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# Rural Power Supply with Local Management: *Examples from Bolivia, India and Nepal*

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## ABBREVIATIONS

| | |
|---|---|
| ACAP | Annapurna Conservation Area Project (Nepal) |
| AEP | Alternative Energy Programme (ACAP) |
| ADBN | Agricultural Development Bank Nepal (Nepal) |
| AHREP | Andhi Khola Hydel Rural Electrification Project (Nepal) |
| BPC | Butwal Power Company (Nepal) |
| CEA | Central Electricity Authority (Nepal) |
| CESS | Co-operative Electric Supply Society (India) |
| CEY | Cooperativa Eléctrica Yungas (Bolivia) |
| COBEE | Compania Boliviana Energia Eléctrica (Bolivia) |
| CRE | Cooperativa Rural de Electrificacíon Limitada (Bolivia) |
| DANIDA | Danish International Development Agency (Denmark) |
| DGIC | Directorate General for International Cooperation (Netherlands) |
| EDC | Electricity Development Center (Nepal) |
| ELFEC | Empresa de Fuerza Eléctrica de Cochabamba (Bolivia) |
| EMC | Energy Management Centre (India) |
| ENDE | Empresa Nacional de Electricidad (Bolivia) |
| ESD | Electrification for Sustainable Development Programme |
| FAKT | Fördergesellschaft für Angepasste Techniken in der Dritten Welt (in GTZ, Germany) |
| GATE | German Appropriate Technology Exchange (in GTZ, Germany) |
| GTZ | German Agency for Technical Cooperation (Germany) |
| ICIMOD | International Centre for Integrated Mountain Development (international) |
| ITDG | Intermediate Technology Development Group (United Kingdom) |
| IREDA | Indian Renewable Energy Development Agency Ltd. (India) |
| ITECO | Company for International Technical Cooperation and Development (Switzerland) |
| KMTNC | King Mahendra Trust for Nature Conservation (Nepal) |
| kW | kilowatt |
| kWh | kilowatt hour |
| MNES | Ministry of Non-Conventional Energy Sources (India) |
| MW | Megawatt |
| NEA | Nepal Electricity Authority (Nepal) |
| NEEPCO | North-Eastern Electric Power Corporation (India) |
| NHPC | National Hydro-Electric Power Corporation (India) |
| NRECA | National Rural Electric Co-operative Association (USA) |
| NRCE | New & Renewable Sources of Energy Programme (India) |
| NORAD | Norwegian Agency for Development Cooperation (Norway) |
| NTPC | National Thermal Power Corporation (India) |
| O&M | Operation and Management |
| OMA | Operation, Management and Administration |
| PFC | Power Finance Corporation (India) |
| PV | photo voltaic |
| REA | Rural Electrification Administration (USA) |
| REC | Rural Electrification Corporation (India) |
| SATA | Swiss Association for Technical Assistance (Switzerland) |
| SCECO | Salleri Chialsa Electricity Company (Nepal) |

| | |
|---|---|
| SDC | Swiss Development Cooperation (Switzerland) |
| SEB | State Electricity Board (India) |
| SELUP | Salleri Electricity Utilisation Project (Nepal) |
| SHDB | Small Hydel Development Board (Nepal) |
| SHPD | Small Hydel Power Department (Nepal) |
| Sida | Swedish International Development Cooperation Agency |
| SKAT | Swiss Centre for Appropriate Technology (Switzerland) |
| SNI | Sistema Nacional Interconnectado (Bolivia) |
| SWER | Single Wire Earth Return system |
| TANESCO | Tanzania Electric Supply Company Limited |
| UNDP | United Nations Development Programme |
| UMN | United Mission to Nepal (international) |
| USAID | United States Agency for International Development (USA) |
| USD | United States Dollar |
| W | Watt |
| WAPCOS | Water and Power Consultancy Service (India) |

**Exchange rates**

| | | |
|---|---|---|
| 1 USD = | 4.7 Bolivianos | (February 1995) |
| 1 USD = | 31.25 Indian Rupies | (February 1995) |
| 1 USD = | 49 Nepalese Rupies | (February 1995) |

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This study could not have been carried out without the grand hospitality and interest in sharing experiences shown by the visited organisations. Both at the governmental and non-governmental level, people in Bolivia, India and Nepal have welcomed us to discuss their situation and ideas. In all three countries we have had an excellent itinerary, much thanks to careful planning from the contacted organisations' end. Not only planning, but the actual provision of vehicles, chauffeurs, and interpreters should be ascribed the visited organisations.

A large portion of gratitude is also addressed to Mr. Makala Kingu and Mr. Juma Mawenge, who represented the *Tanzania Electric Supply Company Limited* (TANESCO) in this particular study. Their role in focusing the study on such issues that are of real interest to Tanzania, cannot be over-estimated. They have also had a major say in condensing the findings from the case studies into relevant conclusions. A separate report, primarily intended for the TANESCO management, is prepared by the two [1]. However, the discussions and point of views raised in this report are those of the authors.

Furthermore, we want to draw the attention to those employees at TANESCO who filled in the gap when the two senior TANESCO-staff members left for several months, during their engagement in this study.

Finally, we would like to express our gratitude to the Swedish International Development Cooperation Agency (Sida) who has funded this project.

Åsa Gerger and Monica Gullberg, Stockholm, December 1995.

[1] Mawenge J., Kingu. M. 1995. Safari Report on International Tour to Bolivia, India and Nepal Between 9th January, 1995 and 11th March, 1995. TANESCO.

## ABSTRACT

Local management of rural power supply is being evaluated in a joint research project conducted by *Tanzania Electric Supply Company Limited* (TANESCO) and *Stockholm Environment Institute* (SEI) on new approaches to management and organisation of rural electrification. In addition to the Tanzanian pilot projects launched, international experience is regarded valuable, the reason for conducting this study.

The study is based on literature, and on data from eight visited local organisations for management of power supply in Bolivia (4), India (1) and Nepal (3). Common for these countries is that the national, rural electrification programmes have encountered difficulties. Governments have failed to generate enough funds from existing power supply systems to cover the cost for a continued rural electrification. In cases where large private companies exist, they have had few incentives for expanding into rural areas since it is often not profit making. A third category may be defined as local initiators to power supply, private or co-operative. In all these countries, locally managed power supply systems have developed as a complement to governmental and other large scale programmes. The national policies pertaining to rural power supply in general and local management thereof in particular are described for each country. The eight case studies aims to explore general experiences and reflections about the benefits of, and difficulties with, local management of rural power supply.

From the study, it appears that local management of rural power supply is a feasible approach in developing countries. Local management of rural power supply can slightly lower the costs of electrification, and it may help accelerate the pace of load development in newly electrified areas. For successful local organisations though, the most significant factor appears to be local peoples' willingness to develop their own area. The local interest outweighs some of the negative factors identified by national interests such as risky investments and poor dividends. Important though, is that proper financial and technical assistance is provided the local organisations, particularly during their first years in operation. Crucial for sound external assistance is that the national rural electrification policies are clear and consistent.

# 1 INTRODUCTION

## 1.1 Context of study

Together with the Tanzania Electric Supply Company Limited (TANESCO), a para-statal utility, the Stockholm Environment Institute (SEI) is evaluating local management of rural electrification[2]. Earlier joint research has focused on the TANESCO rural electrification programme, its successes and shortcomings. During a twenty-five year period of socialism and centralised development programmes, TANESCO has had virtual monopoly of rural electrification in the country. Still, although privatisation policies are increasingly introduced in Tanzania, TANESCO's rural electrification programme remains the only sizeable effort made for expanding power services into new areas.

Political ambitions for electricity provision are grand in Tanzania, as in many other developing countries. Access to electricity enables industrial activities as well as effectiveness in agricultural activities. Furthermore, electricity renders automatic water pumping possible and enables replacement of traditional cooking stoves, for which women and children need several hours a day to collect wood fuel, with electric stoves. Despite the indisputable truth of electricity being a crucial factor for modernisation, most often, all positive effects do not follow directly on electrification per se.

Financial risk taking and managerial efforts are inevitable ingredients in the process of establishing a new power supply system and acquiring loads which generate revenues and development. Managerial engagement typically includes sensitisation of electricity use, promotion of electricity uses in industrial activities, etc. These demanding conditions for state utilities as well as for large private companies antagonise their willingness to help fulfil the political goals. Based on the apparent problem of TANESCO's to efficiently and cost effectively reach rural consumers, it was suggested that new approaches to rural electrification be examined in Tanzania. The ongoing evaluation of local management of power supply aims at strengthening the argument that involving local parties in the rural electrification process may be valuable. Expected benefits of locally managed rural power supply are of two kinds:

- savings in costs and efforts for establishing and managing the power supply system, and
- a more genuine engagement in the load development, i.e. intensified local electrification

Whether the local organisation should be a co-operative, an electricity association or a private firm is debatable. In general, it is believed that the form for the local organisation must be flexible and sensitive to local preferences and conditions.

In a series of prefeasibility studies, TANESCO considered a handful of sites that were not yet electrified, and that could develop into adequate pilot areas of locally managed power supply systems. These systems should also serve as references for TANESCO and the *Ministry of Water, Energy and Minerals* (MWEM), in their design of national policies for support to locally managed power supply systems.

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[2] Sida-funded project co-ordinated by SEI under the Energy, Environment and Development Programme, 1993-1995. Project title: 'New Approaches to the Organisation and Management of Rural Electrification in Tanzania'.

In 1993, a pilot project was launched in Urambo, Tanzania. *The Urambo Electric Consumers Co-operative Limited* (UECCO) became Tanzania's first ever locally anchored organisation for operation and management of power supply. The UECCO is an officially registered co-operative, and its licence3 for power generation and distribution is unique in the country. The UECCO has also pioneered having a service contract with TANESCO, ensuring the co-operative regular services and technical assistance from the state utility. Mbinga is another village where power distribution activities have started but where no definitive steps are yet taken.

The power supply activities in Urambo and Mbinga are in progress. Nevertheless, to achieve effective implementation of locally managed rural electrification projects in the country, SEI and TANESCO recognise the importance of drawing upon experiences from other parts of the world. This is the reason for carrying out a separate study on rural power supply with local management based on examples from Bolivia, India and Nepal.

## 1.2 Prospects of the study

Following the current privatisation tendencies in Tanzania there is a need for comprehensive and well formulated strategies for how to proceed with the rural electrification programme. Present Tanzanian rural electrification policies retain the state of order that TANESCO is responsible for planning and establishment of projects. In terms of domestic know-how in the field of electrification, TANESCO remains the most important source of expertise, although there are specialists at the university as well. In practice, TANESCO continues to be in charge of the national rural electrification programme, but with significantly less funds than earlier.

TANESCO has approved to contribute "help for self-help" to local initiators wanting to establish a power system at their site. Consequently, TANESCO would provide expertise to any organisation supporting rural electrification initiatives. Such a supporting group need not be part of TANESCO, but might as well be autonomous and include expertise from other parts of society, such as the banking system, and possibly from the Co-operative Apex Organisation [4]. It is quite clear though, that for such a group to function effectively, the possibilities rely on a number of factors embedded in the rural electrification policies. Moreover, laws and regulations concerning local people's possibilities to take loans for their business, unauthorised persons qualifications to install electric equipment, etc., should be clear before any large scale efforts to support local initiatives are made. At this stage, it is important to form an opinion of what the local and national factors are that determine the prerequisites of local management of rural power supply.

## 1.3 Objectives

By studying a number of local organisations for management of power supply in different countries, with different national development policies, it is hoped that TANESCO will:

[3] Issued by MWEM.

[4] Tanzania has a history of agricultural co-operatives for which the Co-operative Apex Organisation acts as a co-ordinating unit.

- establish useful contacts with both grass-root organisations and supportive organisations with experience from local management of rural electrification; and consequently
- be able to sharpen their arguments for why certain measures must be taken in the establishment of a national policy supporting to locally managed power supply systems in Tanzania.

## 1.4 Methodology

The study was carried out in two stages: a literature survey, and case studies on site.

The literature survey was made jointly by one TANESCO representative and one SEI employee. Literature was sought from the Stockholm Environment Institute's head offices, during the end of 1994. [5] Based on literature from both industrial and developing countries, it was agreed that the following scope of information would be of interest to the study:

*at the national level*

- national policies and strategies in the field of rural electrification;
- national policies and regulations for local management of rural power supply;
- national structure of support to locally managed power supply systems; and
- technical and managerial solutions to cost efficient rural electrification.

*at the local organisations' level*

- different types of organisational structures of the local actors;
- local organisation's approach to operation and management of the local system, including technical solutions;
- local organisations' financial situation;
- general tendencies in the local organisations;
- the local organisations view on their activities; and
- their relation to the government and aid organisations.

In order to have a qualitative discussion on the information obtained, three countries were selected as case study countries: Bolivia, India and Nepal. The following criteria was taken into consideration when selecting the countries:

- they are developing countries;
- their general development and electrification policies differ from one another, as well as their history and role in multilateral development schemes;
- the countries possess different types of organisations for local management of rural power supply, and have many years of experience in the field;
- both successful and unsuccessful examples of locally managed power supply systems are found in these countries;
- there is a variety of technical solutions to power supply applied in the countries; and
- ultimately, local organisations in the countries were accessible and interested in sharing their experience in local management of rural power supply.

[5] Sources of literature: Nordiska Afrika Institutet (NAI,LIBRIS), Studsvik (ETDE), Swedish University of Agricultural Sciences (ECONLIT; LUKAS), Stockholm Environment Institute (data bases in DIALOG & others).

During January and February 1995, two TANESCO representatives and two SEI employees visited four rural electrification projects in Bolivia, one in India and three in Nepal.

### 1.5 Scope and objectives of the case studies

Visiting the three countries and some selected organisations in each, was regarded as crucial for the study to get a more complete picture of how the organisations actually operate their day-to-day activities. In addition, by consulting grass-root organisations, national policies may be viewed from a different angle. The purpose of the case studies was to identify :

- the features of the local engagement, i.e. what exactly do local people care for in the system, and what does their involvement contribute?;
- the type and scope of external assistance the local organisations enjoys, and what the external assistance contributes; and
- the financial situation of the local organisation.

These points will serve as the basis of the discussion in the summary of findings in chapter 3. In addition, they are reflected in the three subsequent sections on the case studies.

Technical designs were not studied unless when considered important factors for the planning of the work or tariff setting in the systems.

# 2 BACKGROUND

## 2.1 General dilemmas of rural electrification in developing countries

In most developing countries, power supply systems have been built up in which electricity is generated centrally in large scale power plants. Substantial contributions have usually been received from industrialised nations, both in terms of financial support and technical consultancy. A state utility is normally appointed the responsibility for the system and is also commonly requested to care for the rural electrification programme on a more or less autonomous basis. Most commonly, rural demands are met either through grid extension or by installation of local, stand-alone power plants.

On the whole, designs and standards in the Bolivian power supply systems have been copied from the USA. The Bolivian power supply sector is dominated by *Empresa Nacional de Electricidad* (ENDE), the national company, and the privately owned *Compañía Boliviana Energía Eléctrica* (COBEE). While ENDE operates the bulk of generation and transmission facilities, COBEE is the country's largest distribution company. COBEE prioritises urban loads and serves primarily the urban zone of La Paz. CORELPAZ is the company in charge of the rural distribution in the La Paz area. In the 1960's, the US organisation *National Rural Electric Cooperation Association* (NRECA) started rural electrification activities in the country. However, not until a decade later, in the 1970s, national initiatives were taken when ENDE launched their first massive rural electrification programme.

By and large, the design of Indian power supply systems emanates from British engineering. Construction and operation of power generation projects in the central sector are assigned to three Central Power Corporations [6] under the administrative control of the Ministry of Power. The history of rural electrification in India dates back to the 1950's. In 1969, the rate of the electrification activities was intensified with the establishment of the central agency *Rural Electrification Corporation* (REC). Each state of India possesses a *State Electricity Board* (SEB), which is responsible for the state's electrification. REC acts as an umbrella organisation for the SEB's.

The state electricity utility in Nepal, *Nepal Electricity Authority* (NEA), was established in 1985. Its activities have been mainly concentrated to urban areas. The history of planned, grid-based rural electrification is relatively recent [7], although gradual electrification of rural areas adjacent to electrified urban areas has been a common practice. System layout and technical solutions in the national grid are similar to the Indian, and thus originates from the United Kingdom. In Nepal, rural electrification based on aid-, and technology transfer projects, started in the 1960s and accelerated during the 1970s when the international oil crises motivated a harnessing of the abundant hydro power resource available in the country. These decentralised hydropower projects have been limited to relatively few areas. Their existence though, has made mini- and micro hydropower an important energy option in the planning of the national power supply.

Priorities and aims of rural electrification programmes may vary slightly between countries. However, by electrifying their rural parts, developing countries generally aim at enhancing the standard of living in those areas. It is often

[6] National Thermal Power Corporation (NTPC); National Hydro-Electric Power Corporation (NHPC); and North-Eastern Electric Power Corporation (NEEPCO).

[7] NEA, the Nepalese state utility, initiated a grid based rural electrification programme 1984.

envisaged that access to electricity in rural areas will enable enhanced health services and stimulate efficient agriculture, as well as industrial activities.

On the other hand, the actual international status of developing countries motivates them to strengthen their credibility and political value on the international arena. Therefore, although pan-territorial development is ideologically desirable, large industries and other urban loads are often prioritised as they contribute substantially to the growth of the GNP. Moreover, as a means to stimulate industrial and other internationally important activities, electricity has during the establishment of the power sector often been sold at subsidised prices to consumers that are politically and economically important. In most countries, electricity is still subsidised, and before making a profit, many national power supply utilities in developing countries need to reach a point were incomes cover expenses in their existing system.

Rural electrification schemes are seldom financially viable at their initial stage. The reasons are the high costs connected with power system extension to remote areas and the poor revenues from scarcely populated and less industrialised areas. The extra profit power utilities would need to expand into rural areas may be difficult to extract from the urban loads, as they serve as the nerve of the national economy. Their significant role in the economy has also allowed them to become a politically powerful group in society. Given that investments in rural areas usually do not yield until several years later, national decision-makers first and foremost tend to prioritise urban development.

Even though a utility opts for decentralised power generation in areas far away from the national grid, costs remain high for servicing the system, billing the consumers etc. Educated engineers are found in town and to have them servicing a remote power system, one either has to pay their travel costs and/or provide them a decent living on site. A remote site will also have more difficulties in obtaining fuel and spare parts. Shortage of spare parts is a common problem also for easily accessible places in developing countries, and a frequent reason why generating units stand idle.

Electrification rates of villages in developing countries have remained low compared to rates of urban centres. In 1987, it was estimated that the proportions of the rural population with electricity supply were 27% in Latin America, 19% in Asia, and only 4% in sub-Saharan Africa. [8] Individual examples from Asian countries may illustrate the low rate of 1990: 14% in Vietnam, 10% for Bangladesh, 8% for Laos. [9] These figures, however, do not reveal that the actual number of rural households with access to electricity is in reality often much lower. Just because a village is electrified, this does not mean that all villagers are connected to the system.

In Bolivia, about 16% of the rural households have access to electricity, while the electricity rate in urban areas is 87%. [10] In Nepal, the rate of rural households with access to electricity is as low as 1%, according to estimates by interviewees. In India, the corresponding figure for rural households is much higher, i.e. about 40%, varying from 27% up to 98% in the different states.

Rural electrification is necessarily a time-consuming process. For example, the rural electrification in a leading industrialised country like the United States, which began about 50 years ago, has recently been completed. The expansion of

[8] Menanteau, P. In Foley, G. 1992. "Rural Electrification - the Institutional Dilemma". In: *Utilities Policy*, p. 289.
[9] Saunier, G., Mohanty, B. 1992."Overview and Guidelines for Rural Electrification". In: Saunier. G. (eds.) *Rural Electrification Guidebook for Asia and the Pacific*. Bangkok, p. 3.
[10] Figures from correspondence with Daniel Waddle, Executive Director, NRECA-Bolivia, April 1995.

rural electrification network has thus been a fairly slow process in the industrialised world, despite of the fact that these countries have maintained a relatively high average economic growth rate since the second world war. [11]

## 2.2 Rural electrification systems based on local management

Many industrialised countries that have electrified most of the rural areas have, at least to some extent, relied on local management in rural power distribution activities. The main reasons have been both policies promoting local engagement and the simple fact that lack of centrally provided power calls for action from those living in a remote place and wanting to join the industrialisation process of their country.

In the United States, rural electrification co-operatives have been promoted since the mid-1930s. Over the years, they have become more than mere power suppliers to their communities: Today, according to NRECA, they also "...provide the leadership and the technical and managerial expertise and help find the financial resources necessary to address issues affecting the quality of life in their service area".[12]

After the First World War, German farmers' co-operative societies for supplying electricity experienced a remarkable growth. It was claimed that as against municipal ownership, co-operative power generation and distribution was "...made possible a more equitable distribution of burdens and has facilitated financing operations".[13]

Sweden is today a developed country, which has electrified in principle 100% of the rural areas of the country. Rural electrification efforts were initiated in the beginning of this century, when the country still was relatively poor and undeveloped. To get access to electricity smoothly and promptly, (either from the main grid or for example an isolated hydro plant), small electric consumers associations were formed in the early century to manage the distribution and sometimes generation of electricity in the rural areas. By and large, the associations contributed substantially to the initial rural electrification. Between the two world wars, the rural distribution of state power generated by the *Vattenfall* [14] was almost entirely through co-operative societies made up from the consumers themselves. After the second world war, most of the associations ceased to exist, after which the power distribution was taken over by a large power utility, such as *Vattenfall* or *Sydkraft*. Some of the associations have survived until today. There are also some examples of newly established electricity associations.[15]

The situation of developing countries differs from that of the industrial nations during electrification, mainly because they rely on international and/or foreign development policies to a much higher degree. As described above, their existing power supply systems are usually not, or only to a small extent,

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[11] Saunier, G., Mohanty, B. p. 3.
[12] Bergland, B. 1993. *Agenda for Rural America- a Summary of Panel Reports from NRECA's 1993 Regional Meetings*, NRECA p. 1.
[13] NRECA. *Report of the Federal Trade Commission and Cooperation in Foreign Countries* (Senate Document no. 171) In: Rall , U (NRECA), *Cooperative Consumer Association for Rural Electrification*, 1937, p. 3.
[14] *Vattenfall* (Board of Waterfalls) is a public utility which today owns most of the main grid and generates about 50% of the electricity in Sweden. It either distributes the electric energy or sells it to the electric distribution companies, which in turn distributes it to the consumers.
[15] One example of a surviving Swedish electricity associations is *Jukkasjärvi belysningsförening*. The study team visited the association in October 1994. There are also some recently established electricity associations which generate their own electricity from wind energy, for example *Grästorps Energi* and *Göteborgs Vind No.1*.

financially viable with the present layout, and an expansion to less income generating sectors would deteriorate the situation. However, many governments in developing countries have tried out innovative approaches to the organisation and management of rural power distribution as a means to lessen costs in the new service area. It is also envisaged that with these new approaches, positive outcomes of electrification, i.e. enhanced living standards, improved health care, more efficient industry etc., would develop more rapidly. A common and often successful initiative, has been to encourage local community organisations to manage their own electricity distribution system. In remote areas, where the grid is not extended, local people has also been committed to the power generation.

The co-operative organisation is perhaps the most common form for the local management of decentralised electricity systems in developing countries. Rural electrification co-operatives have been promoted with varying success in different parts of the world. National Rural Electric Co-operative Association, NRECA, has been the most active agency promoting this approach internationally.

In 1964, the United States Agency for International Development (USAID) approved the world's first international loan for co-operative rural electrification (Colombia), soon to be followed by similar programmes in Nicaragua, Ecuador and Costa Rica. Funds were authorised for development of co-operatives that would eventually distribute electricity to more than 25,000 farms, rural homes, businesses and industries [16]. NRECA, being the implementing body for those programmes has since launched similar programmes in many other countries, in particular in Asia and South America. NRECA has also been involved in the planning of rural electrification programmes in several countries, including African countries.

In Bolivia, the co-operative approach has been adopted for rural electrification and the co-operation with NRECA has been close. Prior to the 1960's, when rural electrification programmes were launched, no significant efforts had been made to electrify rural areas. The current number of Bolivian rural electrification co-operatives is approximately 120. However, privatisation tendencies that affect Bolivia as well as other South American countries have put the co-operatives in a difficult position and their transition into branches of private distribution companies have started in parts of the country.

India has had traditionally strong rural electrification policies. Even though NRECA has been involved in the rural electrification planning, the implementation has been governed by the Indian REC, while NRECA's ideas have been only moderately applied. Since 1969, the financial support to the 37 rural electrification co-operatives in India amounts to only 1% of the agency's total costs, thereby indicating the modest scale of activities. Apart from co-operatives there are few organisational forms of locally managed power supply investigated in India, although present Indian government plans for rural electrification policies include the opening up for private initiatives on the power supply market.

Of the three countries studied in this project, Nepal is the poorest. The rural electrification activities in the country have to a large extent relied on international aid. Besides grid based power supply, which is the only option for the majority of rural consumers, there are numerous mini- and micro-hydro power plants in the country. Shaft power for milling has been harnessed from water falls in Nepal for

[16] Ross, J. E. 1972. *Cooperative Rural Electrification: Case Studies of Pilot Projects in Latin America*, Praeger Publishers, 1972.

ages. Small locally produced turbines have been used for power generation (sufficient only for the immediate surroundings) since 1984, when the private sector was allowed to generate and sell electricity. Bilateral aid organisations [17] have developed rural power supply systems based on modern micro-hydro plants in selected parts of the country. These systems have generally contributed to social and economic development in the area and often involved the local population in one way or another. Organisational models include:

- a locally dominated shareholder company generating and distributing its own power;
- Village Electrification Committees caring for their own generation and distribution of power as part of a nature conservation project in the unique Himalayan massif; and
- Users' Organisations purchasing power from a larger company nearby.

