Club of African Agencies and Structures in charge of Rural Electrification

Best practices of CLUB-ER's Members

TANZANIA

INTEGRATED GEOSPATIAL RURAL ELECTRIFICATION PLANNING (IREP)

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

Co-financed by the European Commission

Organisation internationale de la francophonie

Institut de la Francophonie pour le Développement Durable IFDD

INSTITUTIONS

Author

Cyril PERRET, IED, Director of Information Systems
c.perret@ied-sa.fr

CLUB-ER's Member: IED

Innovation Énergie Développement

2 chemin de la Chauderaie
69 340 Francheville, France
Tel. : +33 4 72 59 13 20
Fax : +33 4 72 59 13 39
Email : ied@ied-sa.fr
Website : www.ied-sa.fr

Contacts

Denis RAMBAUD MEASSON, President
d.rambaudmeasson@ied-sa.fr

Anjali SHANKER, Managing Director
a.shanker@ied-sa.fr

CLUB-ER Secretariat

c/o Innovation Énergie Développement (IED)

2 chemin de la Chauderaie
69 340 Francheville, France
Tel. : +33 4 72 59 13 20
Fax : +33 4 72 59 13 39
Email : secretariat@club-er.org
Website : www.club-er.org

Editors

Silvia CABRIOLU PUDDU, Project Coordinator
s.puddu@ied-sa.fr

Philippe GARNIER, Project Manager
p.garnier@ied-sa.fr

This document was written based on experiences of CLUB-ER. It is intended as a work paper to feed think tanks and to share experiences between African institutions in charge of rural electrification.

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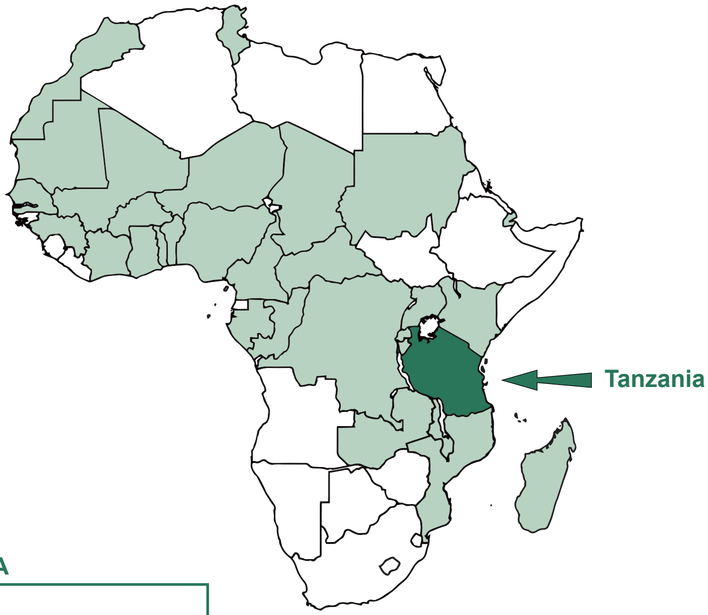

INTEGRATED GEOSPATIAL RURAL ELECTRIFICATION PLANNING (IREP)

THE PROJECT

The Integrated Geospatial Rural Electrification Planning (IREP) project, implemented in 2011-2012 by the Rural Energy Agency (REA) in close collaboration with the French consulting company Innovation Energie Développement (IED), had the main objective to improve rural electrification investments effectiveness in Tanzania by establishing cross sectorial investments and planning capacities and instruments using Geographical Information Systems as the convening factor. In concrete terms, the project aims at the development of an operational planning approach for rural electrification investments at regional and national levels.

1 Introduction

1.1 Context

The rate of access to electricity in Tanzania is very low, under 12%, and it is likely that the scattered and isolated population in the rural areas won't be supplied by the interconnected grid in the near future. Urban and rural electrification coverage rates are respectively around 39% and 2% (IEA 2008) with 36.9 millions of people without electricity over a population of approximately 49.2 Million inhabitants (2012).

In the past, the planning for the extension of electricity services remained a rather isolated process in Tanzania, while the main actors (communities, private sector, state services in charge of the development of public infrastructure services and economic development, etc.) were not involved. A coordinated planning of rural energy services became thus necessary so as to foster the economic development within rural areas. However, skill levels, either technical skills or planning know how, were still limited in Tanzania and the availability of practical and operational tools to develop those capacities within the key institutions were inadequate.

