



The challenge of rural electrification

CIGRÉ's strategy and organizational approach

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On behalf of Study Committee C6

1. Background

Over the years CIGRÉ's Study Committees have addressed the engineering aspects of equipment and systems for large scale electricity supply such as for urban and industrial areas. A few years ago CIGRÉ recognised the need to address the issues that distribution and dispersed generation have on electricity systems. As a result CIGRÉ decided to extend its scope towards distribution, dispersed generation and rural electrification, to cover economic and environmental aspects as well as social drivers and these be added to the pure technical aspects. In 2002, the Study Committee C6 "Distribution and dispersed generation" was established.

In 2004 Study Committee C6 was invited by the South African National Committee of CIGRÉ to jointly organise a colloquium on "Electrification and dispersed generation" in conjunction with the 5th Southern Africa Regional Conference. These events took place in October 2005 and clearly demonstrated the need and desire to share information about traditional and innovative technologies for the electrification of rural areas.

Subsequently the Malaysian National Committee of CIGRÉ hosted a second Colloquium on "Electricity for rural socio-economic development". In 2006 Working Group C6-13 "Rural Electrification" was established to identify specific subjects to be addressed and to include the results of the studies in a number of papers to be presented and discussed during the Colloquium in Malaysia. This colloquium took place in May 2007 and revealed the still existing barriers, the success factors and current and potential technical options for the electrification of rural and remote areas.

Working Group C6-13 concluded its work with a Scoping Report [1] in which the results of the two colloquia and the findings of the group are presented, together with recommendations for possible future work.

The paper in hand has attempted to highlight a strategic approach for CIGRÉ to continue its contribution to the challenge to electrify the depressed areas in this world, to the benefit of nearly two billion people and many small-and medium scale industries still lacking access to electricity.

2. The electrification challenge

At the end of the 20th century, the international community committed to the "Millenium Development Goals (MDGs)" initiated by the United Nations. These are a number of development objectives including the target of halving the number of people in the developing world living in poverty, improving the health situation, reducing child mortality, and making the benefits of new technologies available.

Although energy supply is not directly included in any MDG, reliable, affordable and sustainable energy services, including electricity, are needed to reach most of the MDGs by 2015. In the past few years the donor community, development banks, the private sector,

NGOs and other organisations have developed and implemented a number of initiatives to help improve energy supply to deprived regions in the developing world.

The provision of electric services to rural and remote communities in the developing world is a financial challenge. Assuming all current rural and remote communities in the developing world would be electrified with a grid-based modest service, hundreds of billions US\$ would be needed to cover the costs of the associated generation, transmission and distribution systems. To a large extent the investment has to come from utilities, governments and private investors. Though the multilateral development banks and donors are influential, they are relatively modest investors in rural electrification.

However, the provision of electricity services is only one of the rural development challenges facing the developing world: clean water, sanitation, health services, and safety could even be higher on the priority ladder, but access to electricity facilitates these services.

To cope with the electrification challenge continued technology innovation is needed, particularly in the rural context. In the past, many rural electrification programs have focused on expanding central grids managed by national or regional utilities. In several cases the technical standards for the rural electricity schemes were not adjusted to local conditions. In



some cases technical standards appropriate for urban areas were used or in other cases, standards applicable in the donor countries. In the years to come central grid systems will continue to enable many rural communities to get access to electric services. Cost reduction is a critical issue because one of the biggest obstacles in extending electrification to rural communities are the “up-front” costs of the investment. To reduce costs, further developments in this area are needed.

Rural Electrification in Mali [Picture GTZ/RWI, Germany].

But also new concepts for off-grid electrification, including hybrid systems, and such components as PV, storage facilities and fuel cells need further development and cost reduction. Not only technical concepts need attention. New financial, institutional and business approaches must be adopted to achieve concrete results on the ground. Bringing electricity to the rural communities is not enough, for example local technicians and appliance shops are needed, and the customer base must be informed and educated. To that end cooperation between a utility, the local government and a community-based organization is needed.

New technical concepts and applications need appropriate and international technical standards. Donor country specific standards can lead to higher investment cost, operating and maintenance difficulties and lower reliability of services. There are examples in developing countries where in one area, technologies with different (donor specific) technical standards have been used. There is thus reason to investigate whether there is room for the formulation of generic technical standards for rural electrification facilities for both grid-based and off-grid systems.

In developing countries, major concerns include the lack of financial resources to cover the investment costs in addition to the low affordability of the customer base to pay for the services. The institutional and technical dimensions are challenging as well. To address these challenges, governments, utilities, civil society, the donor community and other stakeholders will have to work together more than they have ever done so before.

In the past, many donor supported rural electrification programmes focussed on the poor segment of the communities. There is a growing understanding that electricity used for productive applications is equally or sometimes even more important because of its positive effects on local employment and income generation for the poor. Planning and funding of the electrification programme should therefore be based on the whole potential consumer base, taking the development objectives into account.