Present national plans for rural electrification, largely based on experiences from the established modern micro-hydro programmes, include local participation and management. In addition, they allow private initiatives to rural power supply even at the smallest scale. Probably, NRECA which formulated a 'ten year plan' for Nepal in 1991, will play a role in future rural electrification programmes in the country.

[17] SKAT, ITDG, GATE (GTZ), FAKT (GTZ), UMN & others.

# 3 SUMMARY OF FINDINGS FROM THE CASE STUDIES

## 3.1 Brief presentation of the power systems visited by the study team

The three countries and eight local organisations visited are listed in table 1.

**Table 1. Names and features of the local electricity consumers' organisations**

| Country | Abbreviation | Full name | Type of Organisation |
|---|---|---|---|
| **Bolivia** | CEY | Cooperativa Eléctrica Yungas | Electricity co-operative purchasing power in bulk. |
| | CEM | Cooperativa Eléctrica de Mizque | Electricity co-operative generating own power. |
| | CSEC | Cooperativa de Servicios Eléctricos Capinota Limitada | Electricity co-operative purchasing power in bulk. |
| | CRE | Cooperativa Rural de Electrificación | Electricity co-operative purchasing Limitada power in bulk for the main system and generating own power in two decentralised systems. |
| **India** | CESS | Co-operative Electric Supply Society | Electricity co-operative, purchasing power in bulk. |
| **Nepal** | AUO* | Aserdi Users' Organisation | Electricity consumers association, purchasing power in bulk. |
| | GVEC | Ghandruk Village | Electricity consumers association, Electrification Committee generating own power. |
| | SCECO | Salleri Chialsa Electricity Company | Shareholder company, generating own power. |

* For the sake of simplicity, here referred to as AUO.

The eight local electricity consumers organisations for management of power supply vary in size: the smallest is *Aserdi Users Organisation* (AUO) in Nepal which represents 150 consumers and the largest is *Cooperativa Rural de Electrificación Limitada* (CRE) in Santa Cruz, Bolivia with a total of 165,000 members.

The average energy consumption of residential consumers [18] in the systems ranges between less than 10 kWh/month, which accounts for *Cooperativa de Servicios Eléctricos Capinota Limitada* (CSEC), and 78 kWh/month in Santa Cruz.

Five of the visited organisations are connected to the national grid: CEY, AUC, CESS, CSEC and CRE. However, CRE also generates power locally. Of the other three, *Ghandruk Village Electrification Committee* (GVEC) and *Salleri Chialsa Electricity Company* (SCECO) relies on hydro power plants, and *Cooperativa Eléctrica de Mizque* (CEM) on diesel.

Their internal tariff structure vary, depending on what type of electricity uses there are, and if the energy is metered or charged for at a permitted maximum power out-take. For a residential consumer, the cost per energy unit ranges

[18] Referring to rural consumers in cases where there are both rural and urban consumers.

between less than USD 0.01 /kWh for some of the rural consumers in the Indian co-operative CESS, and USD 0.26/kWh in the co-operatives in Mizque and Capinota in Bolivia.

Investment per consumer in the concerned power supply systems ranges between USD 207 and USD 650 for those who buy power in bulk, and between USD 277 and USD 1,111 for those who generate their own power.

Table 2 summarises some data from the different organisations. Chapter 3.3.2. discusses the role of local participation in the power systems while chapter 3.3.3. brings up the role of external assistance, both from within the respective country and from abroad. Tariff setting and the financial soundness within the local organisation is discussed in chapter 3.3.4.

**Table 2. Summary of data from the eight visited organisations**

| | BOLIVIA | | | | INDIA | NEPAL | | |
|---|---|---|---|---|---|---|---|---|
| GNP per capita (USD) | 670 | | | | 310 | 170 | | |
| Proportion of rural house-holds with access to electricity | 16 % | | | | 23% | 1% | | |
| **Organisation** | CEY | CEM | CSEC | CRE | CESS | AUO | GVEC | SCECO |
| No. of consumers | 5,600[1] | 262[2] | 1,600 | 161,000 (4,500)[3] | 50,000 | 158 | 253 | 4,000 |
| Power from | Grid | Diesel sets | Grid | Grid (+gas)[4] | Grid | Grid | Micro Hydro | Micro Hydro |
| Installed generating capacity (kW) | - | 182 | - | (6,140)[4] | - | - | 50 | 400 |
| Contracted bulky power (kVA) | on request (max 2,500) | - | 500 | on request | on request | - | - | - |
| Total investment (USD) | 2,011,000[5] | 400,000[6] | 300,000[7] | 83,400,000[8] (3,450,000)[9] | * | 31,000[10] | 70,000 | 2,500,000-4,150,000[11] |
| Total investment (USD/consumer) | 360 | 1,111[12] | 650[13] | 518 (765)[14] | * | 207 | 277 | 625[15] |
| Total investment USD /$kW_{installed\ cap.}$ | - | 2,198 | - | (562) | - | - | 1,400 | 6,250 |
| Domestic consumers energy price (USD/kWh) | 0.08 | 0.26 | 0.26 | urban=0.05 rural =0.15 | 0.15[16] | 0.03[17] | 0.03[18] | 0.06[19] |
| Power supply (hrs/day) | 24 | 4 | 4 | 24 | 24 | 24 | 24 | 24 |
| Peak demand (kW) | 1,722 kVA (Dec-93) | 65 (Nov. -93) | 120 | 146,000 (5,300)[20] | 120 | 28 | 50 | 250 (Jan.-94) |
| Average load factor (%) | 37 % (May -95) | 40% | 40% | urban=60% rural=50% | * | 82% | 50 % | 43 % |

| | BOLIVIA | | | | INDIA | NEPAL | | |
|---|---|---|---|---|---|---|---|---|
| GNP per capita (USD) | 670 | | | | 310 | 170 | | |
| Proportion of rural house-holds with access to electricity | 16 % | | | | 23% | 1% | | |
| **Organisation** | **CEY** | **CEM** | **CSEC** | **CRE** | **CESS** | **AUO** | **GVEC** | **SCECO** |
| No. of consumers | 5,600[1] | 262[2] | 1,600 | 161,000<br>(4,500)[3] | 50,000 | 158 | 253 | 4,000 |
| Power from | Grid | Diesel sets | Grid | Grid (+gas)[4] | Grid | Grid | Micro Hydro | Micro Hydro |
| Installed generating capacity (kW) | - | 182 | - | (6,140)[4] | - | - | 50 | 400 |
| Contracted bulky power (kVA) | on request<br>(max 2,500) | - | 500 | on request | on request | - | - | - |
| Total investment (USD) | 2,011,000[5] | 400,000[6] | 300,000[7] | 83,400,000[8]<br>(3,450,000)[9] | * | 31,000[10] | 70,000 | 2,500,000-<br>4,150,000[11] |
| Total investment (USD/consumer) | 360 | 1,111[12] | 650[13] | 518<br>(765)[14] | * | 207 | 277 | 625[15] |
| Total investment USD /$kW_{installed\ cap.}$ | - | 2,198 | - | (562) | - | - | 1,400 | 6,250 |
| Domestic consumers energy price (USD/kWh) | 0.08 | 0.26 | 0.26 | urban=0.05<br>rural =0.15 | 0.15[16] | 0.03[17] | 0.03[18] | 0.06[19] |
| Average domestic consumption (kWh/month) | 44.5 | 8.5<br>(Mid-93) | 18 | urban=212<br>rural=78[21] | * | 45 | (63)<br>lodges included | Level 1= 27<br>Level 2=123<br>Level 3= 127 |

[1] 4,800 active and 800 passive (May 1995).

[2] Data from November 1993, three months before the rural electrification cooperative ceased to exist.

[3] Number of consumers in the Valles Cruceños system.
[4] Gas power plants, 4,400 kW in Camiri, 1,740 kW in Mataral.
[5] Costs for transmission and distribution network.
[6] The estimated initial investment cost was USD 400,000. When including recent investments under ELFEC´s responsibility the figure is USD 1,300,000. (Interview with Mr. F.G. Chopitea, ELFEC).
[7] The estimated initial investment cost was USD 300,000. When including recent investments under ELFEC´s responsibility the figure is USD 1,200,000. (Interview with Mr. F.G. Chopitea, ELFEC).
[8] Investments in Santa Cruz integrated system, and for distribution only since generation is provided by the state utility. (12/31/1994).
[9] Investments in the Valles Cruceños system: 2,081,000 for generation and 1,398,000 for distribution. (12/31/1994).
[10] Cost for distribution network to Asedri (Phoksingkot excluded).
[11] 2,500,000 is a rough calculation on previous investment costs. 4,150,000 USD includes recent investments for future extension, resulting in a present investment per consumer at approximately 1,000 USD.
[12] Based on the 360 consumers that the cooperative had in mid 1993.
[13] Based on the app. 460 consumers the cooperative had 5 years after its start (Interview with Mr. F.G. Chopitea, ELFEC).
[14] Cost per consumer in the isolated systems.
[15] Based on USD 2,500,000 investment.
[16] For consumers with a maximum peak load of 2 kW.
[17] Subscribed power (W)/ cost per month (USD)/fraction of consumers in category: 25/0.40/13.5%; 50/0.80/73%; 250/2.20/13.5%. Average system load factor: 82%. Result in average cost per kWh: 0.027 USD.
[18] Cost per installed Watt/month: 0.01 USD, average system load factor: 50%. Results in an average energy unit cost of 0.027 USD/kWh.
[19] Subscribed power (W)/ cost per month (USD)/average consumption in category (kWh/month)/ fraction of consumers in category: 100/1.4/27/ 56%; 500/5/123/30%; 2,000/6/127/14%. Result in average cost per kWh: 0.060 USD.
[20] Peak load in the Valles Cruceños system.
[21] The average consumption in Valles Cruzeños is 39kWh/month, improving from 34 kWh/month in 1994.
* Data missing.

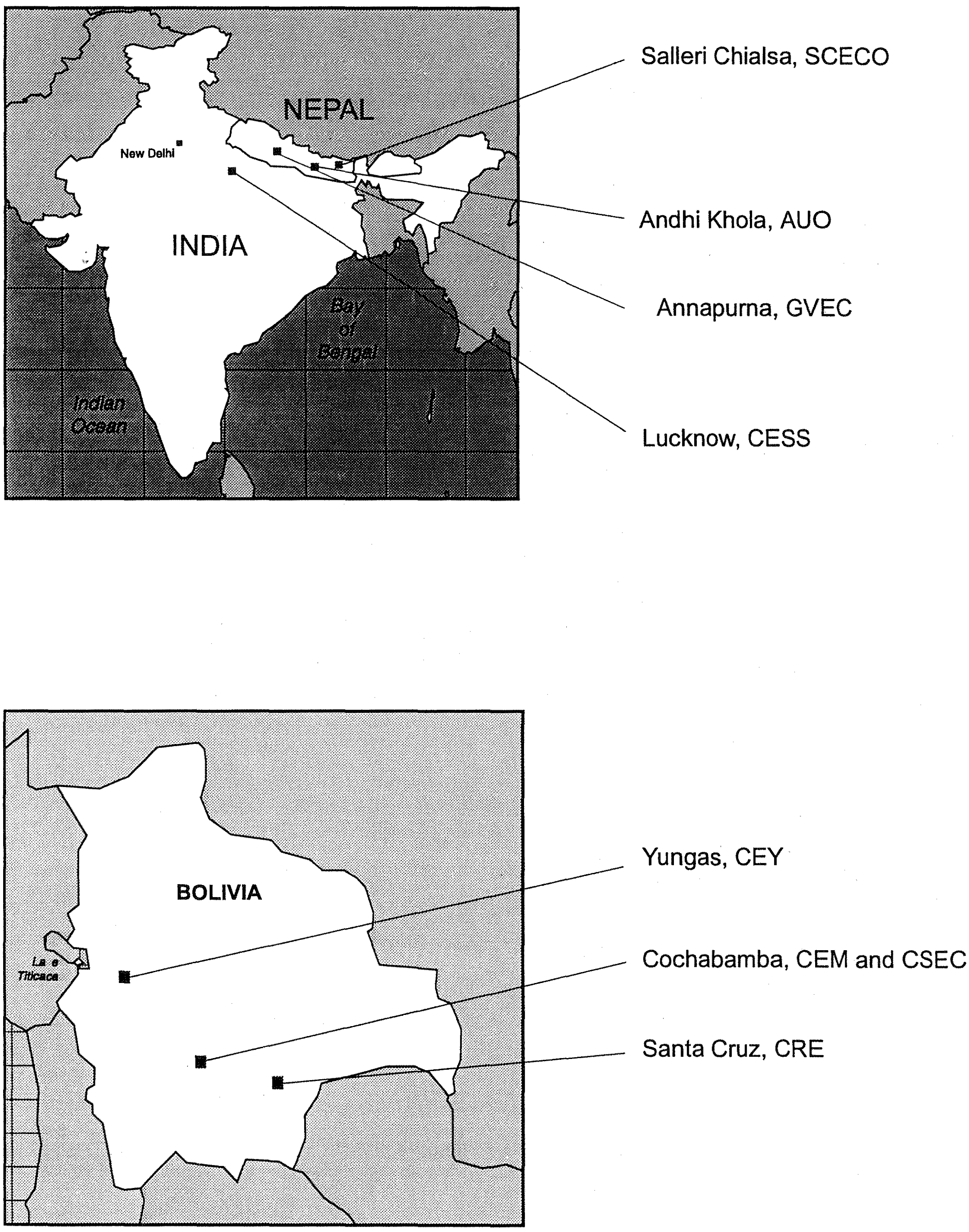


**Figure 1. The approximate location of the eight organisations.**

### 3.2 The role of local participation

Local participation may save the state utility, a large private company, or an aid organisation, some efforts and funds in their attempts to electrify remote areas of the country. When being made aware and involved, local farmers and property owners can facilitate the implementation of the project, for example by ensuring that roads are accessible for transport and land for substation plots. This is true for rural electrification projects in general, while this study particularly highlights what *organised* local participation may contribute. Each of the eight organisations exemplifies how their organised involvement have facilitated and/or enhanced the electrification of their area.

In the construction period, the local people can contribute labour and local material. Communities with a healthy economy may afford to contribute funds to the construction of the system. However, in developing countries, the financial support from the local community is generally low.

During the operation phase, activities such as meter reading, bill distribution and collection and general maintenance of the system are often successfully managed by the local people. Table 3 below lists the operation, maintenance and administration (OMA) costs for the different power supply systems. The systems have different preconditions and they also sort and enter up costs in different ways. Notwithstanding the discrepancies, comparing the costs gives a rough picture of how cost-efficient their operation and management is. Three tendencies appear:

- OMA costs are higher in rural areas than in urban areas for utilities covering both areas, e.g. CEY and COBEE;
- locally managed rural power systems accept having higher OMA costs than centrally managed rural power systems; and
- sometimes locally managed power systems manage to run their systems at lower OMA costs than the government. This is particularly true for the isolated hydro schemes (Nepal).

In addition to savings in commissioning, operation and maintenance, an intense interest from the local people in electrifying their area, may indicate that the pace of load development will gain momentum once electricity is accessible. This lowers the risk for poor dividends from the new branch. Another possible dimension brought about from the commitment of local people is its compatibility with an increased utilisation of domestic energy and material resources.

#### *3.2.1 Bolivia*

Bolivian electricity systems on the whole are built up in accordance with US standards. This also holds for systems run by co-operatives, in which the role of the local people is to manage an imported technology, rather than to contribute to developing indigenous technologies. In the CEY co-operative in Yungas, which purchases power from ENDE in La Paz, the co-operative members participate in the annual maintenance work, such as clearing of trees that grow along the lines, digging of ditches and maintenance of poles.

The local population also participated in erecting the transmission line. CEY is responsible for meter reading and billing in the system, as well as for connecting and disconnecting consumers. A computerised system is used for billing. The CEY co-operative is an important organisation for the area, not only in terms of management of power distribution, but also in terms of acting as a conflict-solving mechanism for all kinds of social problems in the community.

Locally managed power supply systems in the Cochabamba region of Bolivia have never boomed. The Mizque co-operative relied on its own diesel generating sets for several decades, but is now awaiting grid connection. The co-operative will then cease to exist. Up to 1994, responsibilities for the co-operative basically included engines' operation, meter reading and billing. The Mizque co-operative suffered from its members neither paying their connection fees nor electricity bills. Both reliability of service and co-operative management have been critical issues in Mizque. By and large, the co-operative has not been successful, the reason why most of the consumers welcome ELFEC's taking over.

Similar to the Mizque power system, the Capinota power system relied on a co-operative for its management for nearly three decades. The Capinota system, though, has always been grid connected. Initially, the co-operative experienced some fairly prosperous years, but similar to Mizque, the prevalent technical and managerial problems led to its giving up. Power services will now be taken over by ELFEC in Capinota as well. However, the Capinota co-operative will resume and focus on other community issues such as water supply. Apparently, the self-management model did not come out very successfully in these areas. However, the fact that local people have had access to electricity and thus created a demand for it, most likely plays an important role in ELFEC's decision to take over, rehabilitate and expand the systems. From the point of view of a power utility, it is more secure to invest in an area where there is a proven load than in an area without any load.

CRE in Santa Cruz, Bolivia, is an expanding and profit making co-operative with more than 160,000 members and 420 employees. The bulk of power is bought from ENDE, although some is generated locally. Notwithstanding its large scale, CRE exemplifies a locally managed power supply system, which clearly has generated industrial activities and social development in the area. With its local anchorage, CRE also actively runs the system so as to utilise and develop local human, material and energy resources in the most favourable way. CRE runs two gas-fired power plants harnessing Bolivian natural gas. Their total installed generating capacity amounts to 6,140 kW. Other projects of theirs include the introduction of 91 imported photo-voltaic (PV) panels and the implementation of wind turbines (1.5 MW) for demonstration and research purposes. Today, the PV system provides electricity to 100 households and, according to plans, another 1,300 panels will be purchased. Together with NRECA, CRE runs a handful of development projects in Santa Cruz aiming at enhancing service and promoting use of electricity. The electrification co-operative in Santa Cruz has also participated in other regional development programmes.

### *3.2.1.1 Operation, Maintenance and Administration costs*

COBEE, the Bolivian private shareholder company operating in La Paz and Oruro, does not expand into areas potentially becoming a financial burden to the company. One of these non-prioritised areas is the Yungas, where CEY operates. Operation expenses amounts to USD 0.039/$kWh_{sold}$ [19] in COBEE's entire system, to a large extent covering urban loads, while in the CEY system comparable costs are only USD 0.052/$kWh_{sold}$. CEY operates at a higher cost, largely because of the scattered and mountainous service area.

ELFEC, a semi-government company, has both rural and urban consumers in the Cochabamba region. For the rural consumers, the OMA cost is USD 0.12/$kWh_{sold}$ [20]. The Mizque co-operative, also in the Cochabamba region, had a comparable cost at USD 0.04/$kWh_{sold}$ [21]. However, CEM, the co-operative in Mizque is far from financially viable and to argue that its activities are more cost-efficient than ELFEC's would be misleading.

**Table 3. Total cost of operation, maintenance and administration per unit energy sold in different systems**

| System | | USD/$kWh_{sold}$ |
|---|---|---|
| **Bolivia** | | |
| | COBEE | 0.039 |
| | CEY | 0.052 |
| | ELFEC (rural) | 0.12 |
| | ELFEC (urban) | 0.054 |
| | CEM | 0.04 |
| | CSEC | - |
| | CRE (integrated S:a Cruz system) | 0.038 |
| | CRE (Valles Cruceños) | 0.11 |
| **India** | | |
| | CESS | - |
| **Nepal** | | |
| | NEA | 0.020 |
| | AUO | 0.018 |
| | GVEC | 0.013 |
| | SCECO | 0.027 |

CRE is the sole actor in this field in Santa Cruz and its operation and management costs cannot be compared to any larger company in the adjacent area. The figures indicate though, that it is inexpensive for CRE to operate in remote rural areas than in town, something which is unsurprising. It may also be interesting to note, that both ELFEC-urban and COBEE have higher expenses for operation and maintenance than CRE-urban.

NEA serves both urban and rural consumers, although the urban sector dominates. Their operation and maintenance expenditures total USD 0.020/kWh. NEA's figure for OMA costs in rural areas is not separately reported in their annual report. However, it is most likely higher than the average USD 0.020/kWh. The three rural distribution systems listed in table 3.1, Aserdi UO, Ghandruk VEC, and SCECO all have local management. AUO and GVEC have lower OMA costs than USD 0.020/kWh, and SCECO has higher.

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19 COBEE Annual Report 1994, p. 15: O&M expenses, USD 34,805,000; p. 8: total sales, 888,539,000 kWh.
20 ELFEC sold 19,902,689 kWh to its rural consumers in 1993 and had a total operation, maintenance and administrative cost of 11,409,752 Bs for the same category (*ELFEC Memoria Annual 1993, Cuadrado 4-1&4-2, and p. 20*). Urban: 271,389,799 kWh & 69,276,373 Bs.
21 In February 1993, the co-operative in Mizque sold 4167 kWh at an operation, maintenance and administrative cost of 804 Bs (Co-operative internal book keeping ).

### 3.2.2 India

The Government of India has formulated a number of goals for rural electrification co-operatives in the country. Apart from providing reliable electricity services and extending the network in their area, co-operatives are requested to support the comprehensive development programmes of the region and assure local participation. Compiled statistics [22] from Indian rural electrification schemes based on co-operatives reveal that these have generally reached a higher degree of electrification in the respective areas and that the service provided is generally better compared to areas without local participation. 34 of the 37 rural electrification co-operatives have already reached 100 % of their respective areas, whereas the level of household electrification in the society areas is over 50% ranging between 25% in the new societies to over 97%. This may be compared with rural household electrification in SEB areas where it is about 27% only [23].

The CESS co-operative in Lucknow basically manages the entire power system, including line extensions, technical maintenance, connections and disconnections, meter reading and billing. In terms of quality of service and financial soundness, the co-operative manages well, much thanks to several years of on-the-job training. Similar to the Bolivian examples, CESS has for their power system employed standards valid in other parts of the country as well.

### 3.2.3 Nepal

All the three organisations considered in Nepal have sought to keep investment costs low in the system as well as to level out loads over the day in order to reach a higher load factor in the system. Approaches and technologies applied for fulfilling these endeavours include: simple ready-made boards as a supplement to traditional house-wiring; load limiting circuit breakers combined with power based tariffs instead of installing meters and employing meter readers; higher tariffs during peak hours; low-wattage cooking devices that helps retaining a high load factor even in areas with mainly residential loads; and in the case of the AUO, a special distribution system - slightly cheaper than the conventional and much lighter to carry up hills by foot. Operation and maintenance costs in the locally managed systems are generally low [24] compared to NEA's, the state utility, which operates in both urban and rural areas,

Reduced investments in micro-hydro power plants due to local contributions are hard to determine since project costs differ between sites. However, in an attempt to identify possible savings, comparisons can be made with data of schemes in the adjacent area. According to *International Centre for Integrated Mountain Development* (ICIMOD) [25], capital costs per kilowatt installed for hydropower in Asian/Pacific countries ranges between USD 1,000 and USD 8,000. The span for Nepal, given by the same authors, is USD 2,300 - USD 7,000. These capital costs refer to the power plant per se. Two of the sites, which are subject to this study, Ghandruk and Salleri Chialsa in Nepal, rely on hydro power. Their investments per kW installed are USD 1,400 and USD 6,250 respectively,

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[22] Rural Electrification Corporation.1994. *Background Material - Workshop on Decentralised Power Distribution Systems Under the Auspices of Ministry of Power, Government of India.* (unpublished report). New Delhi, 1994.
[23] Ibid.
[24] Note that the O&M costs for NEA include both urban and rural loads. There are no figures to prove that O&M in rural service areas are costlier than in the urban areas, but as this is generally the case, we assume it being valid for NEA as well.
[25] Aitken, J.M., Cromwell, G., Wishart, G. 1991. *Mini and Micro-Hydro Power in Nepal*, ICIMOD, Kathmandu.

including distribution network [26]. The comparison indicates that the investments of the local organisations are comparable to other schemes in the area, but that the plant in Ghandruk required relatively low investments. The Salleri Chialsa region is extremely inaccessible, even from a Nepalese perspective, wherefore costs for commissioning and implementing a power plant naturally becomes high. According to the Swiss designer[27], costs for commissioning and implementation of the Salleri Chialsa scheme would have been lower had the system been built in one go. Part of the costs is set aside for the thorough follow-up at each step, thereby enabling the recipients to accept the project in general, and the company's policy, the institutional and technical set-up etc. in particular.

Butwal Power Company Limited (BPC), is a public power utility operating and managing hydroelectric power projects and associated electricity distribution systems. BPC is the owner of the power system in the *Andhi Khola Hydel Rural Electrification Project* (AHREP). For distribution to the rural areas BPC relies on User's Organisations, one existing in the already connected Aserdi area and one coming in the Phoksingkot area which is not yet connected. BPC does not deal with individual consumers in these areas. User's Organisations (UO's) serve mainly through: gathering and submitting applications for connections to BPC; organising contribution of local materials, for Aserdi most notably wooden poles and labour; collecting periodic bills and fees from consumers; assuming responsibility for routine control and maintenance of the distribution system within the UO's area; and serving as a communications link between the community and BPC.