Through the Electricity Act in 2008, the Government of Tanzania has committed itself in the restructuring of the electricity sector with a strong effort on the promotion of rural electrification and access to modern energy services for local communities.

Tanzania is embarking today in its Rural Electrification Plan and Strategies covering both grid extension and the off grid. In this context, there is an urgent need for the country to develop technical capacity and to be endowed with hands on tools in order to:

- direct electrical investments and decide between off grid and on grid options, renewable or fossil fuel based off grid production;
- determine priority areas to be electrified in order to maximize the socio and economic impacts.

1.2 Objectives

The rationale of the project lies on the assumption that an integrated approach focused on socio-economic development, involving national and local stakeholders from different sectors, has a positive impact on poverty alleviation and therefore will attract additional investments in the rural electrification sector.

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In concrete terms, the project aims at the development of an operational planning approach for rural electrification investments at regional and national levels. Based on this new approach, six regional plans were elaborated to develop electrification projects integrated with the regional development plans.

1.3 Target Group

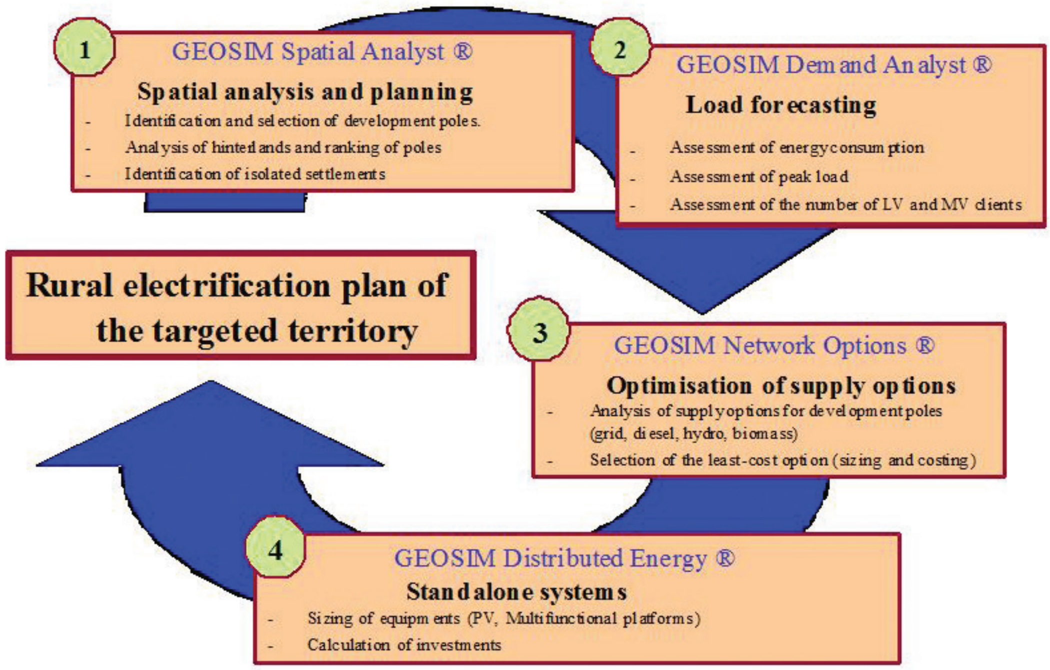
The key target groups were the rural development actors and more specifically the rural electrification planning authorities including REA in charge of promoting and facilitating rural energy development by working in partnership and collaboration with private sector, Non-Governmental Organizations, Community Based Organizations, and Government agencies. Alongside REA, the Ministry of Energy and Minerals (MEM), the National power utility TANESCO, the regulator EWURA, the Rural Energy Working Group (REWG), which gathers key stakeholders from other Ministries: rural development, health, education, agriculture and natural resources, roads and rural industry were involved in the process.

2 The Approach

2.1 Maximising the impact of rural electrification on social and economic development

The socio-economic development is not always at the heart of the rural electrification projects. On the contrary, the geospatial approach developed in the project integrates this dimension already at the planning stage. In other words, the cost per kilowatt-hour or the number of connections achieved will no longer be the only criteria to identify and select promising projects, contrary to the standard planning methods.

