The MEM has also adopted in 2007 the Standardized Power Purchase Agreements (SPPA) and Standardized Power Purchase Tariffs (SPPT) for interconnecting and selling power (<10MW) to the Main grid and to Mini-grids.

The new challenge now was to promote projects in Tanzania and attract new operators in rural areas for energy production and distribution which, combined with the grid extension, will likely improve the actual electrification issue.

IREP project has the ambition to identify a portfolio of viable projects which could be later proposed to promoters and investors.

Mini-hydro projects

Due to a favorable topography, some of the pilot regions such as Iringa and Morogoro regions offered multiple opportunities for mini hydro projects development. As described on the IREP Hydro potential report, more than 60 projects were identified. Most of them were visited. However, regarding the rural electrification planning objective, only 21 projects were studied more in detail. Others were eliminated for the following reasons:

- Sites were located too close to the existing MV grid and therefore the only remaining option would be to produce and inject energy into the grid.
- No demand or villages were located in the vicinity of those projects (within a 20 km’s buffer)

A full economic study was then produced thanks to the GEOSIM® tool for each site. The least cost solution was detailed for the planning period of 20 years including a project map, so as to visualize the project environment.

Biomass projects

The potential for generating energy from biomass residues is very high in Tanzania as large amount of residues from various agricultural fields are simply wasted. However, when it comes to rural electrification, only very few opportunities can really be identified.

The few identified agro-industries are mainly located in urban areas or very close the MV grid. There is little interest for rural electrification within those areas for developing cogeneration power plants. However, some projects might still be relevant considering energy injection into the MV grid network.

IREP focused then on villages close to rice fields to propose some projects using rice husk.

Wind projects

Due to the lack of data from Wind resources in Tanzania, only 1 project was studied. Tanzania is now embarking in a resources assessment study and further enquiries will be possible in the next few years once results published.
Training & recommendations

Training and follow-up
The IREP project is very structuring for REA and the REWG which had the opportunity to access to a modern, technological, socio-economic and replicable approach of rural electrification.

REA’s staff particularly benefitted from intensive training sessions totaling 6 full weeks of specialized technical and practical training on GIS and GEOSIM© use. A very progressive pedagogy was used using local data and real cases studies.

The project initially targeted only 4 regions but due to a successful and efficient use of resources, it was later extended to 6 regions in the framework of IREP. The action was also followed-up by REA which started to extend the study to 10 additional regions in Tanzania mainland. More than 12,000 households surveys were then performed in 2012 using GEOSIM© energy survey templates and surveyors which were trained and mobilized for the IREP survey campaign. Regional Data collection was also extended in 2013 by REA mobilizing about 50 persons equipped with GPS so as to complete missing data required for running GEOSIM©.

REA expressed its ambition to equip its staff with adapted software and tool in order to improve its planning capability.

Lessons learnt and recommendations
Few lessons and recommendations can be learnt:

- Access to data is very important but remain a difficult and time consuming task. It is therefore strategic to associate existing multisectorial stakeholders working groups during the planning process or build a project implementation unit to ensure their full collaboration and get the acceptance benefitting also from relevant inputs.

- There is a real need for data dissemination through different communication channels such as public meetings and internet website. Potential investors are eager to get more information being informed on existing opportunities particularly in Tanzania where the economy is booming, attracting more and more investors in the energy sector.

- To ensure the sustainability of the project, the know how transfer must integrate a “learning by doing” phase and decision makers must be associated to the training phase as much as possible so they can understand the benefits of the approach and adopt a more pro-active behaviour toward the improved approach.

- Local expertise participation is a key issue when gathering field data and identifying renewable energy potentials.

- Coordinating investments in the energy sector must be strengthened. There is strong linkage between energy access and rural development and others sectors may benefit from more cooperation.

- Local workshops done at regional level were welcomed by local authorities and therfore very fruitfull.

Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWURA</td>
<td>Energy &amp; Water Utilities Regulatory Authority of Tanzania</td>
</tr>
<tr>
<td>MEM</td>
<td>Ministry of Energy and Minerals</td>
</tr>
<tr>
<td>NBS</td>
<td>National Bureau of Statistics</td>
</tr>
<tr>
<td>REA</td>
<td>Rural Energy Agency</td>
</tr>
<tr>
<td>REWG</td>
<td>Rural Energy Working Group</td>
</tr>
<tr>
<td>TANESCO</td>
<td>Tanzania Electric Supply Company Limited</td>
</tr>
<tr>
<td>DP</td>
<td>Development Pole</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Position System</td>
</tr>
<tr>
<td>HDI</td>
<td>Human Development Index</td>
</tr>
<tr>
<td>IPD</td>
<td>Indicator for Potential Development</td>
</tr>
<tr>
<td>IPP</td>
<td>Independent Power Producer</td>
</tr>
<tr>
<td>KWh</td>
<td>Kilowatt Hour</td>
</tr>
<tr>
<td>SHS</td>
<td>Solar Home System</td>
</tr>
<tr>
<td>PV</td>
<td>Photovoltaic</td>
</tr>
</tbody>
</table>

Project supported by the second ACP-EU Energy Facility (EFII) within the EU Energy Initiative for Poverty Eradication and Sustainable Development (EUEI)