Aserdi village was selected because of its relative proximity to the Andhi Khola power plant, the enthusiasm of the villagers and their willingness to contribute labour and poles to get electricity in their village. For the Aserdi project, it is assumed that the contribution from villagers accounts for approximately 9% of the total project cost (15% of labour, 6% of material costs). [28] In the Phoksingkot area, people will also contribute money as a large group of retired soldiers who have relatively high incomes from pensions happen to live in the area.

The Annapurna region of the Nepalese Himalayas is visited by approximately 45,000 people per year, the majority being tourists enjoying unique nature, and their porters. The number is close to that of indigenous residents. *Annapurna Conservation Area Project* (ACAP) is a fully Nepalese organisation that has emanated from identified needs to minimising the stress on natural resources and wildlife in the area. One of the project's five sub-programmes is the *Alternative Energy Programme* (AEP), which promotes a cost effective and environmentally sound development of energy use in the area. In Ghandruk, an Electrification Management Committee consisting of 17 people cares for 253 consumers power supply by running a micro-hydro power plant, distributing power and billing consumers. There are three employed operators who work on shift. Continuous maintenance of the Ghandruk power plant includes: operation of the power plant; reparation of the head race canal after floods; maintenance of pipelines; maintenance of the power house; and purchase of spare-parts. Generally speaking, all these activities are successfully carried out by the Management Committee alone, and very few technical incidents have occurred where outside

[26] Salleri Chialsa power plant only, required an investment of approximately USD 4,700/kW. (See further footnote 28).
[27] Neuhaus, M. 1994. *Water Power & Dam Construction: Salleri Chialsa Project.* ITECO.
[28] Inversin, A. 1995. *New Designs For Rural Electrification*, NRECA.

expertise have been required. The committee also supervises the distribution and billing of power and arranges regular meetings. Attendence at the meetings is compulsory for all members/consumers. Furthermore, proper use of adopted technologies, as well as productive uses of electricity are promoted by the Management Committee. Grass-root strategy is the backbone of ACAP, wherefore Ghandruk villagers have been involved in both commissioning and implementation of the plant. In addition, they currently plan for the systems expansion together with technical assistants.

SCECO in Nepal is set up as a shareholder company. Eight local people, two of which handle the administration, has committed the challenging task of running the power company providing service to about 4,000 consumers. To facilitate this work, modern office tools have been introduced, such as personal computers, photo-copiers and telecommunication equipment. In addition to their commitment, ad hoc committees have been nominated by the community, representing each supply area. Although these committees are of no legal relevance within the shareholder company, they play an important role when new ideas are tried out, or new appliances and modes of electricity utilisation are introduced. Power system design in Salleri Chialsa is founded on Swiss engineering, but has been developed to suit the local conditions. Local people were involved in the commissioning of the power plant in Salleri Chialsa, although SCECO was not formed until later.

## 3.3 The role of external assistance

Although local participation and responsibility have shown positive results in many countries, it is important not to over-estimate the local managerial capacity in the initial phase of implementing rural electrification projects. To achieve proper local management and self-reliance, technical and institutional support and training is almost always required during the first years. The needs may differ from case to case and each country, or even region, must find an appropriate approach to develop and strengthen the capacity of the local people to enable them to manage their electricity system.

It is evident that financial support to local initiatives in developing countries is required. The investment required for establishing a power system can be very high, and cannot be borne by local people alone. National and/or international interest in the general development of the area therefore plays a crucial role in this regard. First of all, financial support for the implementation must be assured. To help financing the system, the government can for example provide soft loans, grants and/or set up revolving funds. In most developing countries, international aid organisations have contributed substantially to the implementation of rural electrification projects. Many of them, like USAID and NRECA, have served as mainstays on a long-term basis for locally managed distribution systems.

### *3.3.1 Bolivia*

Bolivia is a country where NRECA is actively involved in rural electrification activities. NRECA returned to Bolivia in 1991, after 12 years of absence in the country. [29] The break in its aid programme clearly had implications on the day-to

[29] According to NRECA/Bolivia, the reasons for withdrawal in the end of the 1970s were of political nature.

day events in the Bolivian electrification co-operatives. Withdrawn assistance in combination with unclear signals from the Bolivian government resulted in many of the rural electrification co-operatives losing their grip on their activities (compare Mizque and Capinota). To date, USAID runs an Electrification for Sustainable Development (ESD) programme budgeted to USD 20 million for a five-year period. After 1996, NRECA will most likely continue supporting rural electrification in Bolivia. Activities include assistance to ELFEC for their restoration of the Mizque and Capinota systems, where NRECA contributes 80% of the project costs.

Currently, the NRECA staff is discussing a follow-on project with the Bolivian Government. NRECA has also formed a Bolivian foundation that it will support to carry out the work NRECA has initiated in the country. According to the Director of NRECA/Bolivia, the success or failure of the foundation will depend upon how much support NRECA provides it, and the dynamics of the counterparts who will form the Board of Directors of the foundation.

NRECA runs rural development projects together with CRE. One such project is the Creagro-shop in the Valles Cruceños. The locally run shop provides electric appliances and equipment to the neighbourhood and promotes increased uses of electricity in general and productive uses in particular.

The CEY co-operative is situated in the Yungas, one of the prime coca-producing regions in Bolivia. No support is provided the co-operative, partly due to USAID's and NRECA's restrictive aid policy towards coca-producing regions in the country.

Other international donor agencies involved in rural electrification in Bolivia are the Dutch agency Directorate General for International Co-operation and the German Technology Co-operation (GTZ).

### *3.3.2 India*

The co-operative in Lucknow, India obtains external assistance mainly from the Uttar Pradesh State Electricity Board. The amount of international aid money that has been channelled to the project is not specified, but the co-operative was initiated by the US organisation NRECA. NRECA also had expertise visiting Lucknow during the co-operative formation. However, there is no precise information about to what extent they were engaged in the process. SEB's role is probably of vital importance to CESS. Amongst the employees though, an irritation could be sensed, regarding the top-down formation of the co-operative. Powerful politicians interfering with the day-to-day work of the co-operative has led to difficulties in involving local members in its activities. As a result there has been poor attendance at general meetings for example.

### *3.3.3 Nepal*

AHREP was established by the United Mission to Nepal (UMN), a Christian Protestant aid organisation, as part of a wider project for general development of the Andhi Khola area. UMN's activities in the Andhi Khola region were launched in the 1960's. UMN promotes an import substitution policy, and has helped to create a number of Nepalese institutions that utilises indigenous human and natural resources, one of which is BPC. A 5 MW hydro power plant was commissioned in the area in the 1980's, with turbines provided from Norway.

While the hydro-power plant in Andhi Khola is economically feasible, the viability of the rural electrification component of the project has been more difficult to establish. In this context, UMN has supported numerous activities in Aserdi and Phoksingkot areas, which aim to reduce costs sufficiently so that people can afford to purchase power from the system. Another aim is that revenues should cover O&M costs, and still allow for reinvestment. The significance of external aid in this rural electrification project is comprehensive, and can be reflected in UMN's ongoing activities in the area: technology transfer, technology development, promotion of ideas and general information about electricity and its possible contributions to the general development of the area.

For construction of the electricity system in Ghandruk, 70% of costs were provided from external donors.[30] Apart from financial support, the Electrification Management Committee in Ghandruk has enjoyed ACAP's close co-operation with ITDG-Nepal in terms of technical back-stopping. The initial education of local managers was carried out by ACAP in Butwal.

The Salleri Electricity Utilisation Project (SELUP) dates back to 1960 when the Swiss Government decided to support Tibetan refugees in the area. Between 1982 and 1986, a small power plant was finally built in Salleri Chialsa, following many phases of preparations and negotiations. Since then, the overall expenditure for all project activities amounts to approximately USD 9.5 million. The specific costs of the power plant itself is approximately USD 1.9 million, of which the Swiss Development Co-operation, SDC-Nepal, has contributed the major part. Most of this support was provided during the construction phase 1984-1985. In 1989, SCECO, the only power producing company with a sizeable local share holding in Nepal, was formed in Salleri Chialsa. SCECO is a product of drawn out negotiations between the Swiss and Nepalese Governments and pioneers the concept of locally managed power supply systems based on shareholder companies in Nepal. During the last years, SDC has spent about USD 88,000 per year on follow-up and technical assistance.[31] Apart from financial support, the Swiss organisations have provided technical and managerial assistance. The Swiss *Company for International Technical Co-operation and Development* (ITECO) designed the power system to suit local conditions. During commission, training courses for local power system staff were organised as well as training sessions on 'small businesses' for potential local entrepreneurs.

### 3.4 Tariff setting and financial soundness

Given the prevailing political view in most developing countries of rural electrification being a matter of equity, private market and free pricing of electricity is commonly not accepted - although privatisation is increasing the Government supervises the tariff in the self reliant systems and adjusts it in accordance with tariffs in the national power supply system. This becomes a dilemma for the self reliant system as their total cost for delivering one unit energy in most cases is higher than what can be covered by tariffs recommended by the government.

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[30] World Wildlife Fund - USA, the King Mahendra UK Trust, the German Alpine Club, Canadian International Development Agency, Intermediate Technology Development Group, USAID, Brittish Embassy, Asian Development Bank, etc.

[31] Interview with Martin Neuhaus, Head of Division Energy and Water, ITECO, Switzerland.

### *3.4.1 Bolivia*

Tariff setting in Bolivian electrification co-operatives normally allows for the systems monthly running costs to be covered, but seldom admits repayment of loans or funding for future maintenance or replacement costs. Until the beginning of 1995, the Bolivian Electricity Law restricted the annual profit of power utilities, including co-operatives, to a maximum 9% of the annual investments. For many smaller electric co-operatives that did not have continuous development costs, the limit prevented them from setting aside money for investments that would be needed every fifth year or so [32]. Domestic tariffs in larger rural systems are typically in the range of USD 0.06/kWh [33], taxes excluded. Three out of four visited co-operatives have residential tariffs corresponding to USD 0.25 /kWh and therefore cannot cover the costs. Although other factors contribute, figures clearly imply that self-reliant, rural power supply systems in Bolivia cannot set tariffs as low as is done by the larger utilities who can subsidise their rural consumers. Not even the current, centrally adjusted tariffs cover capital costs in the rural co-operatives, which is the reason why most of them will face difficulties in surviving the new privatisation in Bolivia that will only favour organisations with a sound economy.

Being the worlds leading electrification co-operative in terms of number of members, CRE represents a small group of co-operatives that have managed to overcome the financial difficulties in Bolivia. CRE operates in the rapidly expanding and economically powerful Santa Cruz region and have consumers in both urban and rural areas. Their tariffs for residential consumers are USD/kWh 0.05 in Urban areas and USD/kWh 0.15 in rural areas. The co-operative is financially sound and invests its profit in research and development programmes.

### *3.4.2 India*

In India, each State Electricity Board (SEB) sets its own fixed tariff which becomes valid throughout the state. The inflexibility in tariff structures sometimes lead to difficulties for the co-operatives as the tariffs are not based on the actual capital-, operation- and maintenance costs of the individual systems. The rural tariffs are, however, always subsidised to about 40-60% of the urban areas. The subsidy system have been quite favourable for the co-operatives and REC has not experienced any difficulties in getting their loans repaid. The CESS co-operative in Lucknow has almost entirely reimbursed its loan from 1969 when the activities started. The present CESS residential tariff is USD 0.04-0.056/kWh or, in small villages [34], USD 1.12/month for loads less than 2 kW.[35]

### *3.4.3 Nepal*

In Nepal, three power supply systems were visited which all are based on relatively modern hydropower technologies. Their organisational layout and financial preconditions differ, but none of them have been steered by the government in their tariff setting. Their tariffs are in the range USD 0.02/kWh to

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[32] The conditions have now changed, see further the enclosed Bolivia Country Report on *Rural Electrification Policies* in Bolivia.

[33] Energy prices for residential consumers, taxes (12-50%) excluded. ELFEC, Cochabamba: USD/kWh 0.0532; COBEE, La Paz: USD/kWh 0.066.

[34] Less than 15,000 people.

[35] Nepal Electricity Authority. 1994. *Fiscal Year 1993/94: A year in review.*

USD 0.06/kWh. As a comparison, residential consumers connected to the national grid pay USD 0.05/kWh if their monthly consumption is less than 20 kWh, and USD 0.08/kWh at 21-100 kWh monthly consumption.

AHREP is jointly undertaken by UMN and BPC. The installed turbines have a maximum power generating capacity of 5.1 MW, and is basically a source of income to BPC as power from the AHREP power plant is sold to the national grid. In the Andhi Khola distribution area, the load amounts to 0.5 MW. Consumers in Aserdi are both 'semi-urban', approximately 350 consumers, and rural, approximately 150 consumers at present. The peak load in Aserdi is 28 kW. About 73% of the Aserdi consumers have subscribed for 50 Watt, which means that they pay USD 0.74 /month for their electricity. The remainder is equally divided between those who pay USD 0.37 /month for a maximum of 25 Watt and those who pay USD 2.14 /month for a maximum of 250 Watt. None of the consumers in Aserdi are metered but have circuit breakers limiting their possible power out-take. To date, the Aserdi branch is not profit making. On the other hand, by contributing labour and administrative service, the 150 consumers have been welcomed into a power supply system where they normally would have been regarded as too heavy a burden. Current revenues generated by sales of electricity to Aserdi currently total about USD 1,700 annually, or approximately 5% of the capital investment in distribution. Of this sum, about 10% is returned to the User's Organisation. The balance covers the cost of energy production and any remains are allocated repayment of the original capital investments. [36]

Ghandruk Village Electrification Committee presently runs their power supply system without any external funding and is expecting to repay all its loans within the next six to seven years. However, until the loans are repaid, the system is not profit making. Monthly revenues amounts to approximately USD 540, of which 134 USD is needed for salaries (three employees), USD 100 are set aside in a fund for future use and the remaining funds are earmarked for reimbursement of loans. The 50 kW generating capacity are shared between 265 households and 18 lodges, who sometimes even overload the system. Given that the average load factor is 50%, the average monthly energy use is 63 kWh, comparable to a subscribed capacity of 88 Watt. However, the lodges use much more energy than do the poorest households and a large group has only subscribed to 25 Watt. Up to a subscribed capacity of 1 kW, circuit breakers are installed instead of meters. The monthly fees per Watt and month are USD 0.01 for residential houses with cut outs and USD 0.015 for those running a business, such as a tourist lodge. There is also the possibility for cut out consumers to restrict themselves to day-time use of electricity and pay only half the monthly fee. Metered consumers can chose between maximum capacities ranging between 1 kW and 10 kW. Each month, they pay USD 0.0025 per available watt (installed capacity) and USD 0.025/kWh for the energy used.

In 1994, SCECO made a profit of USD 4,600 after covering the running costs plus provisions for depreciation compensation of equipment and infrastructure. The SCECO tariff structure is based mainly on the fact that a considerable part of the connections are not metered. [37] The tariff is divided into five levels, two of which represent the bulk of the consumers and are based on maximum installed loads of 100 Watt (48% of consumers) and 500 Watt (25% of consumers) respectively. Consumers in the two load limited categories pay USD 1

[36] Inversin, A. *New Designs...*, pg 19
[37] Neuhaus, M. 1994. *Water and Power...*

and USD 4 respectively per month. Other consumer categories represent higher loads, are metered and pay for both installed effect and energy used on a degressive scale. Electricity use at off-peak time is promoted for the industrial category.

## 4 RESULTS AND DISCUSSION

The experiences and general reflections provided by interviewees, material on the case studies, and to some extent background literature, are summarised below. Comments, clarifications and reflections of the authors are given in italics.

*4.1.1.1 Benefits of local management of rural power supply systems*

- Thanks to local people's engagement in the project, commissioning and implementation can be facilitated and in some cases less costly.

- Local people can successfully, and sometimes at a relatively lower cost, manage meter reading, billing and regular maintenance of their system.

- Where local people are involved in, and financially responsible for their power supply system, the development of income-generating uses of electricity is more easily established.

- By incorporating the local consumers in the design, planning and erection of the system, unconventional and less costly approaches are enabled. Further, and in congruence with the previous point, local production of construction details can be opted for.

- Many developing countries could benefit from a more efficient utilisation of indigenous and renewable energy resources. The local management approach may be one way of disseminating and implementing renewable energy technologies.

*4.1.1.2 Important conditions for a successful, local management of rural power supply systems*

- Careful and proper technical planning with respect to the specific preferences expressed by the local consumers is of great importance to any self-reliant power system.

  *With few exceptions, locally initiated organisations will need assistance with project-design from an experienced and fairly impartial party. The party shall not only be technically skilled but also concerned about fulfilling requirements expressed in the national development plan. If designers are not interested in the welfare of the consumers, power system layout may be over-dimensioned so as to bring the maximum income to the designer. The consumers organisation will then never succeed in repaying its loans, no matter how diligent it is in collecting revenues and promoting productive end uses.*

- Appropriate training programmes at multiple levels must be offered the local people during the period of commissioning, implementation and during the first years of operation.

  *Most locally run power distribution systems run into problems of poor management and inadequate day-to-day maintenance in their activities. Lack of know-how among the local personnel is perhaps the most common reason for failure of consumer organisations. Appropriate training programmes for* *the system's staff are therefore necessary components in locally run power distribution systems. Usually, the training is provided by the national government and /or aid organisations.*

*Particularly in Bolivia, the problem of inadequate training programmes was experienced during the 1970s when USAID and NRECA made a pause in their development assistance to the country. Subsequently, numerous rural electrification co-operatives lost the grip of their activities when problems like poor accountancy; mis-use of funds; weak co-operative leadership; and inappropriate technical maintenance were encountered. The situation was further aggravated by the fact that the Bolivian Government did not make any further attempts to support the poorly managed co-operatives. Numerous co-operatives ceased to exist and has been taken over by larger co-operatives or by a power utility.*

- Financial support for implementation must be provided. Either as favourable loans or as grants justified by the general rural development programme of the country.

*The scope in terms of funding and time frame of the external assistance may vary from different projects. What appears in this study is that most locally managed power schemes require several years of external assistance.*

*Crucial for the smooth handling of assistance to local organisations, technical and financial as well as managerial, is the existence of an indigenous body/organisation with sufficient autonomy to implement rural electrification. The body ensures that rural electrification programmes are well designed and properly targeted. The body also assists the local enthusiasts in seeking for funds from the government or from donors, and work out training programmes for the local staff. As a suggestion from the authors, favourable loans for establishing rural power supply should be provided such organisations that seriously work along the lines of recommendations given by the nation's assisting body.*

- The Government must allow for tariffs to be set locally, with respect to the specific situation of each and every locally managed electricity system.

*Apparently, where standard equipment is used in the systems, like in Bolivia and India, the costs become high. In Nepal, and especially in the cases of AUO and GVEC, it is noted that tariffs can be set low, sometimes even lower than by the state utility. Main reasons for their relatively low costs are most likely their unconventional and low-cost design of the systems.*

*If the Government interferes with tariff setting, it should opt for a tariff covering actual costs in the systems. Alternatively, the Government should be willing to bear the financial burden of the local organisation arising from the social equity objectives imposed by the Government - (compare subsidies in India).*

- Productive uses of electricity must be promoted. Tariff structures should also be designed to obtain a high load factor in the system.

  *Plant- and load factors in the systems need be kept high through promotion of electricity use and by managing the load with tariffs. In many countries, however, few developed technologies exist to be promoted, wherefore attention needs to be devoted toward the development of end uses appropriate to the local context.*

- Any co-operative, association or company that has long-term planning plans for expansion and other enhancement tends to become stronger.

  *To assure local commitment to a local electricity consumer organisation, its objectives and activities must be well-known to all members. Otherwise, people tend to ignore the by-laws, and the Electricity and Co-operative Laws, or other similar regulations. Delinquencies such as non-payment of bills and low willingness of collaboration etc. may be overcome through out-reaching programmes. A strong leadership is pointed out as being of paramount importance by the interviewed organisations. Important in this context is also the national policy for rural electrification in general and the role of local participation in particular is very clear and consistent. As soon as the alternative of not contributing and still getting power supply is there, following vague formulations in the national plans, potential consumers will be less committed to their local organisations.*

# 5 COUNTRY REPORT: BOLIVIA

## 5.1 Country profile

Bolivia is a country located in Central South America, which covers an area of 1,1 million square kilometres. The country has no coastlines, but borders on Argentina, Chile, Brazil, Paraguay and Peru. The climate varies with the altitude: humid and tropical to cold and semiarid. The terrain constitutes of rugged Andes Mountains with the Altiplano (a high plateau located 3,000 to 4,000 meters above sea level), hills, lowland, and tropical plains around the Amazon basin. The environment is attributed of cold, thin air of high plateau, which makes fuel combustion less efficient. Some main environmental problems in Bolivia are overgrazing, soil erosion, and desertification. Arable land amounts to 3% of the surface area but there are no permanent crops cultivated in the land. The country is rich in terms of natural resources: hyrdocarbon resources represents a predominant domestic energy source while other, smaller resources include tin, zinc, antimony, silver, tungsten, iron stone, lead, gold and silver. [38]

In 1993, 7,5 million people were living in Bolivia. More than 50% of the people live in the countryside. [39] The population of La Paz is around 800,000, while about a third of the population lives in the Altiplano, which covers approximately 19% of the national territory. About 30 % of the population live in the Valles, whereas the Tropicos with 70 % of the total area are the least densely populated areas with only 17 % of the rural population. The lowlands have a low population density but experience economic growth [40]. The population growth rate exceeds 2.3% (in 1993) while the life expectancy rate is nearly 63 years (male: 60.9 and women: 65.9 years. Ethnic groups are Quechua (30 %), Aymara (25 %), mixed groups (25-30 %) and Europeans (5-15 %) The literacy is 85 % for men and 71 % for women. The labour force totals 3.54 million people. Most are occupied in the agricultural sector (50 %). Occupation in service sector stands for 20 %, manufacturing, mining and production 7%, and other 10 % (1993).[41]

With a GNP of approximately 760 USD (1993), Bolivia is the poorest country in South America.[42] Above all, the reasons for poverty lies in a long history of semi-feudalistic social control, a dependence on volatile prices for its mineral exports and hyperinflation.[43] The early 1980´s was attributed to Bolivia's worst economic crisis of the century. However, a wide ranging economic stabilisation program was introduced in 1985, which included pricing controls, deregulation in the trade system and the labour market, establishment of a uniform exchange rate and policies to reduce public sector deficits. In fact, these efforts brought an end to the hyperinflation, and the public debt was brought under control in the mid-1980´s. The Bolivian economy is fundamentally dependent on natural gas and mineral exports as sources of foreign exchange and for servicing its relatively large external merchandise exports. [44]

Like most other Latin American countries, the country is a republic with a multi-party system. The state is politically divided into nine departments. The government seat is located in La Paz, while Sucre is the legal capital and seat of

[38] Central Intelligence Agency, *The World Factbook 1994*, p.49
[39] Ibid
[40] World Bank/UNDP, *Bolivia- Prefeasibility Evaluation Rural Electrification and Demand Assessment*, ESMAP report no. 129/91, p. 5
[41] Central Intelligence Agency, p.49
[42] World Bank, *World Tables 1995*, p.161
[43] Ibid
[44] World Bank/UNDP, no. 129/91, p. 6

judiciary. [45] The market economy politics presently pursued by the government is characterised by privatisation of many state-owned assets.

## 5.2 The Energy Situation

The energy sector is a critical area of importance to the Bolivian Government. The energy reserves in the country consist of hydrocarbon resources such as crude oil, condensate, natural gas and potential hydroelectric resources. The proved reserves of hydro carbon liquids reach 109.2 million equivalent barrels of petroleum. The energy sector´s contribution to economic growth remains considerable despite a decline in oil production. In 1990, the energy sector generated 55% of the income of the National General Treasure. Bolivia is also a net exporter of oil and natural gas to countries such as Argentina. The importance of energy in foreign trade has continously increased during the 1980´s, and in 1990, the energy sector stood for 25% of the country´s total export.[46]

Bioenergy is one of the most important components in the total national energy consumption corresponding to approximately 34%. (up to 80% in some rural areas). [47] In the Altiplano, the population suffers from a century old shortage of fuelwood, which has contributed to its total deforestation and substantial degradation of its soil. This has also extended to the adjacent valleys, which are now largely denuded, especially near the traditional mining areas of the southern Altiplano. [48]

Of the energy reserves in the country, the hydro potential is by far the largest known resource. It is practically unexploited, mostly because of its high cost of development which is much higher than the costs of the generation of natural gas.