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 targeted area where there are only households will be significantly lower than that of a project targeting villages with several productive activities, hospitals and schools, although these factors are (supposedly) independent from the electrification project itself.



GEOSIM© Methodology

2.2 Taking into account impact in the planning process

The IREP approach suggests anticipating impact upstream of the planning process. The electrification of isolated localities is particularly problematic since it requires major investment, for a small number of customers that, in general, have limited financial capacity. These localities seldom present real business development opportunities and are dependent on public subsidies. However, these subsidies are available in very limited quantities, and these limited resources should be allocated to the localities with the highest potential for development, even if they are neither 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 their nearby settlements, through a mini-grid for example.

A settlement, with a relatively higher impact potential on the development of its surroundings (or hinterland), is called Development Pole (DP).

The Spatial analysis will allow us to identify the most relevant Development Poles (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 (the choice of the power plant offering the lowest livelised cost of energy) are then used to optimise the projects technically, economically and financially.

2 3 An integrated approach of rural electrification maximizing socio economic impact on population

Capitalising from the experience of IED and the discussions with REA, a broad and comprehensive strategy for rural electrification was developed for the Tanzanian regions. This strategy tackles technical, financial and organisational challenges and particularly strives to contribute to the GOT's electrification targets, using the least-cost options, and targeting at the same time, the areas where the impact of electrification on social and economic development is the highest.

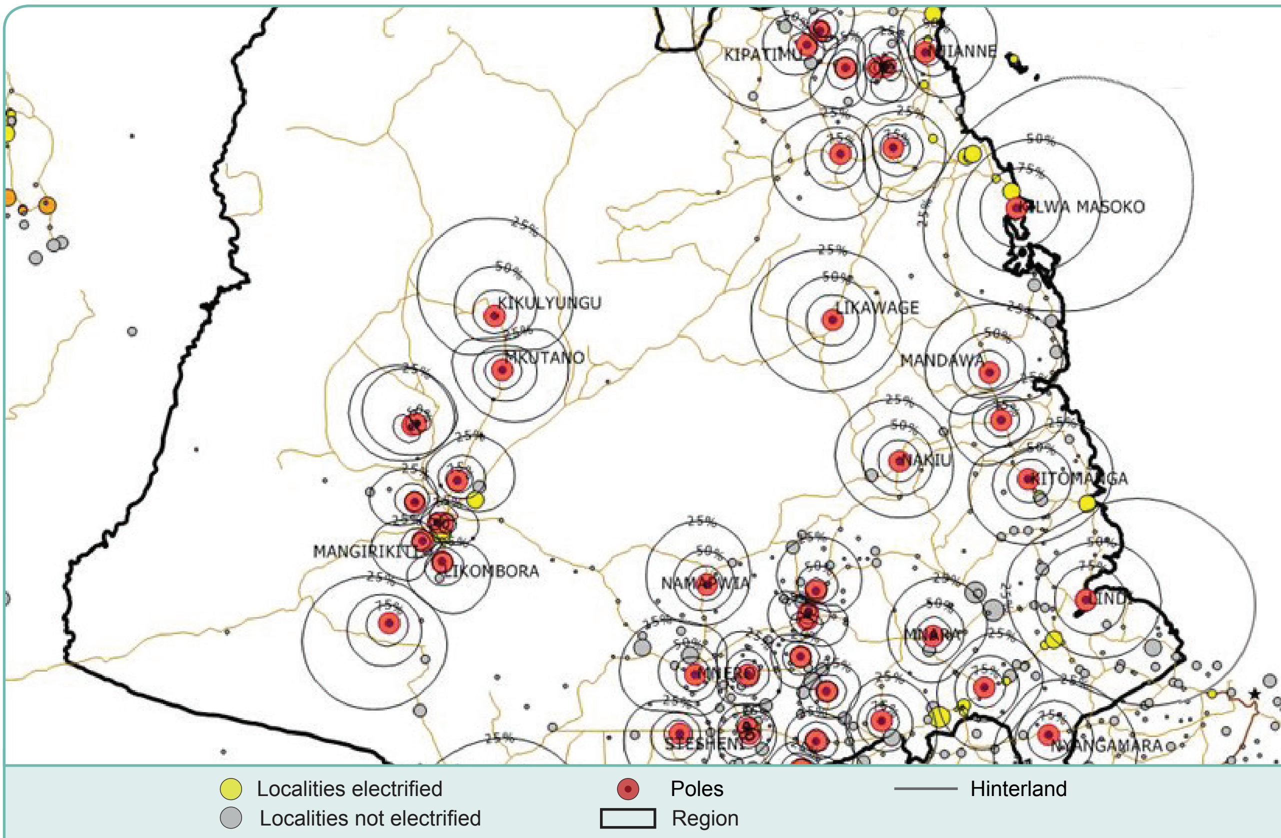
This strategy is supported by a concrete 10-years plan, which identifies the most relevant projects from a socio-economic development point of view, and uses the available least-cost technologies (such as mini hydro, biomass, diesel or national grid expansion). The 10-years plan was drafted with the use of a dedicated GIS-based tool named GEOSIM©.

