PLANNING OF INVESTMENTS AND ORGANISATION OF OPERATING FACILITIES TO SUPPLY ELECTRICITY TO THE RURAL AREAS OF DEVELOPING COUNTRIES.

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SUMMARY

The rural electrification of developing countries can be based both on decentralised systems and network extensions. Determining the most appropriate supply choice for each village in time and space is a complex task. The method described here proposes an answer from a long-term standpoint. It is based on a software model developed by EDF, using planning techniques and taking into account the political, sociological, organisational and financial aspects which often play a determining role in the successful completion of projects.

1. INTRODUCTION

Supplying power to the rural areas of developing countries is a subject that has been dealt with to a considerable extent for more than 30 years, and which will continue to be for quite some time to come, because in some of these countries, less than 5% of the population is able to have access to electricity.

This document is meant to remind us of some pitfalls to be avoided and presents EDF's approach in the field of rural electrification planning.

2. SCOPE

The field studied here is research, at the scale of regions that have still not been electrified, of the 'best means' of supplying power to rural villages the inhabitants of which have low incomes.

Network extensions for the purpose of connecting existing self-producers (food processing plants, for example) or of supplying future customers who are known to be able to pay for the electricity under 'traditional' conditions are not taken into account here-below, because they come under conventional network planning methods (with lightened line construction techniques, if necessary).

3. THE LESSONS DRAWN

The answer provided for the electrification of the populations in rural areas of developing countries encounters structural difficulties that are summed up in a simplified way here, the actual situation being somewhat more complex:

- national electrical utilities extend their networks in areas where the profitability is the least favourable and claim governmental subsidies to maintain tariff equalisation in these regions;

- the public authorities seek fast results and, to achieve them, finance the investments required to set up small generating sets in remote villages, leaving it up to the national utilities to operate these extremely expensive mini-networks, sources of conflict between the administration and these utilities which demand subsidies;

- independent organisations try to take up the challenge by getting close to the inhabitants. Concrete and often innovative projects emerge, but very often their lifetime is short due to the organisation of project management over the long term (financial and maintenance problems), as well as to the quality of the equipment used and its appropriateness with regard to the local context (a problem which comes up in many off-grid electrification projects). In addition, even if some of these projects are durable, they are extremely hard to repeat and are not enough to meet the enormous needs;

- planning studies clash with actual local conditions. One cannot deal with only the technical aspect: the political, sociological, organisational and financial aspects are essential.

4. OVERSIMPLIFICATION TO BE AVOIDED

Nevertheless, one cannot stay behind these aspects and disregard the technical side of the project which has to be carried out thoroughly.

In particular, one cannot do without:

- envisaging the different types of networks possible (single-phase, two-phase, three-phase, with or without distributed neutral) and the various means of generation possible in a region (diesel sets, solar power, wind power, microhydro power, biomass, etc.);

- comparing the technical and financial aspects of these solutions, while not being merely content with using simplistic methods (for example, rough comparison limited to year 0 of the cost of individual solar panel kits with the cost of a systematic network extension);

- studying the development of solutions through time: taking into account of lifetimes and therefore of replacements differentiated according to the techniques; possibility of accepting increases in demand without having to give up the initially-selected solution at a loss; envisaging for the future and according to each technique, the possibility of extending electricity to uses other than lighting, the aim being to favour economic development;

- taking into account, over the duration of the project, the operating costs related to the selected mode of supply (fuels and personnel expenses) and studying the financial viability of the companies entrusted with managing the electrification process.

5. THE COMPLEXITY OF AN OVERALL APPROACH

Conducting a long-term master plan study for the rural electrification of developing countries is therefore a complex task, which takes into account multiple factors that are not only technical.

To do so, EDF has developed an overall approach, which covers extremely diverse aspects, such as:

- sociology: impact of electrical energy on the inhabitants and acceptance of the fact that it is not free, search for organisations acceptable by the populations who do not always have access to paper currency, improvement of the living conditions of women and children, etc.