Bolivia has excellent solar irradiation and a large agricultural potential, which could be harnessed for renewable energy extraction. Due to high costs and storing difficulties, the solar and wind energy is being harnessed only to a limited extent. The country also has a geothermal zone, deposits of uranium in quantities not yet defined and indications of coal and lignite.[49]

## 5.3 The Power Sector

The Government of Bolivia has formulated a National Energy Plan which provides guidelines for the governmental energy policy and also the strategy to implement the energy goals. According to the National Energy Plan, the primary objective of the power sector in Bolivia is to cover the demand with a sufficient level of reliability while providing expansion at minimal costs. An important component in the action programme is to increase generation capacity to be able to meet pending demands in both urban and rural areas. [50]

Electricity in Bolivia is provided through the central inter-connected system (*Sistema Nacional Interconnectado*, SNI) and a number of isolated systems together with non-utility generators. The SNI system is operated by major power utilities, *Empresa Nacional de Electricidad* (ENDE), the national company and the privately owned *Compania Boliviana Energia Electrica* (COBEE). ENDE

[45] World Bank, *World Tables 1993,* p. 47
[46] World Bank/UNDP, *Bolivia National Energy Plan,* no. 131/91, introd. and p. 1
[47] World Bank/UNDP no. 131/91, p. 1
[48] World Bank/UNDP, no. 129/91, p. 9
[49] United Nations, *Energy Statistics Yearbook 1992*
[50] World Bank/UNDP, no. 131/91, pp. 4-6

operates the bulk of generation and transmission facilities, whereas COBEE is the country´s largest distribution company, primarily serving the urban area of La Paz and selling bulk power to Oruro. The two utilities are interconnected at 115 kV (1990). Until 1988, the SNI was structured roughly along a north-south axis (La Paz-Oruro and Cochabamba-Potosí).

Since 1989, SNI includes four principal load centers: the northern system (La Paz) the central system (Cochabamba and Oruru), the southern system (Potosí and Sucre). The eastern system, which has thermal (gas) based generation, was connected in late 1980´s with the hydro-based, north-central south inter-connected system. Besides this, there are also numerous independent systems (diesel/micro/mini-hydro) spread throughout rural areas of the country with capacities ranging from 20 kW to 1,000 kW. Many of those systems have served or are serving mining communities in the Altiplano and Valles. As an example, the area of Santa Cruz has had more than 90 rural electrification co-operatives running on diesel and serving isolated, rural loads.[51]

**Table 4. Statistical data on production, utilization, installed capacity and consumption of electricity in Bolivia, 1992[52]**

| **Net installed capacity of electric generating plant (MW)** | | | |
|---|---|---|---|
| | Total | Thermal | Hydro |
| Total | 726 | 393 | 333 |
| self prod | 102 | 75 | 27 |
| public | 624 | 318 | 306 |

| **Utilization of installed electric generating capacity (kWh/kW)** | | | |
|---|---|---|---|
| | Total | Thermal | Hydro |
| Total | 3,322 | 2,702 | 4,054 |
| self prod | 2,382 | 1,573 | 4,630 |
| public | 3,476 | 2,969 | 4,003 |

| **Production of electricity (GWh)** | | | |
|---|---|---|---|
| | Total | Thermal | Hydro |
| Total | 2,412 | 1,062 | 1,350 |
| self prod | 243 | 118 | 125 |
| public | 2,169 | 944 | 1,225 |

| **Electricity consumption per year (Gwh and kWh per capita)** | | | |
|---|---|---|---|
| Total | Per capita | Import | Export |
| 2,424 | 322 | 15 | 3 |

Europe average: 5,729 kWh per capita per year

## 5.4 Institutional network

There is a relatively small number of organisations involved in the rural electrification programme in Bolivia. Only a few of them are engaged with both generation and distribution, or transmission and distribution activities. The actors relevant to this study are considered below:

[51] Ibid, pp. 7-8

[52] United Nations, *Energy Statistics Yearbook 1992*

### *5.4.1. National Electric Power Company - ENDE*

ENDE is the national power utility which operates the most of generation and transmission facilities in Bolivia through the inter-connected and isolated systems. It sells power to distribution companies throughout the country.

ENDE is also the government agency primarily responsible for rural electrification in the country. The first massive rural electrification programme was embarked upon in the early 1970s. At that time, about 100,000 people were given service in the rural areas of Bolivia. The funds set aside for the initial project amounted to USD. 30,000.

ENDE organised rural electrification co-operatives and provided technical and administrative assistance to their personnel. The aim was to facilitate future co-operative management of electric distribution, and in the case of decentralised electrification systems also the power generation. (See further chapter 2.6.) The agency also provided financial support for implementation of the projects.

According to the Technical Manager of ENDE, the aim was principally to prove that locally managed electrification projects was possible in the country. By copying the co-operative approach of rural power distribution, experiences could be drawn from the organisation and management of rural electrification co-operatives in the United States. [53]

### *5.4.2 Bolivian Power Company – COBEE* [54]

COBEE is the country's largest private distribution company. The utility is principally serving the urban centre of La Paz and selling bulk power to Oruro, which is covered by the central system. ENDE and COBEE are inter-connected at 115 kV, and ENDE sells power to COBEE to cover peak demand. COBEE, on the other hand, supplies off-peak energy to ENDE.

The generation and distribution of electricity in Oruro includes electrification of rural areas. In such areas, COBEE also sells power to the locally managed power systems through lines of ENDE. The technical design of rural electrification grids follows the American models, i.e. specifications of the Rural Electrification Administration (REA).[55] However, cross-arms and insulators etc. can be of locally manufactured design. COBEE distributes electricity to scattered households through single line connections at medium voltage level.

The tariff system is divided into two categories, urban vs rural consumers. The flat rate for domestic consumers in the urban areas totals USD 2.87 for consumption up to 50 kWh per month. For consumption from 51 to 300 kWh, the costs is USD 0.041 per kWh. In rural areas, domestic consumption up to 50 kWh is USD 3.28 while the tariff for consumption exceeding 51 kWh per month is USD 0.067 per kWh. [56] COBEE invests up to the house meters and charges USD 4 in connection fees. The conductor is paid by the consumers and can be paid off immediately or over a four months period. In other places, there is only one meter at the sub-station. Here, the minimum monthly rate for consumption up to 50 kWh is USD 2.5.[57]

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[53] Interview with Federico Lucero Bilbao, Technical Manager, ENDE-Cochabamba.

[54] Interview with Julio Lemaitre, Manager, Engineering Department, COBEE La Paz.

[55] REA is a fully autonomous federal agency within the U.S: Department of Agriculture. REA launched the rural electrification programme in the United States in the 1930s. It has provided the bulk of loans needed for the rural electrification programme in the USA since 1936.

[56] From COBEE´s list on tariff structures of 1995.

[57] Interview with Julio Lemaitre, COBEE-La Paz.

The company's involvement in rural electrification has been limited, and its experiences has been mostly negative in this field. The company has no substantial influence in the decision-making process of the planning of rural electrification. There is no internal policy promoting electrification of rural areas, neither are there any sufficient economic incentives provided from the Government to encourage such actions. There are also some technical problems characterising electrification of rural areas: the main reason is that distribution systems have been constructed by many different distribution companies without any form of comprehensive and proper planning of the technical design. For example, different voltage levels were used, which has resulted in high losses of electricity. Although COBEE and other electric utilities have been aware of the technical problems, the possibility of improving the systems was largely inhibited by the country´s deterioriated economy in the 1980s due to the inflation boom. COBEE is presently rehabilitating a lot of the old electrical equipment, and transformers are being replaced by new ones with altered voltage levels from 6.9 kV to 12 kV in the grids. COBEE is also expanding its generating system into additional rural areas outside the city of La Paz. The grid have lately yielded high losses due to deficiencies in the technical design. In 1986, the losses amounted to 17.5 %. However, in 1994, the distribution losses had decreased to 11.5 %, of which 3-4 % accounted for non-technical losses.[58]

### *5.4.3 The Electric Power Company of Cochabamba - ELFEC- SAM*

*Empresa de Luz y Fuerza Eléctrica Cochabamba*, ELFEC-SAM, is a semi-governmental power distribution company serving the area of Cochabamba. The government ownership is 96%, with ENDE as a main shareholder, while the private ownership stands for the remaining 4%. ELFEC is connected to the national inter-connected grid.

In 1993, ELFEC served about 115,000 consumers, of which 23% were rural clients. The same year, the company sold 304,000 MWh to a 131,304 clients.[59] The number of consumers has since then increased to approximately 140,000, which corresponds to 14% of the population in the province.[60] The average tariff per kWh was USD 0.053 for residential categories in December 1993. [61] ELFEC´s tariff structure provides for fluctuating rates in terms of the currency *bolivianos*, in order to maintain a constant value in US dollars. [62]

At present, ELFEC is responsible for the electric distribution in the previously co-operative managed Mizque and Capinota electrification systems (see further chapter 2.2.9.)

### *5.4.4 National Rural Electric Co-operative Association - NRECA*

NRECA was formed in 1942 to "...provide legislative, communications, insurance, management and other services to the more than 1,000 rural electric co-operatives which provide electric power to much of the rural areas of the United States."[63] It represents about 1,000 rural electrification co-operatives and public

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[58] Ibid
[59] World Bank/NRECA, *Beneficiary Assessment of the Mizque-Aiquile Sub-project*, p.11
[60] Interview with Fernando Gemio, ELFEC S.A.M. 17/1
[61] ELFEC S.A.M, *Memoria Anual Gestion 1993* (Cochabamba 1994), pp.40-54
[62] World Bank, *Beneficiary Assessment*..p.11
[63] NRECA, *The Next Greatest Thing- 50 Years of Rural Electrification in America*, p. 4

districts serving 25 million people in 46 of the states in the country. [64] Due to its strong and active involvement of its members, NRECA is known to be a national organisation with a grass-root direction and bottom-up approach in the decision-making process.

Around the world, NRECA has worked in 50 countries in Africa, Asia and Latin America. Operational and administrative and financial management is given priority in the formation of, and on-going management of electric distribution entities. NRECA´s guiding principles is to provide safe, reliable power to its consumers at the least possible cost, consistent with sound business practice. [65]

After an absence of more than 12 years, NRECA returned to Bolivia in 1991 to support rural electrification under the sponsorship of USAID. During a five-year period, NRECA is managing the USAID-funded Electrification for Sustainable Development Project (ESD) which aims to assist economic development in rural areas of the country. The programme includes the following activities: [66]

- construction and rehabilitation of rural electric generation and distribution systems;
- promotion of productive uses of electric energy [67];
- development of energy conservation and industrial load management programmes;
- technical assistance and training; and
- creation of a rural electrification financing institution.

Up to 1994, about USD 19 million had been invested in project implementation, of which 60% was financed by USAID/Bolivia. The balance has been financed by counterpart institutions including electrification co-operatives, para-statal and private electric utilities as well as private NGOs. Apart from a number of electrification co-operatives, NRECA also cooperates with utilities like ELFEC, ENDE, COBEE etc. [68] In order to discourage coca production activities, USAID only provides financial assistance to the non-coca producing regions of the country.

At present, a joint NRECA-Government of Bolivia follow-on project is being discussed. The funding may derive from NRECA and by a development bank. However, the plans are still in an embryonic phase. NRECA has recently formed a Bolivian foundation with the purpose to carry on their work in Bolivia. The foundation will be supported, but not controlled by NRECA. [69]

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[64] NRECA, *American Cooperation 1991,* p. 290

[65] NRECA, *Building*...pp. 4-5

[66] NRECA, *Llevando Luz donde no existe- Meeting the Needs for Electricity with Appropriate Technology* (information brochure), p.1

[67] Productive uses may be defined as "...any use of electricity which increases the end-users´economic status by facilitating production levelincreases, production cost savings, and /or increased product quality. From the point of view of the utility, productive end-uses would have the effect of load building and generally augmenting the off-peak." (World Bank /UNDP ESMAP -report no. 129/91, p. iii)

[68] NRECA, *Llevando Luz*... p. 1

[69] Correspondence with Daniel Waddle, Executive Director, NRECA/ Bolivia, May 1995

## 5.5 Governmental Policies and Regulations

### *5.5.1 Rural Electrification Policies*

The National Energy Plan of Bolivia treats the status of the energy sector, government action programmes, goals, long-term objectives and strategies to achieve these objectives. [70]

The rural electrification co-operative activities are regulated by the Electricity Law and the Co-operatives Act. The Co-operative Act regulates all co-operative activities in Bolivia. The Electricity Law sets out the norms for the activities of the Electric Industry and establishes the principles for the rates of prices and tariffs of the electricity in all parts of the national territory.[71]

According to the former Electricity law, electric utilities and co-operatives in Bolivia were not allowed to make annual profit exceeding 9% of their total annual investment.[72] This regulation has sometimes had critical implications for rural electrification co-operatives, as it may serve as a bottleneck for potential expansion of their electric systems.

However, the newly amended Electricity law has drastically changed the conditions for the electric co-operatives in the country. According to the new law of 1995, no new co-operatives can be formed, whereas existing co-operatives will be transformed into *Sociedades Anonimas* (Anonymus Societies), with limited partnerships. The profit margin is now based on the average profit for electric utilities for the past three years as reflected in the Dow Jones economic indicators of the United States. This will reflect the reality, i.e. the ups and downs of the market, instead of limiting it.

Large successful co-operatives like the CRE (see chapter 8.4), will most likely remain as co-operatives in the future. However, it is less likely that the CEY (see chapter 8.1) will continue operating as a co-operative in the future. What the exact implications of the new law be remains to be seen.

The Electric Supervision Agency is a government body with national jurisdiction, which fills the function of acting as a regulator for the electrification activities. The highest executive authority of this body is the Superintendent of Electricity. [73]

The Electricity Law stipulates that licences are required for generation and transmission activities. A Public Service Concession is required for distribution and electric activities which are developed in an integrated form in the isolated systems.

One Article in the Electricity Law authorises the Bolivian Government to set the tariff rates of individual systems in the country. The tariff structure is fixed in accordance with the Electricity Law and the individual electric systems do not formally have any say in the tariff design. The tariff is, however, based on some attributes of the individual systems, such as operation and maintenance costs; intangible assets (pre-feasibility studies etc); depreciation costs; and the cross subsidised tariff system.

In general, Bolivia is undergoing a privatisation process where many government-owned assets are sold out to the public. The privatisation policies are also embedded in the newly amended Electricity Law of 1994. According to the Article 15 in the Law, generation and distribution activities within the inter-

[70] World Bank/ UNDP, report no. 131/91
[71] Government of Bolivia, Gaceta Oficial de Bolivia; Ley de Electricidad
[72] Ibid.
[73] Ibid, Art. 12.

connected system cannot be committed by the one and same power utility, nor can one utility be legitimate owners of more than 35% of the installed capacity in the system. This rule aims to increase the competition between different electric companies in the country.

### 5.5.2 *Policies effects on locally managed distribution systems*

Although actors in rural electrification activities in Bolivia do not consider the Government being uninterested in rural electrification, they often claim there is lack of government commitment to it. Naturally, these are point of views of individuals that can be questioned by others: perhaps most of the pessimism origins from bad experiences attributed to most rural electrification projects in the country. What however appears to be easily agreed upon is the fact that there is no target-oriented national rural electrification programme in Bolivia. Like in many other developing countries, rural electrification initiatives in Bolivia has got behindhand electrification activities in the urban areas. If no external assistance is provided, locally managed power distribution systems has to rely on their own financial, labour and material resources.

This problem is realised by the Technical Manager of ENDE. He claims that there is a great interest in rural electrification from the government side. The problem is rather the lack of funds devoted to rural electrification programmes. [74]

The fixed tariff structure does not take into account the investment costs and loans of the projects. Consequently, this restricts the possibility of locally run rural electrification projects to pay off their initial investment, maintenance and expansion costs. The cross subsidised system will soon disappear, according to new rules in the Electricity Law.

Another shortcoming of the government policies is the fact that the Electricity Law and the Co-operative Act are not properly enforced. Many representatives from the projects studied claim that many people involved in the power sector are not familiar with the regulations. [75]

The privatisation policies of the Bolivian Government are expected to a have negative impact on the co-operative activities. [76] Bearing in mind the severe economic situation of many rural electrification co-operatives in Bolivia, it is doubtful whether such co-operatives will become economically justifiable if becoming privatised. On the other hand, private power companies are organised for profit and usually do not care to extend their lines to sparsely populated areas promising only small returns on investment costs, as long as there are few incentives provided by the Government for electrifying such areas. This justifies the significance of local management in rural power systems.

## 5.6 Rural Electrification in Bolivia

ENDE launched the first massive rural electrification programme in Bolivia in the 1970s. The criteria for selecting a rural electrification project is firstly to justify the project socially and productively. The need for lighting should be at least two to four hours a day, and correspond to 30-50 kVA.[77]

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[74] Interview with Federico Lucero Bilbao, Technical Manager, ENDE.
[75] This was expressed by several interviewees, in particular non-governmental representatives.
[76] This was claimed by for example Victor Virreira, ABB/La Paz; Fernando Gemio, ELFEC S.A.M; Federico Lucero, ENDE; Ramiro Portugal, CEY; and Eduardo Elder, Planning Engineer, CRE.
[77] Ibid

By supporting the formation of rural electrification co-operatives, it was expected that this form for local management would release the power generating utility from overhead costs connected with distribution services, meter reading and billing. Rural electrification co-operatives would then run the rural power systems independently of government support.

Despite the expectations, rural electrification has not proven to be an easy task in Bolivia. According to a joint World Bank/UNDP Energy Sector Management Assistance Programme (ESMAP) report, rural electrification has received a low priority in recent energy planning and investment activities in Bolivia. For most households in the rural areas, there is simply no electricity available at all. In 1980, less than 10% of the rural population in the country had access to power. In already electrified areas, a major deterring factor to become a consumer is the connection costs and low rural incomes and productivity.[78] According to recent NRECA figures, the current percentage of number of households with access to electricity is estimated to 16%.[79] The estimated electricity consumption per capita in Bolivia is less than 25 kWh per month.[80]

International aid agencies have sometimes played a crucial role in rural electrification initiatives in Bolivia. External assistance provided has often served as a mainstay for rural electrification co-operative projects. USAID and NRECA are such examples. USAID has provided funds through the prior Alternative Development Programmed (ADEP) and the on-going Electrification for Sustainable Development Programme (ESD) NRECA has actively been involved in the programmes by assisting technically and administratively. NRECA runs a productive uses programme and provide loans for productive use of electricity to the members. NRECA also carries out training programmes for co-operatives in order to improve their accounting and billing systems etc.

For most rural areas, the primary use of energy is for household lightning and cooking. Rural inhabitants have traditionally consumed fuelwood, dried dung and other biomass to meet their basic energy needs. According to the World Bank/UNDP report, the role of productive end-uses for complementing rural development planning and activities has been over-looked in the rural electrification planning.[81]

Electrification efforts in Bolivia have been facilitated by the use of experiences from the United States. The U.S. system has largely served as a model for the Bolivian system. On the other hand, the conditions for rural electrification in Bolivia has appeared to be dissimilar from United States, where the designs of electric systems can be made for a long-term period, i.e. 30-40 years in future. Such long-term planning in the design of power systems has proven to be too risky in Bolivia, in stead five to ten years appears to be more appropriate. The reason is partly that even though there is power available during daytime, the consumption of electricity has remained lower than initially expected. In addition, it is difficult to foresee the rural demand of electricity in the future.

Another lesson learnt, according the Technical Manager at ENDE, is that American standards applied by the Bolivian Government is not always compatible with the national conditions. An example is the Government's attempt to invest

[78] World Bank/UNDP, report no. 131/91, p. 8-9
[79] Correspondence with Daniel Waddle, NRECA, Bolivia, May 1995.
[80] Interview with Federico Lucero Bilbao.
[81] World Bank/UNDP report no. 131/91, p. 9

American electric vehicles for use in the countryside where there was no demand for it. [82]

## 5.7 Local Management in Rural Power Systems

### *5.7.1 History of rural electrification co-operatives*

Apart from urban-based power utilities serving rural areas, a number of communities operate distribution co-operatives in Bolivia. Power for these locally managed systems is either purchased from the national grid or generated by isolated diesel gensets systems operated locally. The responsibility can lie either under a co-operative or a small-scale generation and distribution entity. [83] Rural electrification co-operatives are the most common form for local management in rural power distribution activities in Bolivia. The idea of forming the co-operatives was adopted by the Bolivian government at suggestions from the Americans in the 1960s. The experiences from establishment and management of rural electrification co-operatives in the United States dates back to as early as the 1930s. The American co-operatives also came to serve as models for establishing them in Bolivia.

### *5.7.2 Current status*

There have been over 180 rural electrification co-operatives spread throughout the country, but the approximate number today is 120. In fact, the number has been reduced with 30% in only three years. Many rural electrification co-operatives in Bolivia have ceased to exist due to various shortcomings and the electric distribution has subsequently been taken over by a power utility. Others have been swallowed by larger co-operatives in the nearby. The current tendency is thus that the number of existing co-operatives is reducing, whereas the size of the co-operatives and their distribution systems is expanding.

Another problem related to the limited government funds assigned to rural electrification programmes is the fact that a number of locally run rural electrification projects are relatively dependent on foreign assistance. Much of the funds come from USAID and the administrative and technical assistance from NRECA. However, this support is only offered provinces of the country where there is no production of coca. Consequently, many locally managed rural power systems do not receive donor assistance as may be required.

An ENDE representative claims that most of the rural electrification co-operatives in Bolivia have had administrative and financial problems, which has resulted in inability to cover the debt obligations and to expand the distribution systems. [84]

In areas where co-operatives have ceased to exist or have given up their responsibility for local power distribution and have recently been replaced by a private utility, this solution has improved the chances of prospects for future power distribution in terms of improved power service, new investments and enforcement of bill payments. [85]

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[82] Interview with Federico Lucero Bilbao.
[83] World Bank/UNDP report no. 131/91, p. 8
[84] Interview with Federico Lucero.
[85] Examples are ELFEC's replacement of the former Capinota and the Mizque cooperative's power distribution activities.

There are also some successful rural power systems based on local management in Bolivia. NRECA estimates that out of 120 electrification co-operatives in operation, five to seven are successful. [86] Most of these co-operatives are, however, not strictly rural. Rather, they serve both urban and rural areas and most of the capital costs are covered by revenues from the urban consumers.

Another successful strategy has proven to be to combine electrification activities with other kinds of rural development activities, such as road construction and construction of irrigation systems. The significance of co-ordination between rural electrification and other infrastructural programmes is advocated by government and non-government representatives in the Bolivian power sector as well as NRECA. [87]

## 5.8 Case Studies in Bolivia

### *5.8.1 Rural electrification in the area of Yungas* [88]

#### *5.8.1.1 General Characteristics*

The project area is situated approximately 100 kms northeast of La Paz and is headquartered in Coroico town. The province of Yungas is characterised by mountainous terrain, deep valleys and generally poor transportation networks. There is daily public transportation to La Paz. However, the road is in very bad condition, particularly during the rainy season when it becomes even more hazardous to travel along it. The road between La Paz and Coroico and Chulumani is considered one of the most dangerous in the Western Hemisphere.

The Yungas holds fertile valleys from which a large number of crops, like coffee, vegetables, fruit etc. are produced. The area is also a prime coca-producing region.

The low income of the people in the area is estimated to as low as USD 30-40 per month. The level of education is low. The people are nearly self-reliant in terms of agriculture production. The local industries are mainly based on coffee processing, chicken farming and hotel management. The last category probably yields the best profit. The towns of Chulumani and Coroico have good hotel infrastructure and transportation networks.

#### *5.8.1.2 Electrification of the Area*

Based on a decision taken by local communities in the area, *Cooperativa Electrica Yungas* (CEY) was formed in 1979 in the province of Yungas, Bolivia. The main objective of CEY is to provide comprehensive grid coverage in the project zone. The co-operative is connected to the national inter-connected power system. Many of the small business enterprises in the CEY service area are home-based and are therefore billed at the residential rate class, although a large percentage of the use is commercial.

Until recently, productive uses of electricity has not been actively promoted by CEY. However, the financial benefits of such measures are well recognised and

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[86] Interview with David Kittelson, NRECA/Bolivia.
[87] Examples are NRECA, ENDE, and ELFEC representatives.
[88] If not indicated with footnote, the data in this chapter is based on interviews with Fernando Mercado, NRECA/Bolivia. (former Manager of CEY), Carlos Tudela J., General Manager of CEY, Mario Zapata C. President of CEY, and Ramiro Portugal, Treasurer of CEY.

during the last years, the co-operative leaders have held some training courses for the consumers on electricity use in general.

*5.8.1.3 Generation and distribution*

In the beginning of May 1995, CEY served 5,600 consumers in the Yungas in the main towns of Coroico, Coripata and Irupana as well as small villages surrounding Irupana as well as a commercial district in Chulumani. The co-operative purchases the power from COBEE through lines of ENDE. The electricity is generated in La Paz and transmitted in 115 kV lines to a sub-station in Pichu. The tension in the 75 km main line is 24.9 kV, whereas the tension in the 80 km secondary line is 380/220 V. CEY then distributes the power to principally all the immediate areas in the Yungas adjoining the project zone.

The contracted maximum of power delivery is 2,500 kVA, while total transformer capacity is 7,000 kVA. In 1993, the maximum demand was 1,722 kVA, while the total amount of energy purchased was 4,2 GWh. Energy losses amounted to 19% in 1993, the rest of which was distributed amongst residential consumers (56%), industrial and other larger consumers (18%), and public lighting (7%). In 1994, the electricity consumption per consumer averaged 44.5 kWh per month in the residential category in which demand consists primarily of domestic lighting. In May 1995, the system load factor was 37%.

*5.8.1.4 Technical design*

The technical design of the electric system is of a conventional type. CEY has used standards set by the American agency REA. The residents have installed meters, circuit breakers, and house-wiring of concentric cables. The power for domestic consumption is transmitted in secondary lines, whereas the large commercial consumers have either their own transformer or transformers which have been given to CEY by COBEE. The low load factor in the system is viewed as unsatisfactory and needs to be addressed.