The planning process showed in the previus page was implemented through four main steps: spatial analysis (selection and ranking of areas where social and economic impact of electrification is the highest); load forecasting; least-cost options; and pre-electrification.

2 3 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 were gathered for each locality and entered in the GIS database. These data were then processed through an analytical matrix approved by the REWG, 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 were assessed, and the ones with the highest potential were selected as "Development Poles" (the number of Development Poles to select will depend directly on the electrification targets set for the 10-year plan). These Development Poles were considered to have a higher priority in the rural electrification plan and were ranked according to the rated potential.



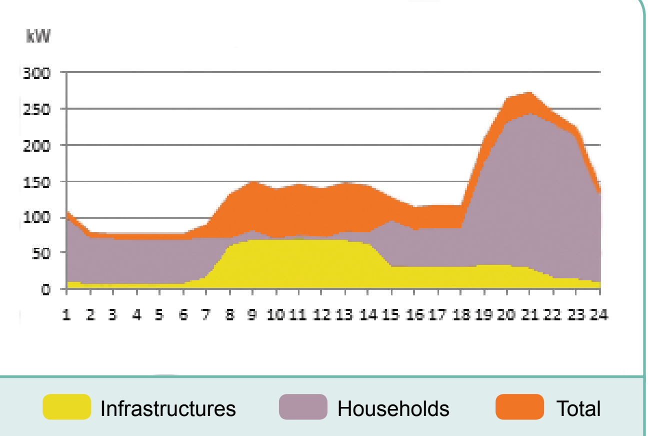
Spatial Analysis with the GEOSIM© software

2 3 2 Load forecasting

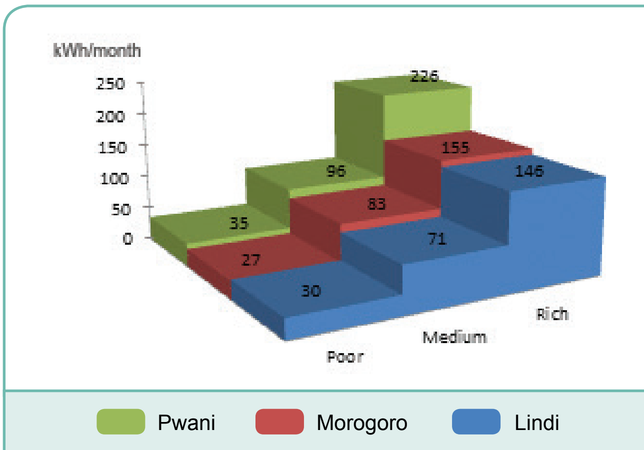
The load forecasting was undertaken for each individual locality using an aggregated approach «bottom-up». Main characteristics of demand were then forecasted over the planning period using average load profiles for different types of end-users (different categories of households, businesses, small industries, public facilities etc.). Socio-economic surveys were conducted to estimate these profiles. Consumer's patterns were defined and population divided in three classes according to their revenues.

This survey based approach offers a unique flexibility to differentiate consumption behaviours which are very different from one region to the others due to the heterogeneity of the Tanzanian geography. Tanzania is in fact mountainous in the north-east, three of Africa's Great Lakes are partly within Tanzania (Lake Victoria, Lake Tanganyika, and Lake Nyasa), central Tanzania is a large plateau with plains and arable lands, while the eastern shore is hot and humid. Furthermore, significant demands located outside villages and characterized during the surveys such as medium and large agro-industries, large social infrastructures and markets, were included in the study.