- legal aspects: institutional developments making it possible to develop electricity within a favourable institutional context;

- financial aspects: tailored tariffs, types of financing for companies, as well as for inhabitants wishing to have access to electricity, etc.

- organisational aspects: creation of village cooperatives and of Decentralised Service Companies, setting up of a customer management system, etc.

- equipment aspects: in the absence of international standards, preparation of equipment and facility specifications adapted to the context of the areas to be electrified;

- the planning aspects taking into account network solutions and decentralised solutions: in this area, EDF has developed a set of methods with the support of the ADEME (French Agency for the Environment and Energy Management) and a software model to help the design engineer work on major regions, with a great amount of data and parameters which have to be varied so as to check the soundness of the solutions selected. These are the aspects which will be developed in the following section.

6. METHODOLOGY AND SOFTWARE DEVELOPED BY EDF

The first stage of a rural electrification programme consists in drawing up a long-term master plan the objectives of which are to:

- determine an **electrification target of the region** concerned by **deciding**, from the economic viewpoint, **whether the centralised** (network) or **decentralised** (collective or individual) **power supply solution is to be adopted**. This consists in proposing an optimum extension of the network and, in areas where the network would be too costly, in determining which decentralised solution is the least expensive;

- propose a chronological order of electrification of the villages of the region, worked out by means of criteria encompassing the economic, environmental, social and political aspects of the decision.

To meet these objectives, Electricité de France proposes a methodology which is based on a Computer-Assisted Software Model for Rural Electrification Planning in Developing Countries.

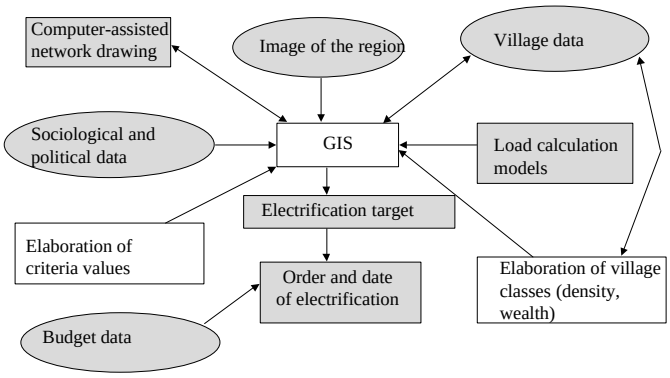
Both the methods and software allow the user (Ministry of Electrification, lenders, electricity distribution companies, etc.) to optimise the distribution of the various modes of centralised or decentralised power supply, to assess investments and their profitability, and to prepare an electrification works programme. The financial, economic, political and technical aspects are taken into account.

The software works in conjunction with a Geographical Information System (GIS) which provides the user with high data display features.

A **scenario manager** enables one to easily simulate the various hypotheses without increasing the number of input operations.

This tool consists of three separate but interactive modules:

- a load calculation module which estimates the peak load and annual consumption of each village of the area in the initial year (load calculation module being supplied with data collected through field surveys and simulations carried out by means of the LVPLAN software model on a representative sample of the villages);
- a module which allows one to work out the long-term electrification target and the chronological order of electrification of the villages through a multi-criteria analysis;
- a drawing module.



LOAD FORECAST

The method is based on:

- a typology of the villages according to geographical, demographic and economic parameters;
- a reconstitution of the standard village load curve for a number of days varying from one to four (a week day and week-end day for two seasons), after a sector-based analysis of the forecast demand of various customer categories based on a field survey;
- the calculation of the maximum load per customer and annual consumption per type of village;
- the calculation of the maximum load and annual consumption of each of the villages in the area.

DETERMINING THE LONG-TERM TARGET AND THE ORDER OF ELECTRIFICATION OF THE VILLAGES

This module serves to determine the electrification solution best adapted to each village (target) which takes into account its specific characteristics , as well as to spread out the electrification through time depending on the financial resources available each year.

This target search means avoiding short-term approaches which do not take into account the lifetime of facilities, their replacement, as well as maintenance and operating costs.