In order to keep the maintenance costs low, the locals participate in the annual maintenance work, such as cleaning of trees that grow along the lines, digging of ditches, and maintenance of poles.

The poles are made from treated eucalyptus and remain in good condition for about ten years. The poles used for low-voltage lines last only for two to three years.

*5.8.1.5 Financing the system*

The total investment cost of the electric system of CEY amounts to USD 2,010,960, which makes the average consumer's investment USD 360. Originally, ENDE contributed USD 950,260 and USAID contributed USD 467,000 to cover the implementation costs of the project. These figures also included administration and inspection costs. Of the USD 950,260, 145,000 were provided as a grant. The loan from USAID has been bought by the Government of Bolivia. At present, there is no external funding provided to the co-operative.

CEY´s economy is balanced, if not taking into account the debt from the loan taken for the initial construction of the system. However, CEY is not financially viable: the co-operative has not had the possibility to pay off its loans to the government for the capital costs. Instead, other companies who want to pay are allowed to buy 22% of the loan. Each company then owns its own share of the debt.

The topography in the Yungas is very steep and hilly, and thus it is difficult to erect and maintain poles and lines etc. The meter-reading cost is also relatively high on account of the large distances between the scattered households. Due to the unfavourable conditions, the Yungas is not attractive for the private sector power utilities in Bolivia. Surprisingly, the CEY co-operative has shown that electricity can be delivered at a total operation, maintenance and administration (OMA) cost of 0.052 $USD/kWh_{sold}$[89]. This can be compared to the OMA-cost in COBEE, the power distribution company acting in La Paz and Oruro, which averages 0.25 $USD/kWh_{sold}$[90]. COBEE's OMA-cost concerns their entire service area, i.e. both urban and rural loads. Of course, costs are entered up differently in different organisations. Also, COBEE naturally defrays more research and development than a small co-operatives like the CEY. However, the difference between the two figures witnesses that local management of power distribution is cost-effective in these parts of Bolivia.

Similar to other locally managed rural distribution projects in Bolivia, the tariff structure of CEY was designed by the government to cover only the annual operation costs of the system. The costs for loans and initial investment has thus not been taken into account in the tariff setting. Another government law prohibits co-operative profit-making exceeding 9% of the total annual investment. The government regulation limiting permissible profit-making up to 9% render it more difficult for co-operatives in the country to make further investments and to expand the system. The current annual operation costs for attending 5,600 electricity users amount to USD 345,175, which corresponds to about USD 62 annually per consumer.

The tariff structure distinguishes between four categories of consumers: residential, small commercial (general 1) large commercial (general 2) industrial (seven with CEY transformers and eight with own transformers). CEY purchases electricity for USD 0.028/kWh from ENDE.[91] In 1993, the energy unit price for residential consumers was USD 0.08/kWh and the commercial category was charged USD 0.09/kWh, the industrial category's price was USD 0.10 /kWh and public lighting USD 0.06/kWh.[92]

Connection costs and fees are also set by the government. The connection cost is USD 20 per person. All consumers who are connected to the system automatically become co-operative members. The consumers are metered and pay their electricity bills on a monthly basis in cash. In cases when bill payments are not fulfilled, the delinquent consumers are disconnected. The re-connection cost is USD 2. However, delinquency of bill payment is not a major problem within CEY. The revenues from the electricity bills cover the operation and maintenance costs but not the capital costs.

CEY charges domestic consumers a minimum of 25 kWh/month and the small commercial consumers 50 kWh/month. Large commercial and industrial consumers are charged both for demand and energy, USD 2/kVA and USD 0.04/kWh. If no meters are installed, the consumer pays for maximum kVA at the transformer. The billing system is computerised. Some local staff are responsible for the metering and revenue collection in certain areas.

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[89] CEY, *Memoria Anual Gestion 1993*, p. 18 and p. 25: Costs of administration + O&M: 829,199 Bs, Amount of energy sold: 3,375,135 kWh. (= 0.24 Bs/kWh = 0.052 USD/kWh)

[90] COBEE annual report 1994, pg 15: O&M expenses, USD 34,805,000, pg 8: total sales, 140,580,000 kWh.

[91] CEY, *Memoria Anual Gestion 1993*, p. 18 and p. 25: Costs for purchased energy: 552,171 Bs, Amount of energy purchased: 4,176,898 kWh. (= 0.13 Bs/kWh = 0.028 USD/kWh)

[92] CEY, *Memoria Anual Gestion 1993*, p. 27

Line extensions from the co-operative are commonly financed by 50 % up-front community contribution and 50 % from the co-operative's funds, if and when available. The community's contribution frequently derives from the regional development corporation CORDEPAZ, which is augmented by some direct money collection among the people. [93]

*5.8.1.6 Management of the power supply system*

During the five initial years, CEY was provided administrative support by ENDE. However, the costs were financed by the co-operative itself. At present, there is little relation between CEY and the government agencies. The exchange with aid organisations is also limited. As Yungas is one of the primary coca producing regions in the country, no development aid is provided by USAID.

The management framework is stipulated in the co-operative's by-laws which were initially enforced by NRECA and ENDE. The by-laws states the role and purpose of the co-operative; its employees and the general meetings and the administration council; as well as the rights and obligations of the co-operative members. The members are requested to personally assist by voice and voting in the Zonal Meetings and Meeting of Delegates; and to redeem the commitments and commissions of the entrustees. [94]

Each community with more than 50 consumers in the distribution area is entitled to elect one delegate to the Meeting of Delegates. The meeting takes place once a year. The Delegates elect the five Directors, which in turn elect the General Manager. The Manager's responsibility is to provide all information data and documents required by the commissioners and to contract the employees. The 25 employees are guided by manuals and the by-laws.

The Directors survey the elections of delegates and inform about the co-operative activities. They are gathered every month to discuss and report to the General Manager. The Directors are elected for a period of three years.

The co-operative by-laws of CEY are generally followed. Amendments in the by-laws can be discussed at the Meeting of Delegates, where members can suggest modifications.

CEY has a contract with COBEE stating that the co-operative is obliged to purchase all the electricity from COBEE. However, there is no agreement with the utility concerning minimum level of power supply. The reason is basically that COBEE´s electricity demand generally exceeds the electricity supply.

As a means to promote electricity use, a seminar was held in 1992 and 1993. CEY employees also visited many communities in the distribution area to train them on meter-reading, calculations of bills, productive use of electricity etc. A seminar was arranged for technicians to train them on how to make own installations, meter-reading, house-wiring etc. During 1994, a training course was held on the same subject.

At the end of 1980s, the co-operative experienced poor administrative management and lacked strong leadership. The tariff rates were very low and did not even cover the administration and operation expenses.

*5.8.1.7 General experiences and tendencies*

CEY has operated the distribution system since 1982. During a period of 13 years, no major incidents have occurred, nor have there been any major achievements.

[93] World Bank/UNDP, report no. 129/91, p. 47
[94] CEY, *Estatutos* (Yungas, 1994), pp. 1-4

The most troublesome years were experienced in 1988 and 1989. One of the main problems encountered during that period was the lack of administrative management, which contributed to the misuse of funds, inadequate book-keeping, lack of knowledge of national electrification laws. Moreover, the unadjusted tariffs were too low to cover the operation, maintenance and administration costs.

In the end of 1990, the price of electricity increased while the service remained defective, which upset the consumers. 1991 was the most critical year when rotten poles began to fall down and there were no funds to replace them. The operators then reinforced the old poles along the primary line. After more than four years, the result has proven to be excellent. The costs for new poles would have been USD 250 each, compared to USD 50 for the reinforcements.

During the last years, CEY has become administratively stable, but not financially viable. That is to say the co-operative has enough revenues to cover the operation and maintenance costs, but cannot afford paying back the capital costs. The improved management of the co-operative, resulting in ameliorated administration and stabilised economy, reliable service and lower tariffs etc. the most positive sign is perhaps people's improved attitudes to the electricity service in the area which is partly a result of the continuance and reliability of the power supply and the stability of the electricity costs.

The Government has suggested that CEY should become privatised, but the members believe it is better to hold on to the co-operative form of organisation. The reason is that the co-operative is an important organisation for the area, not only in terms of managing the power distribution but also in terms of acting as a conflict-solving mechanism for all kinds of societal problems. Some changes have been made recently in the co-operative organisation, for example, one technical employee was recently replaced by an administrative manager. There is no longer any engineer among the co-operative staff.

Many shortcomings still remain though. At times, technical problems occur, which results in losses of power. Roads in bad condition and high maintenance costs are other negative characteristics.

Another problem is the general lack of education among the people in the area. Numerous consumers do not feel as members of a rural electrification co-operative and do not give high priority to electricity. It is estimated that only about 10% of the members have deeper knowledge about the co-operative's activities and objectives. In addition, only a small proportion of the consumers knows how to use electricity in a productive manner.

Recently, a television information dissemination project was launched with the aim to educate and inform the public on proper use of electricity. The co-operative staff has requested the members to pay USD 6 per year to cover the project costs. Some of them are positive about the idea but no decisions have been taken so far. Other major priorities are to increase the information about the idea of the co-operative form of organisation, its objectives and activities.

The expansion in terms of numbers of members is low, about 2%. CEY does not plan any expansions due to financial constraints. The co-operative leaders claim that they have to rely on rural electrification plans formulated by donor agencies. One fund-raising option is to focus on bringing in the tourism into the area.

### 5.8.2 Rural electrification in Mizque, Bolivia[95]

#### 5.8.2.1 General characteristics

The town of Mizque is situated in the Mizque province in the area of Cochabamba. The province is situated 147 kms from the capital in the area, Cochabamba town. The access to the village is fairly good, as the road is partly paved or in good condition the first 10 kms from the capital. The area of Cochabamba is situated in the tropical zone of the country, where most of the coca leaf production takes place. The capital Mizque town has a population of 1,800 (about 600 households). The average density in Mizque province is approximately 13 inhabitants per square meter. During the 1980s, the average population growth for the whole province was 1%.[96]

The economy of the Mizque province is principally based on agriculture and livestock. The major towns of Cochabamba, Santa Cruz and Sucre provide markets for the area's agricultural production. However, this production has declined during the 1990s as a consequence of a decade-long drought as well as high level of out-migration. Incipient economic activities with potential in the Mizque province include viniculture and dairy products. The town uses canals and reservoirs to supply irrigation system with water from the river. [97]

#### 5.8.2.2 Electrification of the area

The first electricity was brought to the Mizque area in 1942. At that time, it was provided by a municipal generator, but only for public lighting, the hospital and the market. However, in 1945, the service was suspended due to technical problems. In 1972, the electric services resumed after nearly 30 years.

*Cooperativa Eléctrica de Mizque* was formed at the end of the 1960s. The residents primarily used electricity for lighting purposes, and secondly for entertainment purposes (television and radio). The commercial use of electricity was mainly for dairy production. In November 1992, the co-operative had 354 members.

The number of connection remained very low during the co-operative's operational years. In mid-1993 there were about 360 members and consumers of the co-operative. In January 1994, before the co-operative stopped its electricity distribution activities, the number of consumers was 262.

#### 5.8.2.3 Generation and distribution

Up to March 1994, the town of Mizque was served by an isolated power station using diesel engines. The system used two diesel generators, one of which was in operation during the last years. The electric system served the immediate areas of the town and ran four hours per evening. During 1993, the average peak demand varied between 60 and 74 kW. The same year, the rate of electricity sold averaged 3,095 kWh98 per month, compared to 6,036 kWh[99] in 1992.

In 1989, a feasibility study for grid extension was initiated by the USAID. This resulted in the setting up of a new system in 1991, in which operations were made possible through donations of new generators by the USAID-funded

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[95] If not indicated with footnote, the data in this section is based on interviews with Marcelo Navia and Fernando Gemio, ELFEC-S.A.M. and Hilda Ocampo, former Secretary of the Mizque cooperative 17/1-19/1 1995.
[96] The World Bank/NRECA. *Beneficiary Assessment of the Mizque-Aiquile subproject* pp. 8-9
[97] World Bank/NRECA, pp. 9-10
[98] According to figures in accounts at the CEM co-operative.
[99] World Bank/NRECA, p. 12

Electrification for Sustainable Development (ESD) programme. The purpose was to inter-connect Mizque with Aiquile town that is located approximately 50 kms south of Mizque, and about 217 kms from Cochabamba town. In order to make the most productive use of the investment of the Mizque-Aiquile project, a loan programme was developed to support productive uses of electricity that will allow users to procure electric equipment in small industry, agriculture and commerce.[100] In the beginning of 1994, about 43.7%, i.e. 262 of 600 households were connected to the isolated grid.[101]

Since 1994, Mizque is inter-connected with the Aiquile town. The 14.4/24.9 kV line is connected to the national grid. Electricity is provided 24 hours/day by ELFEC.

*5.8.2.4 Technical design*

The distribution system was of conventional design. The Caterpillar diesel generator had a generating capacity of 102 kW, and its peak load was about 65-70 during the last year. The capacity of the Scania generator was 80 kW. However, this generator was not in operation during the last years. In 1993, the average load factor of the system was 40%.

The consumers had own house-wiring. Meters were installed in the households/premises and the consumers were metered once a month. A problem was malfunctioning meters, and poor maintenance of them. Meter testing could be carried out at the ELFEC office in Cochabamba town. Other common technical problems were blackouts and voltage fluctuations.[102]

*5.8.2.5 Financing the system*

The former research centre National Institute for the Electrification of Rural Areas (INER) provided soft loans for the implementation of the electrification project. The inital investment cost was about USD 400,000, which if divided between 360 consumers results in USD 1,111 per head. However, this money was never repaid by the co-operative.

Under the Alternative Development Programme, ELFEC and USAID have made re-investments in the local electric system and extended the grid to additional areas. This cost amounts to USD 1,400,000.

The installation costs in the households and premises was USD 70, including connection cable and meter reader. The connection (and thus membership) cost was USD 0.53. Most members did not ever pay these fees though. Similar to the tariff structures of other power systems in Bolivia, the tariff design of the Mizque project was set by the Government. The per unit price of energy was in 1994 USD 0.25/kWh below a monthly consumption of 10 kWh, and USD 0.28/kWh from the eleventh kWh and over. In reality though, the minimum monthly bill for any consumer was USD 2.55, equal to a consumption of 10 kWh. This per unit energy price is about 5 to 7 times that applied in the national systems.[103] The high rate has long been a disincentive to the relatively poor population, although the people place high priority on electrification. It is ranked the second most important commodity after access to water.[104] In February 1993,

[100] NRECA-Bolivia, *Llevande Luz donde no Existe.* (brochure)
[101] World Bank/NRECA, p. 9
[102] Ibid, p. 29
[103] For example, the comparative cost of electricity in La Paz is USD 0.05
[104] World Bank/NRECA, p. 35

the Mizque co-operative sold 4,167 kWh at an operation and maintenance cost of USD 171, resulting in 0.04 USD/kWh.

The system responds to three months of non-payment by cutting off the delinquent consumer's electricity, and ultimately, the consumer who does not pay his/her bill is disconnected and the electricity meter removed. In mid-1993, 13% of the co-operative members were more than three months behind with the payment of their electricity bills. This situation has caused difficulties with the repayment of the co-operative's loans from the government.

*5.8.2.6 Management of the power supply system*

The management framework of the Mizque co-operative was stipulated in the co-operative's by-laws. The Members General Assembly was the supreme authority with decision-making mandate of the co-operative. The General Assembly was entitled to bring all members together once a year. However, in reality, meetings were held more seldom and only a minority of the members participated.

The Administration Council was elected by the General Assembly. The Council included a President, Vice President, Secretary, Treasurer and "Voting Member". The liability of the Administration Council was primary to manage the co-operative's resources by allocating the work among the staff, approve the annual action plans; supervise the fulfilling of the maintenance work etc.

The Vigilance Council, nominated by the Administration Council, was delegated the authority and responsibility to monitor that all the co-operative's activities were followed in accordance with the national Co-operative Law and Electricity Law of the country and the co-operative by-laws and regulations.

Other nominees were a Motorist, an Acquisition of Resources Committee, an Accountant, an Electrician and a Lineman.

Based on monthly meter-readings, bills were collected at the co-operative's office and paid there or at the consumer's house. Non-payments of bills was a rather common problem and the billing system was disorganised and lacked rigorous control.

No training courses were held for the co-operative members although there were some technical schools nearby, and some of the villagers had technical education.

In general, the management of the co-operative was very poor. The leaders were not committed to the co-operative's activities. This resulted in problems such as misuse of the co-operative's funds; poor attendance of public meetings; and lack of staff commitment to the co-operative's businesses. There was a low level of education among the co-operative leaders as well as the consumers. No practical measures were taken to overcome problems of low load factors and technical losses as well as the poor maintenance of the isolated system. The scarcity of funds inhibited the co-operative's activities further. Neither were there any information about proper use of electricity and general concerns of the co-operative.

The relations with other collaborating partners were fairly limited. The co-operative had a contract with ELFEC and one with NRECA. According to the former Secretary of the Mizque co-operative, no support was provided from the Government which always charged the pending costs on schedule.

*5.8.2.7 General experiences and tendencies*

The Mizque electrification co-operative experienced many problems during its active period. A study of the Mizque electrification project produced under The World Bank's Beneficiary Assessment project in 1993 showed that people were dissatisfied with their electricity service, and believed that an integration into ELFEC´s system would have an important impact on their electricity service.

There are some key factors contributing to the members' dissatisfaction about and mistrust of the co-operative, and the following decision to relinquish its power supply activities: Limited hours of service was subject to complaints and technical problems such as frequent black-outs and voltage fluctuations were reported to affect the use of electricity negatively.[105]

According to ELFEC, the main reason for the failure of the co-operative was that it did not expand the system, another reason is that profit-making uses of electricity were not promoted sufficiently that the co-operative could repay the initial investment loans. The leadership made limited attempts of reaching out to people through information dissemination of proper electricity use etc. The revenue collection system was also inappropriate to consumer needs in the sense that they were somewhat mistrustful about the accuracy of billing and recording of payments. The electricity consumers found that frequent tariff fluctuations make budgeting expenses impossible. The reason for such fluctuation is the power utilities´ need to adjust tariffs in *Bolivianos* to maintain a fixed dollar value of their income.

In February 1994, the Mizque electrification co-operative handed over its responsibility of the distribution system to ELFEC. Subsequently, the electric system of Mizque became subject to inter-connection with Aiquile and thus connected to the national inter-connected grid. Prior to ELFEC´s taking over, the general attitude among the citizens was positive to the shift of responsibility and the extension of the system. The expected improvement in management of the system reflects the dissatisfaction of consumers in Mizque and Aiquile with their previous locally managed systems.

Today, most of the consumers believe that the inter-connection with a system centrally managed by ELFEC will have beneficial impact on their power service in the long term. Some expected improvements from both the local people and ELFEC, are enhanced power reliability and enforcement of revenue collection. The programme on productive uses has so far not yielded significant results.

ELFEC is planning to place a solar energy project in the Mizque area. 10,000 to 15,000 solar panels will provide additional electricity to the area. ELFEC envisages that there will shortly be around 2,000 electricity users in Mizque.

### *5.8.3 Rural electrification in Capinota*[106]

*5.8.3.1 General characteristics*

Capinota is located in the area of Cochabamba, about 50 kms from Cochabamba town. There are about 10,000 people living in the Capinota township. Access to

[105] World Bank/NRECA, p. 35

[106] If not indicated with footnote, the data in this section is based on interviews with Marcelo Navia, Fernando Gemio, ELFEC S.A.M. and Toribio Rocabado C., Manager of the Capinota cooperative 17-19/1 1995.

the village from the Cochabamba town is quite good. The area of Cochabamba is a tropical zone where much of the coca production activities are situated.

Capinota township is a low-income area. Most of the population are engaged in the agricultural sector, or are employed at the local cement factory. The factory is the principal source of financial activity in Capinota.

*5.8.3.2 Electrification of the area*

Electricity was brought to the township of Capinota through the formation of *Cooperativa de Servicios Electricos Capinota Limitada* in 1969. The co-operative started its commercial operations in the beginning of the 1970s with 121 members. Electricity in the area was also expected to increase the efficiency in cement production at the factory. The factory also provided the productive use of electricity in the project area.

In January 1995, the number of co-operative members and consumers was 1,600. The number of consumers remained relatively even during the operational years. In the beginning of 1995, the peak electricity demand in the village amounted to 120 kW. The members' electricity consumption averaged 18 kWh per month. Power supply services in Capinota will soon be taken over by ELFEC.

*5.8.3.3 Generation and distribution*

Already during the period of local management, the distribution system was connected to the national grid, and the co-operative purchased electricity from ELFEC. According to the agreement with ELFEC the contracted maximum delivery was 500 kW and was to be purchased solely from the utility.

The main transformer in the system's capacity is 500 kVA, 24.9/6kV. The transmission line from the substation is 7 kms. At the end of 1993, the peak load in the system was 120 kW. Electricity was available only during 07.00 p.m.-11.00 p.m.

A rehabilitation project is being implemented to replace the old distribution system, including installation of a new 115/24.9 kV substation, and extension of the electricity services to neighbouring communities in the vicinity of Capinota.

*5.8.3.4 Technical design*

The electricity supply system is of a conventional type. The mills have three-phase connections, while others have single-phase connections. The clients had meters and house-wiring installed. Installations were made by the co-operative and paid for by the consumer.

Technical problems in the system ocurred frequently, and resulted in poor power service and increasing costs. Typical problems were conductors in bad condition, and overloading of the system. The voltage level was 220 V, but the consumers did not receive more than 190-195 V. The load factor was low, about 37%.

*5.8.3.5 Financing the system*

The initial investment cost for the project was USD 300,000, which was provided by the Government as a soft loan. The total investment costs per consumer after five years in operation was approximately 650 USD. The loan has so far not been reimbursed.

The co-operative business was never financially viable. In the 1980s, the Capinota co-operative became constantly deficit making. Even the running cost was difficult to cover and the co-operative frequently found themselves in a debt situation with ELFEC as a result of its inability to pay for the power. Consequently, there was no money available for training and promotion programmes of productive end-uses of electricity. No financial support was provided later in the project. The co-operative had difficulties with funding the operation and maintenance costs.

The tariff rate was, like in other Bolivia electricity systems, set by the Government. Similar to the Mizque project, the cost of electricity was five to seven times higher per kWh than the primary rural tariff in the country. In Capinota, there were two different categories of consumers, domestic and industrial. However, both groups were charged the same cost per kWh, USD. 0.25. The clients also had to pay for the house-wiring, and meters, at the latest 24 months after connection.

USD 782,000 is being invested in new installations under the new rehabilitation project. USAID finances 80% of the total project cost and ELFEC provides the remaining 20%.

*5.8.3.6 Management of the power supply system*

The co-operative's activities and the rights and obligations of the members were stipulated in the by-laws. According to the by-laws, Members Meeting was to be held every six months. However, meetings were not held on a regular basis. About 30-60 members usually attended these meetings, others did not pay attention to them or did not even know about them. The lack of interest and low attendance of meetings was perceived as a problem by the co-operative leaders. No serious attempts were made to reach the local people in order to prevent this problem.

By and large, the by-laws were not properly enforced. In fact, only a small number of the co-operative members were conscious of their rights and obligations as a consumer as well as the objectives and activities of the co-operative.

There were ten Directors, each of whom was responsible for his own area of activity. In addition, there were three Secretaries, two Linemen (Engineers) and one Meter-Reader. Only the Manager was paid. Besides the linemen, there were no technical personnel in the co-operative.

The co-operative functioned well in the beginning, but there was no proper follow-up of the project. The debt situation inhibited the co-operative's possibilities to operate, maintain and expand the system as required. Neither was it feasible to fund appropriate training programmes. The leaders were not able to reduce the high service rates due to inadequate technical capacity among the personnel. At times, ELFEC provided some informal technical training of the local staff, but the co-operative was charged for it. The General Manager of the former co-operative claims they could not afford arranging training programmes for the personnel and the members. The general lack of education and training was particularly apparent in situations when technical troubles occurred. For example, when the transformer broke down, they simply had to wait until ELFEC came to repair it.

Meter reading and revenue collection was carried out once a month. A frequent problem though, was the delayed payments or non-payments of electricity bills. In the case of non-payment, the household or premise was meant to be disconnected after one month. However, in reality this was not done until after 6 months.

*5.8.3.7 General experiences and tendencies*

The Capinota co-operative was running fairly satisfactory during its first years in operation. After the initial period, technical and administrative problems occurred. The dissatisfaction was evident, and no consumers opposed the idea of ceasing the electricity supply activities.

The main reasons for the failure of the Capinota co-operative resembles those of the Mizque project:

- Inadequate tariff rate structure;
- Inefficient administration and institutional weaknesses;
- Electricity supply only during 7 p.m. to 11 p.m;
- billing and revenue collection systems were not designed with respect to local needs and variations in paying ability.

Since February 1995, the distribution of electricity in the Capinota area is under ELFEC´s responsibility. ELFEC´s objective is to improve the quality of the service provided their clients and increase their coverage in urban as well as rural areas. ELFEC is a semi-governmental agency, but will soon become 100% privatised.

Just like in the case of the Mizque co-operative, the former members of the Capinota co-operative believe the taking-over by ELFEC will have beneficial impact on the electricity services.

Since 1994, the Capinota distribution system is subject to a rehabilitation project. It was designed to completely replace the old system in the community, install a new substation, and to expand the electricity services to neighbouring communities in the vicinity of Capinota. The total project cost including the costs of a new 115 to 24.9 kV substation, will be approximately USD 782,000, with USAID financing 80% and ELFEC 20%. The project will provide additional power capacity to the local cement factory. Moreover, it will provide improved electric service to other small industrial and commercial consumers, as well as residential consumers. The system will connect 2,300 consumers, thereby benefiting around 10,000 people.