Based on some validated assumptions, the model could therefore build load curves at village level that were useful for the following planning phase for the identification of the least coast options.



Load Curves - Year 20



Household Consumption

2 3 3 Least-cost options

This third step consists in studying different technical supply options for the selected Development Poles: isolated diesel or diesel-based mini-grids; mini and micro hydro; biomass; PV hybrid system; wind hybrid system; grid expansion.

Each option was analysed so that its kilowatt-hour levelized cost is calculated taking into account several different technical, economic and financial parameters, and adjusted to each regional context. The least-cost option is selected for each identified Development Pole.

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

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

- **Scenario 2- Extension scenario:** From the baseline scenario, it was considered the full electrification of the region carried out only through regular grid extension (33kV lines) or using SWER technology.

- **Scenario 3- Integrated scenario:** Starting from the baseline scenario, the decentralised options for the off grid area using renewable energy sources (biomass, hydro, hybrid PV/Wind/diesel) were considered. All Development Poles are electrified with decentralized options.

  It is on the base of the Scenario 3 that the six electrification plans have been developed in the frame of IREP project.

2 3 3 Pre-electrification

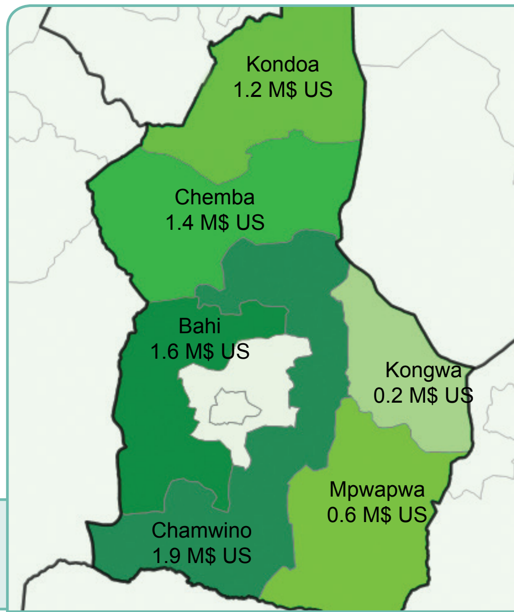
In areas where conventional electrification options are not provided at the end of the 10-year plan, provisional solutions were suggested. The solutions included:

- PV systems for community health and education facilities;
- multifunctional platforms (engines) for income generating activities and battery charging stations.

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

With the help of GEOSIM© it was possible to determine then the total investment and equipment needs if such pre-electrification program had to be implemented in the future.

< 0.5 M$ US
Between 0.5 and 1.0 M$ US
Between 1.0 and 1.3 M$ US
Between 1.3 and 1.5 M$ US
Between 1.5 and 1.7 M$ US
Between 1.7 and 1.9 M$ US



Total investment and equipment needs to accelerate the energy access

3 Renewable energies as a priority

As previously mentioned, it is the integrated scenario (scenario 3), fostering the development of renewable energy in Tanzania, that has been chosen as a base to develop the six electrification plans within the IREP project. This is an innovative approach as so far rural electrification was traditionally carried out through grid extension by the national state owned utility TANESCO. Today, the new institutional framework set in 2008 thanks to the Electricity Act, opens to Independent Power Producers (IPP) and to the development of renewable energies with the implementation of Feed-in-Tariffs (FiT) adjusted by EWURA for on-grid and off-grid injection. IPP regime is set with standard procedures, Power Purchase Agreements (PPA) and annual licenses for plants of over 1MW. In some case IPPs can get investment support from donors but in any case for operation. Furthermore, in 2007, the MEM also adopted 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.

In this context, the challenge of the IREP was to promote projects that can attract new operators in Tanzanian rural areas for energy production and distribution. To this aim, IREP project identified a portfolio of viable projects to be later proposed to promoters and investors. Combined with the grid extension, this approach will likely improve the rural electrification picture in the country.