Though the electrification of rural and remote areas in the developing world continues to be a challenge in the next decades, the growing migration of rural dwellers to informal urban areas causes serious problems. Some five years ago about one billion people were living in these areas in the developing world [2]. These informal, low-income and often illegal settlement areas are normally not covered by the infrastructure planning of the government and service providers. In some cases electricity is provided by local entrepreneurs or stolen from accessible distribution lines or connections. In an attempt to improve the living conditions, curtailing theft, and to reduce the number of accidents caused by illegal connections and unsafe house wiring, some municipalities and utilities together with other organisations took up the challenge to electrify these areas.

Recent research [3,4] revealed that the electrification of these informal urban settlements features specific physical and institutional obstacles, though most of these areas are often



not very far from distribution lines and substations. Another outcome of this research was that innovative organisational and technical approaches are needed and that all stakeholders must be involved to achieve a legal, affordable and safe electrification.

While there are similarities (poverty, small loads, small-scale enterprises, etc) the electrification of these areas is different from that of rural areas. The provision of electricity to the informal settlement areas should preferably be part of urban infrastructure development (water, sanitation, energy,...) and not be treated as a stand-alone activity.

Informal settlement area in South Africa

[Picture Lakervi, Finland].

3. Existing knowledge and future needs

Apart from utilities and equipment manufacturers, many organisations including NGOs, consultancy firms, development banks, the donor community and universities are involved in the electrification of the rural areas in the developing world. Many of them produced (and still produce) relevant and high-level documents. The available literature includes guidelines and documentation on among other the design of rural substations and distribution systems, best practices, mini-grid design, small-scale hydro-facilities, gender aspects. The Energy Sector Management Assistance Programme (ESMAP), for example, published in 2007 a 300 pages document on rural electrification covering the experiences with successful programs. Part of the ongoing World Bank “Energy for Rural Transformation” programme in Sub-Saharan Africa was the preparation of a document in which existing systems and a number of cases related to various African countries are described aiming at mainstreaming low cost innovations in electricity distribution networks.

At the request of CIGRÉ's Study Committee C6 "Distribution and dispersed generation", Working Group C6-13 contributed to international colloquia on rural electrification with a number of papers and the result is presented in a recently produced scoping report [1].

It is justified to argue that the setting of rural electrification and the best practices are sufficiently addressed in the existing literature and forthcoming documents from other organizations. It must, however, be said that most of the information is not easily accessible because of its dispersed nature. Many of the available documents also relate to specific communities, countries and circumstances and the information is not necessarily valid for other situations.

Though substantial documentation is available, specific issues remain to be addressed in more detail. For example Working Group C6-13 recommends in its scoping paper consideration of the subjects listed in Table 1 for further study by CIGRÉ. Many of these subjects require a multi-disciplinary approach for which cooperation between various disciplines and organizations is needed.

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| <ul style="list-style-type: none"> • Practical experience and lessons learnt with prepaid meters: technical and implementation data to be collected and conclusions drawn. • The wide variety of technical and quality standards, for both grid-based (medium and low voltage) and off-grid systems, need to be investigated in more detail. • Cost comparison of grid-based and off-grid electrification based on actual projects and figures. • Small and multi-MW hybrid systems: feasibility and limits in terms of capacity, benefits, practical experiences, standards. • Opportunities and limits for consumptive and productive use of stand alone PV systems. • Service interruption costs for rural consumptive and productive uses: preliminary results given but further study needed. • Business models for both grid-based and off-grid systems, also in a liberalized environment. • Building relevant local technical and managerial capacity. |
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Table 1. Subjects identified by CIGRÉ WG C6-13 for further study [Source: 1].

To substantially increase access to electric services in the next decades, the emphasis must be on the actual realisation of electrification programmes. As a result it might be expected that in the near future specific implementation-oriented niches in knowledge will emerge. For example renewable technologies including Solar Home Systems and mini grid systems with mini-hydro power plants, and biogas gasifiers are seen as viable options for the electrification of rural and remote areas. The practical experience with these technologies in the rural context of developing countries might justify a survey.

There are also indications that some existing documents require a "translation" into a more practical, implementation oriented guide. Other issues that probably need specific attention include the adoption by governments and utilities in the developing world of adapted and low cost practices. Development banks and donors must adopt new practices in their lending and funding for rural electrification, aiming for successful development and poverty alleviation.

4. CIGRÉ's strategy and organizational approach

As appears from the previous sections the electrification of rural areas in developing countries is a multi-faceted task, and where financial, organizational and technical challenges are to be solved. Despite this observation and the current technological and other developments in this field, there is no permanent platform to exchange knowledge on these topics. To really and effectively take advantage of the existing but dispersed knowledge

resources there would seem a strong need for such a platform that could work as the core of a global network so that it could turn into a favourable instrument for listing and exchanging relevant information, and for efforts to adopt policies and standards relevant for developing countries.