The members will retain the co-operative form of organisation as a base for local management of other activities. Most likely, they will focus on promotion of the agricultural sector in the region.

### *5.8.4 Rural electrification in Santa Cruz* [107]

*5.8.4.1 General characteristics*

Santa Cruz is one of nine areas in the central and eastern part of Bolivia. It is situated in the tropical zone of the country. The whole area has a population of about 1.2 million people, of which 600,000 live in the countryside. The town of Santa Cruz is the fastest growing in South America. The income of the inhabitants in Santa Cruz is significantly higher than the average income of Bolivians. The region has fairly well developed industries and commercial businesses such as petroleum based industries and cellulosa industry.

[107] If not indicated with footnote, the data in this section is based on interviews with Eduardo Elder S. Planning Manager and José Kreidler G. General Manager of C.R.E. 20- 23/1 1995.

*5.8.4.2 Electrification of the area*

*Cooperativa Rural de Electrificación Ltda* (CRE) was founded in 1962. In 1965, the co-operative was authorised by the national power utility ENDE to distribute electricity in the town of Santa Cruz as well as in the adjacent areas. The primary objective of CRE is to provide electricity for particular consumption to the public in all urban and rural areas in the area of Santa Cruz. CRE has a service area covering 375,000 square meters. About 85% of the area is electrified (albeit the same proportion of people is not connected to the grid).

In the 1970s, the CRE participated in the Project of Rural Electrification Phase One, funded by the USAID, NRECA and the Government of Bolivia via ENDE. Thus, C.R.E. has been supported by the American agencies for about 25 years. The initial focus was to provide electricity to the town of Santa Cruz. Since then, the decentralised systems, Valles Cruceños and Cordillera, have been constructed and expanded throughout a large area of the area.[108]

Today, the co-operative provides electric services to 165,500 consumers and members in the area, of which 161,000 are within the Santa Cruz integrated system. Herewith, in terms of number of consumers, it is the largest co-operative in the world. The distribution system is expanding rapidly. Today, consumers average power consumption amounts to 212 kWh/month in urban areas and 78 kWh/month in rural areas. Accordingly, in the isolated Valles Cruzeños system is 39 kWh per month, thereby improving from 34 kWh in 1994.

*5.8.4.3 Generation and distribution*

The total peak demand in the three CRE systems was in November 1994 about 150 MW. The peak demand in the main system was 146 MW, whereas peak demand in the isolated system was 4.5 MW. The main system has four substations. It also gets power from a generating plant in the south-eastern part of the service area. The electricity is received from ENDE at 25 kV. Electricity is provided 24 hours a day. The amount of delivered bulky power is based on request.

In the isolated system of Valles Cruceños, there is one gas fired power plant in Mataral. Its installed capacity is 1,740 kW. The Camiri power plant, generating power in the Cordillas system has nominal capacity of 4,400 kW. Total line lenghts in the systems are approximately 400 km for Valles Cruceños and 130 km for Cordilleras. Altogether, the distribution system that CRE services is 4.800 km.

Within the Santa Cruz integrated system, the main rural electrification has been implemented in the north, i.e. up to 180 kms from the town. Another 180 kms extension has been made to San Juan in the west. The growth rate of additional consumers is 11% per year.

From November 1993 to November 1994, C.R.E. sold 652 GWh in the integrated system and 1.2 GWh in Valles Cruceños.

*5.8.4.4. Technical design*

The distribution system is designed according to US standards (REA). All consumers are metered. The meters are the property of the co-operative. House-wiring is beyond CRE´s scope. Internal installations is done by private, skilled people. The equipment has to be sent to CRE for approval before installation.

[108] C.R.E, *Carta de Intenciones*, annex 5.

The average system load factor is 60% among the urbans clients and 50% among the rural clients. The residential load growth factor is 14% and in the industrial category about 19%. In the valleys (Valles Cruzeños) the load factor growth amounts to 35%.

The most common wood used for poles is *cuchi*. It is known to be very dense, hard and durable wood which last up to 30 years. The tree has been abandoned in the eastern part of the area though. After NRECA brought in a conservation expert who claimed that the tree was threatened. Future plans for CRE includes introducing underground cables.

One of CRE´s programmes addresses the problem of voltage losses. CRE has software which shows the voltage levels in the whole system. A new cost reduction programme was recently launched by CRE. A firm of consultants, Strategic Energy Efficiency Association in Miami, is contracted to prepare software to optimise the place and size of the transformer. Separate from the three distribution systems, CRE have introduced 91 PV-panels for the provision of electricity to 100 households in Brecha Casarabe. During November 1994, the photovoltaic system generated 564 kWh [109]. Another 1,300 PV panels are planned for. Also, CRE has erected the countries first wind turbines for electricity generation in Parque Eólico. Three sets each rated 0.5 MW have an estimated annual production of about 4,000 Mwh. However, up to date, the wind turbines are more or less for demonstration and research. Both NRECA and GTZ (Germany) are involved in those projects.

### *5.8.4.5 Financing the system*

The investment costs of Santa Cruz integrated system was USD 83,379,000 by December 1994, resulting in a total investment cost per consumer of USD 518. Investment costs in the Santa Cruz integrated system are all in distribution since generation is provided by the state utility. The generation and distribution costs of the Valles Cruzeños isolated system is USD 3, 479,000, which corresponds to USD 765 per capita. For these systems, no donations have been offered, but loans have been provided by USAID through NRECA. In the 1970s, NRECA provided USD 5 million for the first phase of the rural electrification programme. Later, CRE purchased the debt from USAID. In 1984, CORDECRUZ (the Regional Development Corporation of Santa Cruz) provided USD 5 million for the implementation of the project. The money was provided as a loan which was to be reimbursed within 15 years. Of this sum, about 0.5 million was donated. For this money, C.R.E. implemented some non-feasible projects which where approved by CORDECRUZ. This loan is entirely paid back today, but the financial situation of CRE was difficult in the mid-1980s due to repayment of loans and interests. Another USD 1.5 million from USAID is devoted for generation investments and USD 350,000 for reparation costs for engines in Camiri. USAID has also committed USD 100,000 for a productive use programme.

The operation and maintenance costs are financed through the connection, membership and tariff fees. During November 1994, total energy sold by CRE amounted to 63,815,500 kWh, of which 98% was sold within the integrated system. CRE's costs [110] for delivering energy in Valles Cruceños are about three times higher than in the Santa Cruz integrated system. In Santa Cruz, expenditures

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[109] CRE, Estadistica de Produccion, Noviembre 1994

[110] Ibid. (Includes: Gastos de explotacion, Gastos de administracion, Gastos de Comercializacion, and Otros gastos.)

amounts to USD 0.038/$kWh_{sold}$, compared to USD 0.11 /$kWh_{sold}$ in the valleys (USD 0.054/$kWh_{sold}$ in the Cordillera system). For the same period, average tariffs applied in the three systems were: USD 0.068/kWh in Santa Cruz, USD 0.16/kWh in Valles Cruceños and USD 0.076/kWh in Cordillera. The membership fee is USD 10. The connection fee is USD 400 if paid in cash, and USD 500 and USD 600 provided that reimbursement is made within five and ten years respectively. In the Valles Cruzeños valley, the cost is USD 500 if repaid within 20 years.

There are as many as nine tariff categories in the Santa Cruz integrated system. Residentials pay in the order of USD 0.05/kWh in the integrated system, while they pay about USD 0.14-15/kWh in Valles Cruceños. Further in the integrated system, General 1 category is applicable to schools, public offices etc and is charged USD 0.07/kWh in round figures. General 2 is commercial consumers category, which are charged around USD 0.10/kWh. Industrial 1 are industries supplying themselves from low tension grid for up to 10 kV. They pay approximately USD 0.04 /kWh, and USD 1.4 per kW. Industrial 2, i.e. large industries furnishes between 10-25 kV, are charged USD 0.04-5/kWh and USD 2.7 per kW. Farmers pay USD 0.07/kWh and USD 1.4 per kVA. The public lighting cost is USD 0.073/kWh while the special category, i.e. larger hotels pay USD 0.05-6/kWh and USD 3.6/kW. The 173 water co-operatives in the integrated system are charged USD 0.088/kWh. The Valles Cruceños system have four categories in addition to the residential. Those are: General, paying USD 0.16/kWh; Small industrial, paying USD 0.14/kWh; Large industrial, who is charged USD 0.12/kWh plus USD 5 per available kW; Public lighting, with an electricity price of USD 0.15/kWh. [111]

The tariff structure is not designed as to maintain a high load factor, but CRE is considering the possibility of adjusting it accordingly. In new settlements of the growing town of Santa Cruz, the cost is USD 100 /person for electrifying the area. There are no penalty fees for non-payment delinquencies. Instead, the delinquent consumer is disconnected after two unpaid bills. The reconnection fee is USD 0.50. There is no penalty for illegal consumption.

Billing system requires 20 days of work, i.e. 10 of reading the bills and 10 days of sending them. A Payment Centre has been established to make the process more efficient.

Unlike most other electrification co-operatives in Bolivia, CRE´s activities are profit-making businesses. However, as the Co-operative Act prohibits co-operative profit-making businesses exceeding 9%, CRE uses its additional income for new investments and to expand the system into new areas.

*5.8.4.6 Management of the power supply system*

Like other co-operatives in Bolivia, CRE´s objectives, activities and the management framework are stipulated in the co-operative's by-laws. The activities of CRE are of a magnitude that is comparable to power companies in Bolivia. The co-operative is a large organisation with 480 permanent employees. About 10% of them are professionals. The management level consists of the member's General Assembly, the Administration Council (the directive and executive agency altogether 12 members), the Vigilance Council, and its advisers. The responsibility of the Assembly is to elect the representatives of the Councils and the Special Commissions, to consider, approve, observe or reject the government

[111] Tariffs valid from May 01 1994.

finances, and the memoranda of the Administration Council and other task established in the Letter of Convocation. CRE´s consumers are all members with right to vote and to become elected.

The General Manager has the responsibility to execute the decisions taken by the Administration Council and the subordinated following managers: Manager of Engineering and Planning, Administration Manager, the Manager of the North District and the Manager of Santa Cruz district. Subordinate to them are the Directors/Wardens (varies between two up to six per Manager). All staff has to report regularly to the General Manager.

Besides the by-laws, CRE also relies on the Manual of Description of Functions. This Manual describes the functions and attributes of all its main bodies up to the level of the Directorate (at medium level). At local level, there are District Boards of three members which constitute the voice of the CRE consumers. CRE has five offices in the distribution area. All planning is made though from the town of Santa Cruz.

With the aim to improve and expand the electric services in the distribution area, CRE activities include five sub-projects. A large proportion of assistance to the projects is provided by USAID under the Electrification for Alternative Development Programme (ADEP) which is run by NRECA. The USAID has assigned a great share of the programme's funds to CRE. The ADEP was implemented from February 1992 to January 1993. NRECA provides various alternatives of technical assistance and necessary equipment and material totals USD 1.63 million.

The Valles Cruceños Project is one of CRE´s five project activities. The purpose of the project was to provide electric supply to the Valles Cruzeños through inter-connection between various villages in the area. The participating institutions NRECA, CRE and CORDECRUZ provided funds necessary to install gensets, to construct new lines, distribute and to connect in order to improve the electric services. CRE is the owner of the electrical system and hence it is responsible for the administration, operation and maintenance of the system. NRECA has obtained the equipment for installations of the gensets with a capacity of 2.5 MW for which the NRECA/Bolivia disbursed USD 1.3 million. At the same time, the partners have established a productive use programme to promote the electricity consumption, which were expected to yield income. NRECA provided 100,000 USD intended for the establishment of a revolving fund which should provide loans to the users of productive use of electricity. The ultimate goal was to increase the productivity, the income and employment opportunities of the commercial activities, industries, and the agriculture existence. [112]

CRE has also established a small co-operative-managed electrical store, CREAGRO. This is a pilot project which is a totally new experience in Bolivia. CREAGRO was established in 1994 in Mairana village with the purpose to promote the use of productive uses of electricity throughout the Valles Cruzeños project. The shop offers electric machinery, electric pumps and domestic appliances as well as provides the necessary technical assistance to local CRE members. Members can purchase electrical equipment and household appliances on credit to improve their production and standard of living. This part of the programme required a capital investment of USD 200,000, financed in equal parts

[112] CRE, *Carta de Intenciones*, annex 5

by USAID/ESD and CRE. NRECA has provided the technical training and assistance. CREAGRO is considered as being a great contribution to the promotion of electricity use within CRE.

The second project, named Training and Technical Assistance consisted of the realisation of a feasibility study performed by NRECA and CRE with the aim to establish a Technical Assistance Programme and a Training Center (a fund) etc. NRECA provided expertise by having a specialist in this field which co-operates with CRE. USAID through NRECA has financed 40,000 USD for this project. [113]

The "Isolated Systems Project" aims at providing electricity to consumers in isolated areas through harnessing of renewable technology. This is a pilot project, which determine the feasibility for this type of service. 91 PV panels has been installed and another 1,300 panels are being purchased. Moreover, CRE has an agreement with the Dutch Government to invest in another 5,000 solar panels. Wind energy is also considered of high interest, and CRE has installed some initial wind farms. NRECA provides a total of USD 125,000 in technical assistance for designing a wide program that includes maintenance, financing (loans) and co-ordination with the development agencies in other countries. [114]

For the fourth project, called Camiri Electric System Project, the participants have made a feasibility study in order to find solutions for reorganising the Camiri Co-operative, COSELCA. The purpose was to seek ways to improve the problems of the gensets and distribution networks, as well as in the operation and maintenance of the system. NRECA has provided 12,000 USD aimed for hiring of an expert that evaluates both the gensets and the distribution network. [115]

In the fifth project, "Load Management Project", the partners were carrying out a study in order to reduce the load and the peak hours in the Santa Cruz City. They were to find characteristics of the load in all sectors of electric energy consumption to reduce the electricity load those days when there is notable increase. The value of the project was estimated to 50,000 USD and was disbursed by NRECA. [116]

#### *5.8.4.7 General experiences and tendencies*

In a number of ways, C.R.E differs largely from many other rural electrification co-operatives in Bolivia. CRE is not strictly a *rural* co-operative, it includes both urban area, i.e. the town of Santa Cruz, as well as rural parts of the Area of Santa Cruz. It operates more like a power utility than a co-operative. It is also probably the biggest co-operative in the world in terms of number of consumers. And unlike other rural electrification co-operatives in Bolivia, CRE runs both a grid-connected system and isolated generation systems.

Without doubt, CRE is the most successful co-operative in Bolivia. In 1994, the economic growth was 13.8%, an indication of the co-operatives' success. A main reason is that CRE also serves the urban centres of Santa Cruz. The town is large, and there is the extensive use of electricity for commercial businesses. The revenues from the urban areas easily cover the high costs of electricity service in the rural parts of the area. Most of the income is devoted to new investments and extension of the electricity services. There is also a steadily growing energy demand among the consumers.

[113] ibid
[114] ibid
[115] ibid
[116] ibid

CRE is successfully co-ordinated with other development programmes. By collaborating with CORDECRUZ, rural development initiatives are efficiently implemented. CORDECRUZ has also funded some of CRE´s activities. For example, CORDECRUZ has provided USD 2 million only for the Valles Cruceños electrification project.

Important reasons for CRE´s success are the proper management of the co-operative: the sound and broad approach towards extensive rural electrification in the area and the external assistance provided by above all USAID, NRECA and CORDECRUZ.

CRE also focuses on training and education facilities for the co-operative leadership and its personnel. The skilled and dedicated management staff has assured that the electric services are carried out satisfactory.

Productive uses of electricity is being effectively promoted since the establishment of the CREAGRO store. On the whole, the use of electricity is higher than in other rural parts of the country.

Most likely, CRE will expand substantially in terms of number of consumers and power supply. In addition, CRE seems to focus on new pilot projects based on renewable sources of energy. The environmental concerns are also well considered in the co-operative's future planning.

## 5.9 Conclusions of the Bolivia Study

Bolivia represents the poorest, and probably the least developed state in South America. Nevertheless, Bolivia is rich in terms of natural resources: not only is Bolivia self-sufficient in production of oil and gas, it also exports these energy sources to other countries such as Argentina.

Power supply activities are divided into generation, transmission and distribution of electricity. A relatively small number of power companies is engaged in both generation and distribution or transmission and distribution activities in the country. However, as a means to stimulate competition between enterprises, the newly amended Electricity Law currently prohibits enterprises to undertake more than one of these operations. This is one concrete example of the privatisation and capitalisation policy presently promoted by the Government.

Both private, government-owned and semi-government owned utilities are concerned with the rural electrification in Bolivia. Some of the main actors are the privately owned Bolivian Power Company (COBEE), the semi-government-owned Electric Power Company of Cochabamba (ELFEC), and the government-owned National Power Company, ENDE. ENDE operates the bulk of generation and transmission facilities in the country. COBEE is the largest distribution company in the country, and ELFEC, another large company involved in both generation, transmission and distribution of electric power within the area of Cochabamba. As a step toward privatisation of state-held assets, the government ownership will gradually diminish in these and other utilities.

In general, rural electrification efforts in Bolivia are inhibited by the fact that there is no clear rural electrification programme and limited rural electrification implementation efforts. The electrification index in rural areas is approximately 16%. There is a widespread pessimistic feeling about rural electrification among most power utilities and little faith in the government's commitment to it. Indeed, many representatives agree that there is an apparent lack of commitment from the government side, but above all, the pessimism origins from sad experiences gained from rural electrification projects in the country. Many projects have grappled with internal problems, such as poor management, very high financial losses and inadequate tariff structures.

The co-operative is the most common form of organisation for locally managed rural power systems in Bolivia. The history of rural electrification co-operatives dates back to the 1960s, when USAID through NRECA introduced them in the country. The rural power generation or distribution systems were handed over to the co-operatives after which they were left to run the activities without qualified personnel.

There have been over 180 rural electrification co-operatives spread throughout the country, but the approximate amount today is 120. In fact, the number has reduced by 30% over a three-year period. The current tendency is thus that the number of existing co-operatives is reducing, whereas the size of the co-operatives and their distribution systems is increasing. Those co-operatives who cease to exist are normally taken over by private companies or swallowed by a larger co-operative in the nearby. In Mizque, for example, the former electrification co-operative ceased to exist in February 1994, after which ELFEC became in charge of the local power distribution. The number of successful co-operatives in Bolivia is estimated to about five to seven, while the rest are running more or less with difficulties.

The main problems of rural electrification co-operatives in Bolivia are the following:

- Lack of government priorities to rural electrification. There is no clear rural electrification programme in Bolivia. No government incentives such as soft loans, grants, subsidies or technical assistance etc. are provided to locally managed power schemes. Electrification has mainly been confined to urban areas where projects more easily achieve financial balance.

- Rural electrification activities are largely dependent on foreign aid, particularly assistance by USAID and NRECA. Between 1970 and 1980, the American agencies withdrew the development assistance from the country due to political reasons. Consequently, during this period many co-operatives lost the only external support they got, leaving them too weak to survive.

- The associated national laws are poor and not strictly followed. In fact, very few members of the co-operatives are familiar with the co-operative's rights and obligations. Neither of the laws are being enforced by the Government.

- Inadequate tariff structures. The tariff is approved by the government and kept within a certain range from USD 0.05-0.06 (in La Paz) up to 0.35. A problem is that the tariffs are usually too low to cover the investment costs of a rural electricity system. In Mizque, the villagers are very poor, while the cost for electricity is high, USD. 0.26 (0.40 in 1992). Many people could therefore not afford being connected or paying the bills. Consequently, the co-operative could not even cover the running cost from time to time, such as purchasing diesel for the generators.

- A government law limits profit-making activities for co-operatives in the country. Like other kinds of co-operatives in the country, rural electrification co-operatives are not allowed to make a profit exceeding 9% of the annual investment costs. Smaller co-operatives that are not expanding or developing their activities may have difficulties to fund money for future rehabilitation.

- Inadequately qualified personnel to run the rural power system. In Mizque, for example, there was no technical expertise among the operators in the beginning. When the machines broke down, the operators could not always repair them themselves. In Capinota, there have sometimes been problems with the transformer. When it broke down, they simply had to call ELFEC to come and repair it as there were no technically skilled people among the members.

- Delayed payment or non-payment of electricity bills. In the Mizque project this problem resulted in revenue losses for the co-operative. Consequently, they could not afford purchasing diesel for the two generators.

- Lack of incentives for co-operative employees. There is little encouragement for engagement in the co-operative activities. A common problem is the low salaries provided the operators and the administrative personnel. In Capinota, the Board of Directors are employed without getting paid. According to the by-laws, the co-operative is supposed to change its staff every year. This is not fulfilled, as there are very few consumers willing to take over the duties.

- Inadequate commitment to the project from the co-operative leadership. In Capinota, especially during the first 10 years, the Board did not pay attention to problems such as poor technical and administrative training and education among the co-operative employees. The importance of creating awareness of the co-operative business has usually been ignored. Strong co-operative leadership has proven to be fruitful for the CEY co-operative. The leaders have successfully focused on bringing down the tariff rates and improving the electric service. Despite the fundamental long-term constraints, the consumers are more satisfied now than they were only five years ago, and the number of co-operative members is increasing.

- Lack of funds to operate, maintain and expand the electricity system. This problem was evident particularly in the Mizque co-operative and the Capinota co-operative. However, as ELFEC has taken over of the operation of the Mizque power system in March 1994 and Capinota system in February 1995, new funds have become available for investments in the respective systems. The reason is the present tendency to support private management power systems in the country. NRECA co-operates more and more with ELFEC in rural electrification projects. In the case of the Capinota and Mizque, NRECA provides 80% while ELFEC provides the residual 20% of the costs for rehabilitation of the Capinota power system and the inter-connection between the villages Mizque and Aiquile. During the first year under ELFECs´ management, the Mizque system has experienced improvements in forms of new equipment; no non-payments of electricity bills; expanded system which now allows for waterpumping; and better education. In 1988-1989, CEY also grappled with administrative and maintenance problems.

- Poor book-keeping and administrative management. A previous problem in Capinota was poor budget planning and poor control of the accounts. Money could easily be spent for other purposes, which also occurred occasionally. Lack of administrative management was also salient in the Mizque co-operative and up to five years ago in CEY.

- Lack of members' awareness of the co-operative's objectives and activities. This was particularly evident in the former Mizque co-operative, where some members did not even know about the co-operative's existence. The CEY co-operative, on the other hand, has grown to become an important social organisation for the people in the area, i.e. not only as a forum for electricity purposes, but also for dealing with other social issues. General meetings are seen as important instrument to the local society. The national government wants CEY to become privatised, but the CEY members want to maintain the co-operative idea of organisation.

- By-laws are not properly enforced. All co-operatives studied in Bolivia have had by-laws stipulating that general meetings should be held on regular basis and voting should be vested by membership. In reality, few general meetings are held regularly, if ever. Furthermore, few members attend these meetings and therefore are not in a position to vote. This problem was prevalent particularly in Capinota and Mizque. In the same co-operative projects, many people had not even been aware of that the by-laws existed.

There are also some more successful rural electrification co-operatives in Bolivia. We visited one of them, CRE in the area of Santa Cruz. CRE is not strictly a *rural* electrification co-operative as it covers both urban and rural areas of the area of Santa Cruz. This is probably the reason why CRE has grown so strong: The cost per delivered kWh is lower in the town of Santa Cruz than in the rural areas (USD 0.038 and 0.11 respectively). Moreover, the income level of the urban dwellers is much higher, wherefore the co-operatives have applied cross-subsidies in their service area. CRE is well equipped and properly managed. It is expanding both in terms of area covered, installed generation capacity, members and activities. CRE is also an outstanding example of an electrification co-operative which is seriously trying out new alternative sources of energy in pilot areas, such as PV, wind power and biomass technologies.

There are also some general findings of more technical character in the locally managed rural power systems studied in Bolivia. Some noteworthy examples are listed below:

- Most of the rural electric loads are for lighting purposes. Therefore, in many systems single phase distribution is applied to reduce investment costs

- In a majority of distribution lines extended to rural areas, power is distributed at 25 kV. At times, the 25 kV lines are too long and will result in unacceptable voltage drops in the remote areas when the load increases.

- Normally, the distribution company is responsible only for distribution up to the meter. Installations of meters and housewiring lies under the responsibility of the consumer. In rural areas, service connections and meters are provided on credit basis repayable in a two to twenty year period.

- Utility companies and electrification co-operatives do not draw attention to the quality of households´ internal wiring. This has resulted in poor installations and low electricity security in many households.

- Meters are located on outside walls of the premises/houses that can be reached and read by the meter reader without any difficulties. This solution is common within several co-operatives, among them CRE in Santa Cruz.

- Bundled conductor systems are frequently used in some rural power systems, for example in CRE´s isolated system of Valles Cruceños.

- In isolated areas, where grid connection or thermal generation is not favourable, renewable energy sources are being tried. In this sense, CRE is the foremost electrification co-operative in Bolivia.

In 1991, USAID and NRECA returned to Bolivia to support rural electrification activities for a period of at least five years. By providing financial, technical, administrative and institutional support, the American agencies has facilitated the realisation of rural electrification projects. In addition, USAID/NRECA contribute a large part of all investment costs to some of the companies. ELFEC, for example, receives 80% from NRECA for taking over the management of Mizque, Aiquile and Capinota co-operatives.