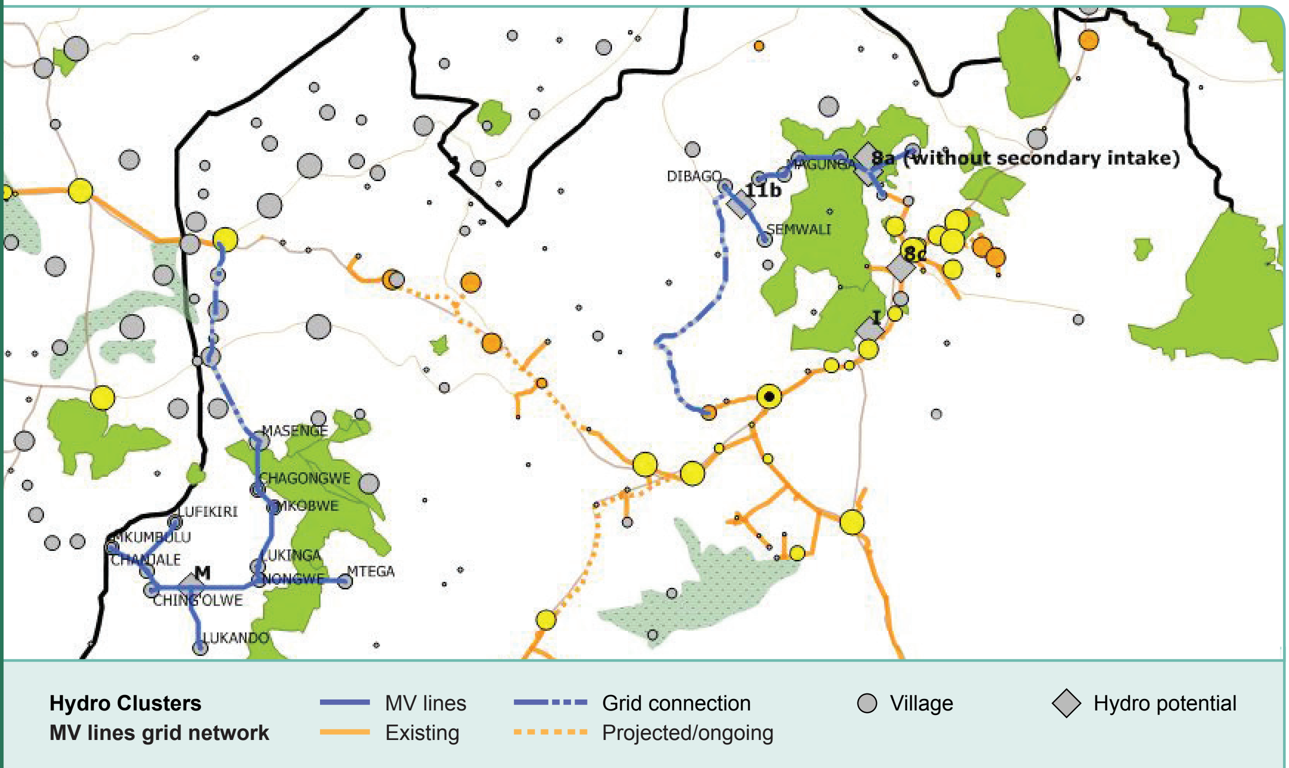
In total, 104 projects were identified by IREP. A quarter of these projects involves renewable energy, especially hydro and biomass, the rest is distributed between network extensions and diesel/photovoltaic hybrid power plants. The latter are taken into consideration when the sites are far from the network and the cost of diesel becomes even higher due to the inaccessibility of the sites. Due to the lack of data on wind resources in Tanzania, only one wind project was studied and for which Tanzania is now carrying out a resources assessment study.

3 1 Mini-hydro projects

Due to a favourable topography, some of the pilot regions such as Iringa and Morogoro regions offered multiple opportunities for mini-hydro projects development. In the frame of IREP project, more than 60 sites were identified and most of them were visited. However, regarding the rural electrification planning objective, only 21 projects were studied more in detail. The others were eliminated for the following reasons:

- the sites were located too close to the existing MV grid. Although these projects were potentially very interesting for injection and strengthening of the grid, this option fell out of the scope of the project;
- there was not much energy demand/villages located in the vicinity of those projects (within a 20km's buffer).