Solar-diesel hybrid station [Picture ERGON, Australia]

It is clear that the governments, utilities, local communities and small-scale energy enterprises in the developing world are the most important stakeholders in the field of rural electrification, apart from the consumers. The value of a platform would reside in its capacity to specifically serve their needs through their representatives. A network concept could offer them opportunities to benefit from the activities of, for example, a forum.

As is stated in the Masterplan 2006-2011, CIGRÉ recognises that electricity is increasingly vital for the development and well being of the world and that it is, therefore, of utmost importance that CIGRÉ continuously responds to the needs of industry and society. The electrification of rural and remote areas is, as appears from the previous sections, one of the major challenges. It is CIGRÉ's desire to actively contribute to meeting this challenge.

CIGRÉ has a global mandate and its mission as an independent organization is to develop and to facilitate the exchange of knowledge on design, operation, maintenance and management of electric systems. CIGRÉ's leadership in the development and exchange of electrical engineering knowledge is widely recognized and in the electricity supply and manufacturing sector the organisation has a strong convening power. CIGRÉ also maintains strong relations with IEC, CIREN, utilities, manufacturers, universities, consultants, and research institutes. But CIGRÉ's relations with organizations involved in the electrification of rural areas such as development banks, the donor community, NGO's and implementation organizations are less developed.

The outcomes of the colloquia and discussions with peers revealed that the activities associated with electrification of rural areas are typically multidisciplinary and need the input

from many stakeholders. CIGRÉ has limited expertise regarding the social and financial dimensions of rural electrification. On the other hand, CIGRÉ is uniquely qualified to assist in terms of engineering and innovation/standardisation and to bring utilities, manufacturers and other relevant organisations together.

It is clear that CIGRÉ can do more but in focused working groups and close collaboration with other organizations. CIGRÉ can facilitate bringing ideas together and offer assistance and work forces for studies of niches in knowledge (e.g. as listed in Table 1), organising colloquia and joint conferences, etc. However, taking the lead in organizing a specific platform such as the suggested forum, has practical impediments. CIGRÉ has currently no facilities to develop and maintain a forum on the Internet with a moderator and technical administrator. At present most of the documents are only available for members of the working bodies but wider access will be considered. Moreover CIGRÉ's bi-monthly publication *Electra* has a rather limited circulation outside membership and those involved in the engineering of electric systems. It is also noted that the target groups in terms of the electrification of rural areas are very different and much broader than those of the other Study Committees. This also suggests another approach to the communication with stakeholders.

Until the Study Committee C6 (Distribution and Dispersed Generation) was established some years ago, CIGRÉ's efforts in terms of the electrification of rural, and remote areas have been rather poor. Since a few years this subject is high on the agenda, and the Working Group C6-13 "Rural Electrification" has been set up and colloquia organised in collaboration with CIGRÉ National Committees in South Africa and Malaysia. According to CIGRÉ rules, this working group has been disbanded in December 2008.

The concept of a single rather broad temporary working group was a good solution to identify and prepare within a short time several papers for the Malaysia colloquium in 2007. It is quite clear from the previous sections that activities associated with the electrification of rural areas are typically multidisciplinary and need the input from a variety of disciplines, also from outside CIGRÉ. Future study activities will be related to a diversity of subjects and to properly respond to emerging needs and priorities the establishment of smaller but specific work forces, purposively staffed with members with relevant expertise, would be a better and manageable solution.

To assist the Study Committee in the preparation of work and decision making a permanent Advisory Group on this thematic area will be set up within Study Committee C6 "Distribution and Dispersed Generation". This group, with some 5 members with appropriate expertise and background, will act as a think-tank aiming at listing niches in knowledge and converting the results into concrete recommendations for studies by workforces. To that end, the group will initiate and maintain linkages with target groups and other organisations involved in the electrification of rural areas, identify and assess demand-driven needs, and prepare Terms of Reference for temporary Working Groups or Task Forces. Membership of the latter workforces will be open for experts from CIGRÉ and other organizations, local, regional and international.

This Advisory Group on Rural Electrification offers a good balance between an innovative and flexible approach, and is expected to be a major driver of ideas on what really needs additional study. The practicalities of this approach including the scope and membership of the Advisory Group will be worked out in the next stage. To enhance the involvement of developing countries, SC C6 will promote the use of its web site to particularly provide information on this thematic area for people in these parts of the world.

Acknowledgement

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References

- [1]. "Rural Electrification: a Scoping Report", IWD5 CIGRÉ WG C6-13 (Rural Electrification), 2008 (www.cigre-c6.org, publications > other documents).
- [2]. "The Challenge of Slums", UN Habitat, Human Settlement Programme, Global Report on Human Settlements, 2003.
- [3]. "Meeting the needs of the urban poor", ESMAP Technical paper 118/07, June 2007
- [4]. "Innovative approaches to slum electrification", USAID Report, December 2004.