In the future, it is hoped that government funds channelled through the nine District Governments of Bolivia will be spent on rural electrification in combination with the implementation of other infrastructural programmes, such as constructions of road and irrigation systems. Different areas have different strong and well-organised local governments. Even if funds are available, some of them may not be in a position to electrify their area due to a lack of technical know-how and poor infrastructural planning in general. It is, however, still unclear how the rural electrification will be financed.

At the moment, NRECA is discussing a follow-up project with the Bolivian Government that may be financed by them and a development bank. However, these discussions are still at a preliminary stage. NRECA has also formed a Bolivian foundation that will be supported (but not controlled by NRECA) to carry out their work.

# 6 COUNTRY REPORT: INDIA

## 6.1 Country Profile

India is situated in southern Asia and borders on Pakistan in the north-west, Bangladesh, Burma and Bhutan in the north-east, Nepal in the north-centre and China in north. The total area covers 3.3 million square kilometres. The north of the country is bordered by the long sweep of Himalaya, the highest mountains on Earth. Other parts of the country are surrounded by the Arabian Sea and the Bay of Bengal. India is more like a continent than a country. It is so vast that the climate conditions in the far north are very dissimilar to those of the very south. [117]

India became independent from British governance in 1947. In the same period, the vast British Empire was divided into one Muslim dominated area, Pakistan, and one Hindu dominated, India. India has a parliamentary system of government with certain similarities to the US government system. The central government is relatively strong, but there are also state governments with legislative assemblies. There is a strong division between activities handled by the state government and those handled by the national government. Education, the police force, agriculture and industry are under the state government's area of responsibility. Some areas are jointly administered by the two government levels. [118]

In 1991, India had 866 million inhabitants.[119] The population growth is about 2.1% per year. Indians are not a homogeneous group: the people, the languages, and the customs vary between different regions. The country is also the home of the powerful caste system, although it is weakened today. The major religion, Hinduism, is followed by 80% of the population. The second largest religion is Islam with a following of 10%.[120]

In 1992, India had a GNP of 300 USD per capita.[121] About 75% of the population live in the rural areas. Together, the rural population and the urban poor constitute about 80%.[122] Average life expectancy for both men and women is 58 years. Gross enrolment rate is 81% for women and 98% for men respectively. About 70% of the population is engaged in the agricultural sector. The sector represents 32% of the GNP/year. Industry engages 13% of the inhabitants and amounts to 30% of the GNP. The service sector engages 17% of the population, whereas the GNP of the sector amounts to 38%.[123]

India is relatively dependent on foreign development aid. In 1995, the total development aid is 1.1% of the GNI, most of which are soft loans from the World Bank, International Monetary Fund and Asian Development Bank.[124] In 1990, most of the foreign assistance was allocated to the forestry and agriculture sectors (32%) and the health care/population issues (39%) and the infrastructural sector (23%).[125]

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[117] Crowther, G., Raj P & T. Wheeler, *India, a travel survivial kit* p. 28
[118] ibid, p. 25
[119] Utrikesdepartementet, *Svenskt bistånd 1992/93* p. 160
[120] Crowther. G;... pp.
[121] World Bank; *World Tables 1995*, p.353
[122] Bhagavan, M. R., *"India's Energy Policy into the Late 1980s"*, Economic and Political Weekly Vol. 21, No. 44 and 45, November 1-8 1986, p. 1951
[123] SIDA, *Indien - svenskt samarbete,* brochure
[124] Data from the Ministry for Foreign Affairs I U 2 department, Sweden, March 1995
[125] SIDA..

## 6.2 The Energy Situation

Like many other developing countries, India suffers from energy shortage. The energy demand increases more rapidly than does the energy supply. This is obvious from the fact that notwithstanding a 42 fold increase in electricity production between the years 1950-51 and 1991-92, still leaves a gap of 7% energy shortage and 17.8% peak shortage. In 1993, there was a need to import 26.8 million mega ton of crude oil and petroleum products and 4.5 million mega ton coal per year.[126]

Energy is being used in various forms. Fuelwood, agricultural residues and animal waste are traditional sources of energy that continue to cover the bulk of the energy requirement in rural areas of the country. However, particularly in the urban areas, these non-commercial fuels are gradually replaced by commercial fuels such as petroleum products, coal, natural gas, lignite and electricity. India's per capita annual consumption of commercial energy at 208 kg oil equivalent units corresponds to one-eighth of the world average. The growth in energy intensity of the Indian economy is, however, extremely high, whereas energy efficiency remains very low. The energy policy so far has put emphasis on the expansion of capacity to meet the increasing demand. The past trend in sectoral energy consumption reveals that after industry, transport is the main consumer of commercial energy, especially of petroleum products.[127]

Compared to other developing countries, India has the largest programme for development and utilisation of renewable energy sources. Furthermore, India has rather well developed energy technologies. According to a joint UNDP/World Bank study of 1988, the non-conventional energy systems which were expected to have good prospects in the near term for commercial development and deployment in India are:

- co-generation system using agro-industrial residues, particularly bagasse;
- irrigation-based mini-hydro power plants (i.e. utilising waterflows and head drops in irrigation system) with off-the-shelf equipment available from both foreign and domestic resources;
- and wind farms

All of these technologies are envisaged to be appropriate for grid-interfaced power generation in the near future. Further, India had in 1988 the most field experiences among developing countries in wind-farm energy, acquired through the operation of some 5.5 MW of total pilot installed capacity.[128]

## 6.3 The Power Sector

Electricity plays a crucial role in both the industrial and the agricultural sectors and, therefore, consumption of electricity in the country serves as an indicator of productivity and growth. In view of this, power development has been given high priority in development programmes. The demand for electricity has been growing at a rate faster than other forms of energy in India. While the demand for electricity in the entire economy rose at the rate of 9.7% during 1980-87, the demand in the residential and agricultural sector rose at a rate of 14% and 14.6% respectively per year. The power industry has indeed recorded a phenomenal rate

[126] Research and Reference Division of Ministry of Information and Broadcast, *India 1993* (New Dehli 1993)
[127] Ibid, pp.479-
[128] UNDP/World Bank, Activity Completion Report, India ESMAP report no. 091/88, pp. ii-iii

of growth both in terms of its volumes and technological sophistication over the past decades. The installed power generation capacity in India has increased from a meagre 1,400 MW in 1947 to 81,204 MW in 1992. A problem is, though, that the bulk of the pumpsets, appliances and equipment used in these two sectors are highly energy inefficient. [129]

**Table 5. Statistical data on production, utilisation, installed capacity and consumption of electricity in India, 1992** [130]

| **Net installed capacity of electric generating plant (MW)** | | | | | |
|---|---|---|---|---|---|
| | Total | Thermal | Hydro | Nuclear | Geothermal |
| **Total** | 81,204 | 59,596 | 19,573 | 2,005 | 30 |
| **self prod** | 8,854 | 8,850 | 4 | - | - |
| **public** | 72,350 | 50,746 | 19,569 | 2,005 | 30 |
| **Utilization of installed electric generating capacity (kWh/kW)** | | | | | |
| | Total | Thermal | Hydro | Nuclear | Geothermal |
| **Total** | 4,038 | 4,216 | 3,569 | 3,366 | 1,067 |
| **self prod** | 3,029 | 3,028 | 3,750 | - | - |
| **public** | 3,476 | 2,969 | 4,003 | 3,366 | 1.067 |
| **Production of electricity (GWh)** | | | | | |
| | Total | Thermal | Hydro | Nuclear | Geothermal |
| **Total** | 327,913 | 251,285 | 69,848 | 6,748 | 32 |
| **self prod** | 26,815 | 26,800 | 15 | - | - |
| **public** | 301,098 | 224,485 | 69,833 | 6,748 | 32 |
| **Electricity consumption per year (Gwh and kWh per capita)** | | | | | |
| **Total** | Per capita | Import | Export | | |
| 329,340 | 374 | 1,500 | 73 | | |

Europe average: 5,729 kWh per capita per year

## 6.4 Institutional Framework

There are many government bodies engaged in the power sector in India. The responsibility of the power sector lies both with the Central and State governments. There are some engaged exclusively in the rural parts of the country as well. Below the main actors engaged in the central sector[131] and/or the rural sectors are listed.

### *6.4.1 Ministry of Power*

At the central level, the Ministry of Power is responsible for the development of the country's electrical energy sector. Hence, it is concerned with policy formulation, administration and enactment of legislation with regards to power generation, transmission and distribution, perspective planning, processing projects for investment decisions, monitoring of projects and training and manpower. In addition, the Ministry is responsible for the Electricity (Supply) Act as well as the Indian Electricity Act and undertake such amendments as may be

[129] Research and Reference Division of Ministry of Information and Broadcast, *India 1993* (New Dehli 1993), p. 479

[130] United Nations, *Energy Statistics Yearbook 1992.*

[131] Research and Reference Division of Ministry of Information and Broadcast..., pp. 481-492

necessary from time to time in accordance with the Government's policy objectives. An Investment Promotion Cell has been formed within the Ministry to deal with matters relating to and promoting of private sector participation in power generation, supply and distribution. One of the overall aims is to fulfil the Government´s long-term objectives of narrowing the gap between demand and supply in the power sector.

### 6.4.2 Central Electricity Authority - CEA

CEA is the premier engineering organisation of the Government of India in the field of water resources development. According to the Electricity (Supply) Act, it is under CEA´s responsibility inter-alia to develop a national power policy and to co-ordinate the activities of various agencies and State Electricity Boards (SEB). CEA undertakes pre-feasibility and feasibility studies, investigations, preliminary and detailed design, preparation of technical specifications, providing necessary supervision and guidance for effective implementation of the projects relating to irrigation and drainage, dam and reservoir engineering, hydropower etc.[132] Furthermore, CEA advises the Ministry of Power on technical, economic and financial matters.

### 6.4.3 The Central Power Corporations

Construction and operation of power generation projects in the central sector are entrusted to three Central Power Corporations, namely the National Thermal Power Corporation (NTPC), National Hydro-Electric Power Corporation (NHPC) and North-Eastern Electric Power Corporation (NEEPCO). These are under the administrative control of the Ministry of Power. NTPC was incorporated in 1975 as a thermal power generating company in the Central sector with the main objective of planning, promoting, and organising integrated development of thermal power in the country. NHPC was incorporated under the Companies Act (1956) the same year. Its objectives are to plan, promote, and organise an integrated development of hydro-electric power in India.

The Power Grid Corporation is responsible for construction and operation of transmission lines, substations load despatch centres and communication facilities to move large blocks of power from Central Generating Stations and potential surplus form SEB´s to load centres within the and across the regions with reliability, security, and economy.

The Power Finance Corporation (PFC) was incorporated in 1986 with the purpose to provide finance for power generation projects (hydro and thermal), transmission and distribution, systems improvement, urban renovation and modernisation survey, investigation and training of staff involved in the power development programme. The funds are mainly provided to the State Electricity Boards (see chapter 4.8) and the State Power Corporations. The activities of PFC aim at increasing resources for the power sector and bringing about improvement in operational and financial efficiency during the Eighth Five-Year Plan (1992-1997).

[132] WAPCOS; Consultancy Services in Water & Power development & Management, p.4

### *6.4.4 Energy Management Centre - EMC*

EMC was established by the Government of India in 1989 to act as a focal point for exchange of experience among energy institutes within India but also between India and the European Communities. The Centre is an autonomous body with responsibility for training, research, and information exchanges between energy professionals. In addition, it is in charge of formulating programmes for energy conservation.

### *6.4.5 Ministry of Non-Conventional Energy Sources - MNES*

In 1982, the Government of India established MNES to execute and implement the programmes and policies pertaining to the programme of New & Renewable Sources of Energy (NRSE). Among other things, the Department plans and implements various programmes and introduces solar photovoltaic and small-hydro systems, amongst others, renewable energy sources, for village electrification in remote areas.

### *6.4.6 Indian Renewable Energy Development Agency Limited - IREDA*

IREDA was incorporated in 1987 as the financial and promotional arm of the Ministry of Non-Conventional Energy Sources, of the Government of India. The objectives are to promote renewable energy, to extend financial support to manufacturers and users, and to act as a financial intermediary and to assist in rapid commercialisation. Among other things, it operates a revolving fund to develop and promote commercially viable NRSE technologies in India. IREDA also finances co-operative societies in the country.

### *6.4.7 Rural Electrification Corporation - REC*

A significant step in the field of rural electrification in the country was the establishment of REC in 1969. The main objectives of REC are to "...finance rural electrification schemes; promote and finance rural electric co-operatives; and to administer money received from time to time from Government of India and other sources for financing rural electrification projects."[133] REC promotes rural electrification co-operative projects by giving up to 70% of the capital costs in the form of soft loans. This money shall be paid back within 30 years. So far, the support to rural electric co-operatives has been limited, only 1% of REC´s total financial assistance benefitted rural electrification projects.[134]

Over the years, REC has emerged as a major developmental financial institution at the national level. It has sanctioned financial assistance of nearly Rs. 10,000 crores (USD 3.24 billion) for over 27,000 rural electrification projects in various states envisaging electrification of nearly 320,000 villages and energisation of about 590,000 pumpsets.

Since inception, REC has been assisting the SEB´s in identification of potential areas, formulation of potential viable projects, undertaking of their appraisal, providing guidelines to and exercising constructive supervision over

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[133] I.S. Anand & S.N. Kamra, Rural Electrification Programme in India, p. 1
[134] Interview with Rao, S. & Anand, I.S. & Kamra, S.N. REC.

them through periodical monitoring. REC also carries out training activities for their personnel as well as other government institutions.[135]

### *6.4.8 State Electricity Board - SEB*

In 1994, SEB´s had been established in 18 out of 25 states in India. The Boards are mainly responsible for generation and distribution of electricity in their respective states. They are state government bodies which are centrally assisted by REC although they work independently from it. The SEB´s make the decisions as to what areas should be electrified and also set the tariffs. In addition, the SEB´s have some influence on the organisational settings in the rural electrification co-operatives in that state and at least one board member of each co-operative was until recently appointed by the respective SEB.

### *6.4.9 Water and Power Consultancy Services (India) Limited - WAPCOS.*

WAPCOS is a Government of India Undertaking under the Ministry of Water Resources. The company was set up in 1965 to provide consultancy services for planning and development of water resources in the country. It is the prime organisation established in the public sector to provide consultancy and technical assistance to clients in India and other countries. Its experiences cover planning, design, maintenance, operation and management of all types of water resources development projects. Examples of project activities are: feasibility studies, hydrological studies, environment studies, water management, operational studies etc. [136]

## 6. 5 Government Policies and Regulations

### *6.5.1 Rural electrification policies*

The Government of India has a well developed rural electrification programme on the agenda. The Electricity (Supply) Act (1948) forms the basis of the administrative structure of the electricity industry. The Act provides for the setting up and operation of CEA. In 1976, the Act was amended to enlarge the scope and functions of CEA and to enable the creation of companies for power generation. There is also a Co-operative Societies Act under the Ministry of Law and Justice. The Act stipulates, among other things, the rights and liabilities of co-operative members; duties and privileges of registered co-operative societies; rules for inspection of co-operative affairs and dissolution of societies. [137]

The use of renewable energy for electricity is given increasing priority from the governmental point of view. The Rural Renewable Energy System Programme is designed to integrate a variety of small-scale non-conventional energy technologies into schemes to provide relatively small amounts of electrical and mechanical power to isolated communities. These include solar PV units, biomass gasifiers and windmills.[138]

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[135] Ibid
[136] Interview with Rajappa, R. Chairman & Managing Director, Rai, R.N. Chief Engineer, and other WAPCOS representatives.
[137] Ministry of Law and Justice of the Government of India, The Cooperative Societies Act, 1912.(modified up to the 1st of September 1987)
[138] Interview with Bakthavatsalam, V, Managing Director, & Ramachandram, M. General Manager, IREDA

The Indian Government has recently (1994) constituted a Committee of the National Development Council (NDC) for looking into the various aspects relating to the generation, transmission and distribution of power including alternative and renewable energy sources, energy efficiency and energy conservation. [139]

### 6.5.2 *Privatisation policies*

The Indian Government has been planning for some time to liberalise and to bring in private initiatives into the areas of generation, transmission and distribution of power. In September 1990, the Ministry of Energy announced a policy decision, including certain incentives to attract private sector participation in the power generation. Steps are yet to be taken for opening the power distribution for private and other suitable agencies.

As a means to encourage private investments in the power sector, the Indian Government has amended some of the financial, administrative, and legal aspects in the Indian Electricity Act (1910) and the Electricity (Supply) Act. Since 1990, private companies can set up enterprises to operate either as licensees or as generating companies. These companies can then sell power to the SEBs through a structured two-part tariff with reference to (efficient) operational forms and an optimal plant load factor. The new policy has also raised the rate of return, now allowing 100% foreign equity participation for projects set up by foreign private investors. [140]

### 6.5.3 *Promotion of locally managed electrification systems*

The rural electrification programme also includes promotion of local management of rural distribution systems. The Government has expressed the need for extending electrification to the socially and economically backward and commercially unsuccessful consumers in the country, that is particularly in the rural areas where 76% of the population live. The purpose is to bring in administratively more meaningful and sustainable local organisations which can be responsive to the needs of the consumers.

In this light, rural electrification co-operatives is recognised as being a proper form of consumer organisation in India. One way of promoting rural electrification co-operatives has been to provide financial support in the form of subsidies (40 to 70%) and soft loans. The funding system enables a smooth flow of money from REC to the co-operatives via the SEBs. [141] In addition, REC waives interest charges for the five first operational years to each electrification co-operative. This amount is thought to be utilised by the co-operatives for promotional work like setting up of workshops etc. [142]

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[139] Ministry of Power India 1993
140 Interview with I.S. Anand, Monitoring Chief, REC
[141] Ibid
[142] REC. *Background Material- Workshop on Decentralised Power Distribution Systems under the Auspices of Ministry of Power*, Government of India, p. 140

### *6.5.4 Problems associated with shortcomings in policies: from the local organisations' point of view*

There are some government policies with negative impact on the rural electrification co-operative activities in India. National and political interests determines the direction of the rural electrification programme, what areas to be electrified and what type of organisation should manage the rural power distribution systems. This does not leave much freedom of action for local initiatives on this matter.

The tariff is, as noted previously, set by the SEBs. However, this is commonly pointed out as a problem by many co-operatives, as they do not reflect the individuals systems capital and electricity supply costs.

The flat rate system has also yielded other consequences. In the co-operative societies, the revenue earnings from the agricultural load is only 25% of the total as against the connected load of 59%. This indicates that while the power consumption in the agricultural sector is high, the revenue is very low on account of its highly subsidised nature. According to REC, this is the cumulative effect of the state policy of introduction of flat rate tariff.[143]

## 6.6 Rural Electrification in India

Before India became independent in 1947, electrification was mostly limited to urban areas and a few villages near the larger cities. The main objective of national rural electrification up to as late as 1965 was confined to lighting of villages and rural homes. However, since 1966-69, the programme of rural electrification, with vastly increased outlays, has been geared up to agricultural production.[144] Village electrification is the primary concern in the programme.[145] The first target is to electrify 100% of the villages. Since the end of the 1960s, the level of village electrification has risen from 12,8% to 85% up to March 1994. However, it only requires one single connection for a village to be regarded as "electrified". [146] Based on available statistics, we have calculated that about 23% of the rural households in India have access to electricity.[147]

The remaining 15% unelectrified villages in India offer little load potential, most of them having a population of less than 500 with scattered households. It is assumed that these villages would take considerable time and effort to electrify. Moreover, they require concerted effort to develop load potential to accelerate the process of electrification.[148]

During the 1990s, decentralised electrification programme has gained particular attention, which gives it a prestigious place by the planners in India. The Indian Government aims to enable participation of local level agencies and consumer groups.

Several studies have been carried out by research groups to appraise the impact of the rural electrification programme in India. These studies has revealed that the impact of electrical energy has been noticed in rural areas in terms of increased irrigation intensity, an increase in food production, the setting up of new agro-based industries, and new employment opportunities. In addition, the studies

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[143] REC... pp. 131-133
[144] I.S. Anand & S.N. Kamra, Rural Electrification Programme in India (1994) paper, p. 1
[145] REC, Background material - Workshop, pg. 111
[146] Goud, R.S, "Rural Electrification through Cooperatives" in Yojana (September 16-30, 1989) p.10
[147] Rural Electrification Corporation, Background material - Workshop, p 111: 85% of Indian rural villages are electrified; p 133: 27% of households are electrified in electrified (SEB-)areas.
[148] Ministry of Power. p. 102.

have shown that rural electrification contributes to positive input into agricultural and industrial development.[149]

## 6.7 Local Management in Rural Power Systems

### *6.7.1 Development of rural electrification co-operatives*

The idea of adopting the co-operative form of organisation in the sphere of rural electrification emanates from the growth and development of rural electrification co-operatives in the United States. In the mid-1960s, a study team of USA experts from NRECA assessed the prospects for the formation of rural electrification co-operatives in India and also identified five suitable pilot projects to be set up in different states.[150]

According to the Government of India, the co-operative form of organisation have been conceived because they are better suited to meet the special requirements of rural distribution for an improved consumer service, consumer participation and better load development. Besides this, as an institution with independent control on people, money and material it is especially equipped for spear-headed areas development and function as an effective focal point for co-ordinating the activities of various rural development programmes operating in the areas.

To achieve the goals, the following objectives are assigned to these co-operative societies:

- to extend the electrical network in their areas quickly and economically;
- provide proper services to the consumers taking into account the local situations and conditions;
- support the wider programme of development of the area for increasing agricultural production and stipulating the growth of rural industries; and
- to ensure local participation in the management of rural distribution of electricity.[151]

The immense socio-economic impact of co-operative systems was recognised already in 1982 at the Committee on Rural Electrification Co-operatives (Mathur Committee). The Committee also found that overall physical performance of the co-operatives compared favourably with the SEBs.[152]

### *6.7.2 Financing rural electrification co-operatives*

Since 1969, the financial support provided by REC to these rural electrification co-operatives corresponds to only 1% of the agency's total costs. The total amount sanctioned by REC for project loans is about USD 23.5 million of which about USD 3.15 million (13.4%) is loan to the state governments for contribution towards share capital. Of these sums, about 90% and 96% respectively of the sanctioned loans had been released by March 1994. The co-operative societies had by the same period together electrified 4,129 villages as against the phased target

[149] Interview with I.S. Anand & S.N. Kamra, REC. p.5
[150] Goud, R.S...p.11
[151] Rural Electrification Corporation; Background material - Workshop.. p. 127-128
[152] Ibid, p.141

of 4,257 constituting 97%.[153] The utilisation of the funds has so far been chiefly in accordance with the provision in the respective projects. REC has not experienced any major problems of delayed loan reimbursements from the co-operative societies.

### *6.7.3 Current Status*

Up to date, there are 37 rural electrification co-operatives in India spread over 11 States which are connected to the state grid.[154] They have been closely linked to the State Electricity Boards and their activities have been top-down controlled. Four of them have been in operation for more than 20 years, another 18 are between 10 and 20 years old.

34 of the 37 operational co-operative societies have with their electrification reached 100% area coverage.[155] The level of household electrification in the co-operative society areas is over 50%, ranging between around 25% in the new co-operatives to over 97% in Sircilla society. This figure compares quite favourably to rural household electrification in SEB areas where it is about 27% only.[156]

Despite the modest number of rural electrification co-operatives in India, this form of local organisation has proven to be a relatively successful approach in India. Statistical data reveals that, relative targeted goals, the co-operatives have been more successful in their performances than other REC funded schemes, both in terms of service released per village and density of load in relation to the infrastructure created by them.[157] Table 1 summarises comparisons from the 11 Indian states where co-operatives act.

**Table 6. Comparison between electric co-operatives and other SEB funded rural electrification schemes**

| Issue | Co-operatives | Other SEB funded electrification |
|---|---|---|
| **Services released per village** | 67.0 | 15.6 |
| Pumpsets | 16.9 | 9.9 |
| Industries | 1.4 | 0.3 |
| Other (i.e. domestic, commercial, etc.) | 48.7 | 5.4 |
| **Service connections per km of lines** | 13.6 | 3.8 |
| **Percentage of total load being agricultural load** | 59 | 23* |

* Figure valid for all India

A background paper written for a Workshop on Decentralised Distribution Systems identifies the main factors which have contributed to the accelerated achievements. They are as follows:[158]

1. Smooth flow of money;
2. Localised decision making;
3. Nearness of the societies to the consumers;

[153] Ibid pp. 130-131
[154] An additional rural electrification cooperative exists, but it is not operational any more (REC, p. 130)
[155] Ministry of Power...pp. 131-133.
[156] Ibid.
[157] REC; pp.131-132
[158] REC... p.133.

4. Compact area operation;
5. Active involvement of the consumers;
6. Effective co-ordination with other development and financial institutions operating in the area;
7. Load promotion through consumers education; and
8. Services oriented approach which is ensured by adopting simplified operational procedure tuned to the convenience of consumers, prompt release of service connections, better maintenance system, timely attending to break-down and door steps service release by holding camps, collection of energy bills in a manner convenient to consumers etc.