A comprehensive technico-economic study was then produced for each site thanks to the GEOSIM© tool. The least cost solution was detailed for the planning period of 20 years including a project map, so as to visualize the project environment as showed in table below.



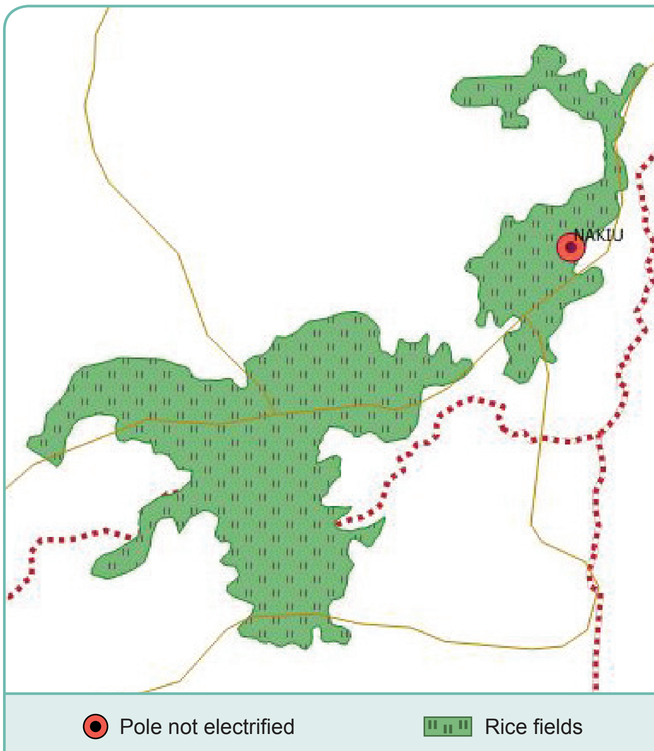
Project map of Iringa and Morogoro regions (GEOSIM© tool)

3 2 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 could really be identified.

Around five agro-industries were identified in the regions considered by the project. These are mainly located in urban areas or very close to the MV grid. Consequently, there is little interest for rural electrification to develop cogeneration power plants within those areas. Some projects might still be relevant considering energy injection into the MV grid network. However, as it has been the case for the hydro projects, these falls out of the scope of IREP project which considers renewable energies only as off grid technologies. IREP focused then on villages close to rice fields to propose some projects using rice husk.

For such cases, the most adapted technology seemed to be a gasifier to be set around the Development Poles where rice mills are more generally located. About ten projects were identified for such technology. Rice husk shall be collected from small farmers and brought back by trucks to the Development Poles where a gasifier power plant will supply the village with electricity.



Rice fields of Nakiu region (7,410ha)

3 3 Training and follows-up

Through the IREP project the REA and the REWG had the opportunity to access to a modern, technological, socio-economic and replicable approach to rural electrification.

REA's staff particularly benefitted from intensive training sessions totalizing six full weeks of specialized technical and practical training on GIS and GEOSIM© use. A very progressive pedagogy was used through the help of local data and real cases studies.

The project initially targeted only four regions and thanks to a successful and efficient use of resources, it was later extended to two supplementary regions. The action was also followed-up by the REA which decided to extend the study to ten additional regions in Tanzania mainland. In 2012, more than 12,000 households' surveys were performed using GEOSIM© energy survey templates and it was made use of surveyors which were trained and mobilized for the IREP survey campaign. Regional data collection was also extended by REA in 2013 mobilizing around fifty persons equipped with GPS so as to gather missing data required for running GEOSIM©.

CONCLUSION

Few lessons and recommendations can be drawn from the implementation of the IREP project:

- access to data is very important but remains 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.

- it is fundamental to disseminate project information and data through different communication channels such as public meetings and internet website. Potential investors are eager to get more information on existing opportunities and this is particularly evident in Tanzania where the economy is booming and is 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 that they can understand the benefits of the approach and possibly contribute to its improvement.

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

- the project confirms that coordination of investments in the energy sector must be strengthened. There is strong linkage between energy access and rural development and others sectors may benefit from an enhanced cooperation. As an example local workshops done at regional level were welcomed by local authorities and therefore very fruitful.

TANZANIA

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