This dynamic approach takes into account the fact that one must not base the study on a snapshot of the existing situation, but look forward in time, while integrating network extensions, the increase of the rate of connection of the inhabitants to a power source, as well as the population growth rate.

A first stage consists in working out an optimum network solution which will serve as a reference for the comparison of the various means of electrification (solar panels, diesel generating sets) for each village. This network solution is established while taking into account minimum requirements concerning the service provided (voltage drops, number of MV power outages, losses, etc.), requirements which may vary depending on the context.

The module then calculates the most suitable electrification mode for each village for the time period considered for the study (electrification target) by using a catalogue of electrification solutions which lists the various parameters to be taken into account (investment, replacement and operating costs, availability, efficiency, constraints, etc.), the data concerning each village (estimated consumption, number of households, local energy resources available, rate of increase, etc.), the geographical characteristics of the areas studied (accessibility, types of fields encountered, etc.) and the various socio-economic data (electricity selling price, economic or political importance of the villages, inter-regional balance, etc.).

To simplify the logistics of the works and carry out electrification in an optimum way, once the mode of electrification of each village has been determined, the villages electrified according to the same mode are grouped either on the basis of the notion of geographical proximity or the notion of connection to the same network.

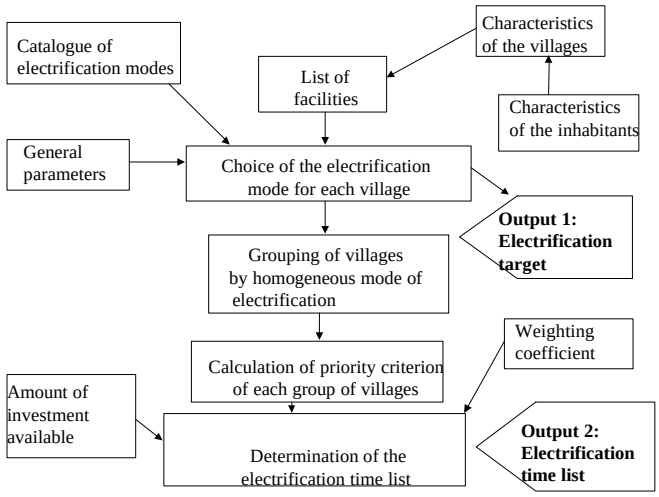
A ranking of the groups of villages by priority of electrification which takes into account the financial resources available is then proposed. This ranking makes it possible to draw up the short-term works programme in keeping with the electrification target which has been established.

The comparison of the various electrification modes is mainly based on economic considerations, but one may also include more qualitative aspects, such as environmental impacts, meeting a certain level of energy efficiency or the utilisation comfort of each electrification mode.

Upon completion of processing, tables are provided which indicate the electrification mode selected for each village and its electrification cost, according to the viewpoint of the local authority or that of the investor or operator.

The ranking function is based on a multi-criteria analysis of various parameters (financial aspect, development potential of the villages, political aspect, solvency of potential customers, inter-regional balance). These parameters are assigned weighting coefficients which must be defined upstream of the decision-making process by consulting the various partners involved in the electrification project.

GENERAL ALGORITHM OF THE MODULE FOR DETERMINING THE TARGET AND ORDER OF ELECTRIFICATION:



7. CONCLUSION

The quality of design engineers, planning methods and software models are a major means of support for projects concerning the electrification of rural areas. However, experience shows that all of the technical aspects have to be dealt with and that one must also be able to go beyond them and integrate the economic, sociological, financial, organisational and institutional aspects within a combined approach.

This is the overall approach chosen by EDF, witness the many projects under way: master plans, specifications of equipment adapted to the context, construction of networks with streamlined standards, participation in village cooperatives and in the creation of companies grouping several services in rural areas, etc.

As is the case for traditional network planning, rural electrification studies must serve as an objective basis on which lucid decision-makers will have to take political decisions committing the infrastructures of their countries over the long term.

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