Notwithstanding the progress of the rural electrification co-operatives, there are still a number of challenges facing a majority of them in the quest for sustainability and economic viability. REC has identified some certain structural problems of theirs:

- they do not have any says on the tariff costs as they are obliged to supply power at the rates decided by the states for the SEB´s consumers;
- the fundamental co-operative principle is missing in the operations of rural electrification co-operatives. They are created through top-down actions - a co-operative is constituted through a departmental effort and the co-operative entity inherits the existing consumers. None of these are prima facie members of the co-operative, nor have they constituted themselves into a co-operative society;
- successful co-operatives (sugar, dairy etc.) in India have bottom-up formations at the time of formation and implementation and are commonly small enough to be meaningfully manageable.[159]

## 6.8 Case Study of India

### 6.8.1 Rural electrification of Lucknow Township

*6.8.1.1 General characteristics*

With a population of nearly 2 million, Lucknow is the capital of the Uttar Pradesh state. It is located in the north of India, about 600 kms east of New Delhi. Uttar Pradesh has over 100 million inhabitants and covers an area of 294,413 square meters. Geographically, the state has significant variations, with high Himalayan peaks in the north-western corner and the vast Ganges plain in the south. Besides Hinduism, there are many followers of Buddhism and Islam in the state. Lucknow is the principal Muslim Shi'ite town in India.

*6.8.1.2 Electrification of the area*

Formed in 1969, the Co-operative Electric Supply Society (CESS) in Lucknow is one of the oldest rural electrification co-operatives in India. The primary objective of the CESS is "to make electricity available to its members at the lowest cost consistent with sound economy and good management" and its secondary

[159] Ibid, pp. 29-31

objective to "...include supply of electric energy to non-members also under areas coverage approach."[160]

The idea of forming the co-operative was based on recommendations from a NRECA team. The area was considered suitable as a pilot area together with four other pilot projects. Since 1971, CESS runs its commercial operations outside the town of Lucknow. Today, the co-operative serves about 55,000 consumers. Power is available 24 hours a day.

*6.8.1.3 Generation and distribution*

CESS purchases bulky power from the central grid by State Electricity Board of Uttar Pradesh (UPSEB). The power is then transmitted to nine substations transforming power from 33kVA to 11kVA, and with a total rated capacity of 45 MVA. Maintenance of substations is included in CESS's responsibilities, although the purchased power is metered on the 11 kV side. From these stations, the power is distributed over a fairly large area. There is no contracted minimum or maximum delivery from the grid, i.e. supply is based on demand. Presently, connected load amounts to 90% of distribution system capacity.

*6.8.1.4 Technical aspects*

The equipment and system design are of Indian conventional standards, origin from British standards. Some of the equipment, 600 km of 11 kV lines, was at place already when the co-operative started its commercial operations. Today, there are 3,800 km lines, all voltage levels included.

CESS is in charge of the service up to the meters in the households/premises. CESS also seeks to avoid reactive power. Consumers having loads less than 2 kW are connected via single phase lines, while others have three phases. One method used to retain a high load factor though, is to disconnect one phase during peak hours.

*6.8.1. Financing the system*

Initially, CESS was provided a loan from the Government totalling USD 1.4 million. The co-operative was not obliged to repay until after five years in operation. Today, almost everything is paid back. The economy is balanced and revenues from consumption cover costs for provision. No external financial support has been provided since the initiation of the project.

The membership fee is USD 0.064. All members are obliged to purchase at least one share at the cost of USD 0.8. In case the connected load consists of machines or similar, the consumer buys two extra shares for each installed horse-power. Consumers also pay USD 18.6[161] for the connection, and USD 0.13/month for meter rent. Energy prices are divided into thirteen different consumer categories. They are: domestic, commercial, public (light, water and workshops), private water pumps, political water pumps, agricultural, industrial (small, medium or large), temporary arrangements (up to seven days) and World Bank power supply. The tariff structure has to be approved by the respective State Government. The overall rule is one state, one utility (the SEB) and one tariff. In Uttar Pradesh, the energy price for domestic consumption is USD 0.04/kWh for the first 100 kWh, and then USD 0.056/kWh. In villages though (less than 15,000

[160] CESS; By-laws of the Cooperative Electric Supply Society Limited, p.2

[161] Consumers pay USD 9 for the connection and USD 9.6 as a security to the cooperative.

people), electricity costs USD 1.12 per moth as long as the load does not exceed 2 kW. Many of the other categories pay for both energy and installed power.

*6.8.1.6 Management of the power supply*

The co-operative relies on by-laws that were adopted in 1970. Every consumer holds membership of the co-operative. The Board members consist of one Chairman, seven Elected Representatives and one Nominated Representative. The Board serves as a policy-making body which acts without renumeration. The co-operative has General Manager, Secretary and Vice Secretary, Senior and Junior Engineers. Besides these employees, there is one Petrolman, and a number of Linemen, Meter Readers and Administrative Personnel. Altogether, there are 317 full-time staff. Their salaries are covered by revenues.

Connection is divided between a number of classes: lighting, commercial, individual, motor, industrial; temporary; and fan-street lighting. All classes need licence for load. The consumer must complete the wiring work and earthing before the line connection. Billing and meter reading is conducted by 12 meter readers. There is the practical problem of collecting revenues in remote areas. The whole process takes about 20 days including computerised billing. In case the members do not pay their bills, they are disconnected after a month. Disconnection is not so common, however.

General meetings are held on a regular basis. A problem is though the members lack of interest in the concerns of the co-operative. Many consumers are critical to the fixed tariff rates set by the state, which are considered being too high. Since December 1994, a new Chairman is steering the Board. To some extent, his commitment to the co-operative has changed people's attitudes in a positive way. During 1995, additional members have turned up at meetings.

*6.8.1.7 General experiences and tendencies*

CESS′ businesses are running relatively satisfactory, according to its General Manager: it has a fairly balanced economy and almost all initial loans are paid back. No external technical or financial assistance is required anymore. The leaders are relatively diligent and committed to the co-operative' activities. The quality of power service is also quite satisfactory. One of the main reasons for the stable situation is the long experience of power distribution. The staff has had the opportunity to learn by doing.

Relations with the State Electricity Board are fairly good, though there are some complaints about the uniform tariff structure. Otherwise, the co-operative does not have close relations with other government agencies, nor does it exchange experiences and information with other rural electrification co-operatives.

During the last 10 years, there have been major changes in lifestyles on account of the access to electricity. One positive outcome is the increased load factor in the system. The income level has also increased in the project area.

The only major problems have been of political character. Many powerful politicians interfere in the day-to-day work of the co-operative which has caused some disputes and delays of the power supply activities. A difficulty emerging from top down control has been to involve the consumers in the co-operative's activities. One result has been lack of attendance on general meetings, although this tendency has become weakened in the past year.

The CESS distribution area is still expanding slowly but surely. In April 1995, one electrification programme was to be launched for another 10 new villages. No external funding is provided. REC will assist the co-operative by providing technical expertise.

## 6.9 Conclusions of the India Study

The Government of India has given high priority to rural development issues, among them rural electrification. In the beginning of the 1960s, the rural electrification was confined to lighting of villages and rural homes in the country. However, since the end of the 1960s, the national rural electrification programme, while expanding to incorporate new remote areas, shifted the focus toward strengthening of the agricultural production in the country. The impact of rural electrification has been salient in terms of additional areas irrigated, an increase in food production, generation of new employment opportunities and establishment of new agro-based and other industries.

National and political interests determine the direction of the rural electrification programme, what areas to be electrified and what type of organisation should run the rural power distribution systems. Both the Central and the State Governments in India are powerful entities but there is a strong division between their areas of responsibility. The Central Government through Rural Electrification Corporation (REC) is in charge of the overall planning of rural electrification and acts as a donor agency. The State Electricity Boards (SEB) are State Government representatives and the implementing agencies: they carry out studies, technical designs identify project areas and advise the villages etc. in their respective state. In 1994, there were SEBs in 18 out of 25 states in India.

In the late 1960´s, the idea of establishing rural electrification co-operatives in India emerged as a result of recommendations given by NRECA. After initiating the formation of the co-operatives at project-level, the Corporation (REC) hands over the system to the local community to run it independently. However, only 1% of REC´s funds has been devoted to support of rural electrification co-operatives. Bearing this in mind, it is not astonishing that the number of rural electrification co-operatives throughout India is only 37. Most of them purchase bulky power from the respective SEB systems, but a few of them generate their electricity locally by diesel generation or renewable energy sources (biomass, biogas, wind and photovotaics etc). Besides the co-operatives, there are not many other forms of organised local management of rural power distribution in India.

The power distribution of most of rural electrification systems in India are under the responsibility of the SEBs. The influence of the SEB´s in rural electrification becomes even more salient when bearing in mind that until recently, they appointed at least one board member in all the rural electrification co-operatives. In addition, each SEB set their own fixed tariff, which becomes valid throughout that state. The inflexibility in tariff structure sometimes lead to difficulties for the co-operatives as the tariff is not based on the operation and maintenance costs of the individual systems. The rural tariffs are, however, always subsidised to about 40-60% of the urban areas. The subsidy system is quite favourable to the co-operatives in India and REC has not experience any difficulties in getting their loans back from the rural electrification co-operatives.

During the 1990´s, the Government of India has put emphasis on privatisation of the electricity sector and a number of initiatives are in pipeline. However, steps are yet to be taken for opening the electricity distribution for the private sector. Other types of suggested local management groups are joint sector companies (semi-governmental) and multi-purpose societies. These organisations are still not operating in the power sector, but are expected to be formed in areas which cannot attract private investments.

The overall performance of the SEB´s has not been very satisfactory and the efficiency of power generating plants has been much below that considered to be minimum viability of such capital intensive projects. On the other hand, rural power distribution based on local management has in general proven to be a relatively successful alternative in India. Statistical data reveals that electrification co-operative societies have substantially better service and density of load than adjacent areas where SEBs are in charge of the power distribution. However, most co-operatives are still not commercially viable and sustainable organisations on account of some structural problems, such as lack of influence on the tariffs, lack of awareness of co-operative principles, intrinsic top-down structure in the co-operative organisation etc.

In comparison to other developing countries, India has a large programme for utilisation and development of renewable energy technologies. There are several government bodies dealing with alternative energy sources which play significant roles in the rural electrification programme, like India Renewable Development Association (IREDA) and Water and Power Consultancy Service (WAPCOS).

Formed in 1969, the Co-operative Electric Supply Society (CESS) in Lucknow, Uttar Pradesh, represents one of the oldest rural electrification co-operatives in India. According to its general Manager, it is running relatively satisfactory: it has a fairly balanced economy and almost all initial loans are paid back. No external technical or financial assistance is required. The quality of power service is also quite satisfactory. The only major problem has been of political character, as powerful politicians interfere in the day-to-day work. A difficulty has been to involve the consumers in the co-operative's activities. One result has been lack of attendance at general meetings.

# 7 COUNTRY REPORT: NEPAL

## 7.1 Country Profile

Nepal is situated along the Himalayan Mountain Range of in southern Asia. The neighbouring countries are China (Tibet) in the north, India in the south and east and Bhutan in the west. About 83 % of the total area of 147,000 km is covered by the Himalayas and other mountains, and there are many isolated communities scattered throughout the foothills of the mountains. The inaccessibility of them hampers attempts to develop the infrastructure and productive base of the country. Those same mountains, however, provide one resource in abundance: water.

The small kingdom is divided into 14 administrative zones. Nepal has a population of slightly more than 21 million. The population is predominantly rural: In 1990, approximately 90% lived in rural areas. The rate of urbanisation is about 4.5 %. The average population growth rate between 1970 and 1985 was 2.7%, which was nearly equal to the annual growth of real GDP during that period. It has however decreased to 2.3% since then.

With a GDP of approximately 170 USD, Nepal is among the poorest and least developed countries in the world. Agriculture is the mainstay of the economy. About 90% of the population is dependent on agriculture activities for their living, and the agricultural sector accounts for 60% of the GDP. Industrial activity is fairly limited, while it mainly involves the processing of agricultural products, such as sugarcane, tobacco and grain etc.

Production of textiles and carpets expanded during the 1980´s and accounted for 85% of the foreign exchange earnings in 1991.

Nepal is heavily dependent on development aid. In 1991, the value of the development assistance amounted to 13.6% of the national GDI.[162] A bulk of the aid is aimed for the agricultural, forestry and fishery sectors (16%) whereas transport sector receives 14% and the natural resources receives 11%. 50% of the development aid is channelled via the Government of Nepal.[163]

## 7.2 The Energy Situation

About 15 % of the world's hydropower potential are found in Nepal.[164] However, far from most of it is tapped already. In contrast to its richness in hydropower resources, Nepal has no exploitable fossil fuel resources and dependence on imports has become both a strain on the economy and a point of vulnerability. Dependence on imported fuels has increased with the expanding economic activities. Fossil fuels imports accounted for 24% of the total export earnings in 1987/88.

In Nepal, where 75% of the people have used wood and cow dung for burning by default is causing serious threat to the so far existing flora and fauna and the ever deteriorating fragile ecology of the Himalayan belt. The demand exceeds by far the yield capacity. In fact, Nepalese population has finished about 50% of the country's forests in the last 30 years The trend is exponential due to an ever increasing population and diverse needs.[165]

[162] World Development Report 1994
[163] Ministry for Foreign Affairs, IU 2 department, Sweden, March 1995
[164] K.S. Jayaraman, 'Poor outlook for development' , article in: Nature, Vol. 320, 24, April 1986.
[165] Interview with Shankar Lal Vaidya, Alternative Energy Officer, ACAP.

## 7.3 The Power Sector

Electricity consumption in Nepal is one of the lowest among the Asian countries both in terms of per capita and per unit of GNP. In 1986, the level of electricity consumption was only 20 kWh per capita, while it was 186 kWh per USD 1,000 of GNP. Electricity supply was initially seen as means to stimulate industrial growth, bring social benefits and to improve exchange of communications between urban centres and rural communities.

Electric lighting is also seen as a way to overcome the problems of deforestation and consequent soil erosion in Nepal. These common problems of environmental degradation are making daily life even harder for people in the rural areas. [166.]

Numerous rivers in the country offer enormous potential for electric power generation. Out of an estimated hydroelectric potential of 83,000 MW, 25,000 MW is regarded as being economically exploitable, out of which less than 300 MW of the hydro-electric potential is currently exploited. There is a large number of small, mini- and micro-hydropower schemes spread throughout the country. [167]

**Table 7. Statistical data on production, utilization, installed capacity and consumption of electricity in Nepal, 1992**168

| **Net installed capacity of electric generating plant (MW)** | | | |
|---|---|---|---|
| | Total | Thermal | Hydro |
| **Total** | 277 | 42 | 235 |
| **Self prod** | 13 | 13 | - |
| **Public** | 264 | 29 | 235 |
| **Utilisation of installed electric generating capacity (kWh/kW)** | | | |
| | Total | Thermal | Hydro |
| **Total** | 3,361 | 1,452 | 3,702 |
| **Self prod** | 1,923 | 1,923 | - |
| **Public** | 3,432 | 1,241 | 3,702 |
| **Production of electricity (GWh)** | | | |
| | Total | Thermal | Hydro |
| **Total** | 931 | 61 | 870 |
| **Self prod** | 25 | 25 | - |
| **Public** | 906 | 36 | 870 |
| **Electricity consumption per year (Gwh and kWh per capita)** | | | |
| **Total** | Per capita | Import | Export |
| **926** | 45 | 80 | 85 |

Average in Europe: 5,729 kWh per capita per year

## 7.4 Institutional framework

### *7.4.1 The Nepal Electricity Authority - NEA*

Established in 1985, NEA became the sole government utility responsible for generation and distribution of electric power in Nepal. It supplies electricity to

[166] The definition of a rural area in the field of rural electrification is not always clear. Although the district headquarters in the hills are categorised as urban centers for administrative purposes, they are included in the rural electrification schemes due to their low levels of load and development infrastructure. For the purpose of planning rural electrification schemes an area comprised of rural administrative units (Village Development Committees) with a population under 10,000 is defined as a rural area. (Rural electrification Guidebook for Asia and the Pacific, p. 414)

[167] Small hydro systems is defined as installations of capacity that range from 1001-5000 kW, while mini-hydro systems corresponds to 101-1000 kW. Hydro units less than capacity of 100 kW are called micro-hydro.

[168] United Nations, Energy Statistics Yearbook 1992

some isolated areas mainly district headquarters through a number of small-hydro power plants.[169]

Within the agency, the Directorate of Distribution and Consumer Services looks after the planning, construction and operation of grid distribution systems including the grid based rural electrification programmes.

In order to supply electricity to remote load centres, particularly the district headquarters in remote parts of Nepal, Small Hydel Development Board (SHDB) was established in 1975. Some years ago, the Small Hydel Power Department (SHPD) under the Rural Electrification Directorate of NEA took over, among others, the functions of the Small Hydropower Development Board. SHPD is responsible for the construction and operation of a bulk of the mini-hydro plants in the remote areas of the country, where electrification from the grid is not economically viable. In 1992, SHPD had 23 hydro plants ranging from 32 to 345 kW capacity, totalling 3,591 kW in operation, and another six are to be operational in the near future (1992). In the fiscal year 1985/86, mini-hydro plants operated by SHPD produced approximately 2.44 GWh of electricity, which was less than 1% of the total electricity generation by NEA that year.

### *7.4.2 The Agricultural Development Bank of Nepal - ADBN*

ADBN is a government-owned bank, which promotes agricultural development by giving loans to farmers. It has branch offices all over the country with local expertise that can advise on how loans can be taken out, what subsidies are available and what procedures are to be followed. Among other things, ADBN is the major source for financing micro-hydro plants in the private sector.

The ADBN Act has provided the Bank with the responsibility to implement effective approaches for the development of agricultural and agrilcultural-related fields. One of the main function of the Bank is to provide the rural population with credit and the technical input necessary for the development of alternative sources of energy. The aim of the energy programme is to improve the quality life of the rural people through the development and dissemination of technologies compatible with local resources.

### *7.4.3 Electricity Development Centre - EDC*

The Electricity Development Center was established in 1993. It is a government body under the Ministry of Water and Resources which promotes private investors in new electrification projects. The purpose is to promote competition in the electricity sector. It is the agency which approves and allocates licences for generation and distribution of electricity.[170]

### *7.4.4 Company for International Technical Cooperation and Development - ITECO*

The Company for International Technical Cooperation and Development (ITECO) AG is an independent engineering and consultancy company which was formed in 1982. ITECO AG has a permanent professional staff with collaborators working on specific foreign projects. The objective of the company is to provide a

[169] ICIMOD; Country Report on Mini- and Micro-Hydro Power Programme in Nepal, p 33
[170] Interview with Shrestha, Vijaya S, Director General, EDC

competent project planning and implementation service for engineering projects abroad, in particular for technical cooperation with developing countries. The most important clients include the DGDC of the Swiss Federal Government, the World Bank, regional development banks, FAO UNDP and other UN organisations.

ITECO´s activities cover advisory services; engineering design and construction management; institutional build up; project preparation and planning; technical assistance and all other aspects of project implementation in the field of infrastructural engineering etc.

ITECO Nepal (P) Ltd. was formed in 1987 as a joint venture company between ITECO AG and local partners (with major shareholding of local partners) to meet the needs of a third world country like Nepal in the field of multidisciplinary consulting services. ITECO Nepal (P) Ltd. is involved in the Salleri Chialsa Hydel Electrification Project (SELUP). It was constructed by the Swiss Government to carry out the project planning and design and construction of the hydropower plant. ITECO is still assisting the SELUP by giving advice and following-up of the project. [171]

### *7.4.5 King Mahendra Trust for Nature Conservation - KMTNC*[172]

Established in 1982, KMTNC is an autonomous and non-governmental organisation devoted to the field of conservation in Nepal. It is the country's leading environmental NGO. KMTNC has focused on fund raising activities from national and international agencies who wish to see the biodiversity of Nepal maintained from generation to generation. The organisation receives support from seven international aid agencies of the U.K., U.S.A., Canada, Japan, Germany, France and the Netherlands.

KMTNC´s activities have focused on providing matching efforts, by understanding the needs and aspirations of local people, who are affected by the creation of national parks and also leading them into the main stream of conservation for development in the national parks. KTMNC´s establishment of Annapurna Conservation Area Project in western Nepal has been a step ahead in this endevour. The project is under the guidance of the Trust since 1986 (see further chapter 8.2).

### *7.4.6 Butwal Power Company - BPC*

BPC is a state utility operating and managing hydroelectic power projects and associated electricity distribution systems in Nepal. BPC is the current owner of the hydro electric scheme of Andhi Khola. BPC´s objective with the Andhi Khola Hydel Electrification Project is to provide electricity to the rural consumers in the Andhi Khola area and to promote productive use of electricity to increase the disposable income of the rural consumers (see further chapter 8.1).

### *7.4.7 United Mission to Nepal - UMN*

United Mission is a Christian Protestant organisation involved in health, education, engineering, industry and rural development in around 20 developing

[171] ITECO Nepal (P) Ltd: Company Profile, pp. 1-2

[172] Thapa, G.J.Annapurna Conservation Area Project- Two Year Progress Report January 1990-December 1991, p. i

countries. In Nepal, the prime emphasis in the UMN programme has been on supproting and implementing the mini- and micro-hydro programme through the establishment of Butwal Technial Institute in 1963, Development and Consulting Services in 1972, Butwal Engineering Works in 1977, and Nepal Hydro Electric Company in 1986.[173] The Mission is among other projects, involved in the Andhi Khola Hydel Electrification Project. In fulfilling its mission, UMN has over the years developed institutions and infrastructure that utlilize Nepal´s natural and human resources and promote a policy of import substitution [174] (see further chapter 8.1).

### *7.4.8 Swiss Development Co-operation - SATA*

The Swiss Government through SATA has supported the development of a micro-hydro power programme together with the private company Bajalu Yantra Shala (BYS) since 1960. [175] SATA has provided technical expertise to improve the different models of cross-flow turbines in Nepal. In addition, it has supported in the field of small-hydro power development through the technical and financial assistance programme. SATA has also through ITECO worked for the Salleri Chialsa Electrification Project in eastern Nepal (see further chapter 8.3).

### *7.4.9 Intermediate Technology Development Group - ITDG*

Established in 1965, ITDG is a voluntary non-profit making organisation. It is funded by donations, grants from the British Government and income from commissioned work. The agency is based in London, England, but have offices in some developing countries, such as Peru, Nepal, and Pakistan. ITDG specialises in technical assistance and fund-raising, developing partnership with other NGOs, and organising assistance. Main areas of interests are micro-hydro power, increasing of local capacity in design, manufacturing and utilisation for rural industries, agro-processes and domestic illumination/electrification. including collaboration with manufactures and local organisations. ITDG also conducts research and development of low cost techniques.

ITDG has been working to strengthen the micro-hydro power sector in Nepal since the beginning of the 1980s. Among other things, ITDG provides technical support to and conducts evaluation studies of the Annapurna Conservation Area Project.[176]

### *7.4.10 International Centre for Integrated Mountain Development - ICIMOD*

The primary objectives of ICIMOD is to help promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of mountain populations of the Hindu Kush - Himalayan Area which, including Afghanistan, Pakistan, Bangladesh, Bhutan, China, India, Myanmar and Nepal. ICIMOD is a multidisciplinary centre based on the systematic exchange of knowledge and experiences through an organised information network. It is also a focal point for the mobilisation of conduct, and

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[173] ICIMOD; Country Report on Mini- and Micro-hydro power Programme in Nepal, p 33
[174] Inversin, Allen; New Designs for Rural Electrification- Private Sector Experiences in Nepal, pp. 1-2
[175] BYS manufactures propeller turbines, cross-flow turbines and associated equipment which are used for agro-processing purposes and in rural electrification programmes. It also exports to other Asian and African countries.
[176] Interview with Bikash Pandey, Programme Manager, ITDG- Nepal

co-ordination of applied and problem-solving research activities as well as for training on integrated mountain development. Moreover, ICIMOD is a consultative centre to provide expert services on mountain development and resource management in the region.

The Centre has an energy programme dealing with energy planning and promotion of energy in rural areas.[177]

*7.4.11 Salleri Chialsa Electricity Company Ltd. - SCECO*

SCECO was established in accordance with an agreement between the Government of Nepal and the Swiss Development Cooperation in the early 1980's. It is a shareholder company responsible for the management of the Salleri Chialsa Electricity Utilisation Project (SELUP). The organisational structure of a share holder company was considered being most appropriate to achieve the goals of the project. SCECO is the only private power utility with a sizeable local shareholding in Nepal. The Company receives technical and administrative assistance by ITECO (see further chapter 8.3).

## 7.5 Government Policies and Regulations

### *7.5.1 General rural electrification policies*

The general objective of rural electrification according to the Government of Nepal is to contribute to the growth of the rural economy through expansion of agriculture, commerce and small industry. The first national plan was the Fifth Five-Year Plan of 1975-1979.[178]

Since then, the Nepalese Government has with varying emphasis expressed the need for rural electrification initiatives in the subsequent Five Year Plans. One clear change is that the more recent plans have more specific and target-oriented formulations of the national rural electrification programme objectives.

A number of policy declarations and legislation related to mini- and micro-hydropower has been enacted during the recent past. In 1992, for example, five new policies and acts were promulgated and many aspects of hydropower has been dealt with in these policies. The Ten Year Rural Electrification Programme of NEA (1991) selected areas for rural electrification prioritising them on the basis of economic potential. Most of the areas selected under this programme are to be connected to the national grid through grid extension.[179]

The Small Hydropower Development Master Plan of NEA (1992) aims at a systematic identification of optimum small-hydro power potential to match the electricity demand of rural communities in the mountains and to rank identified projects.[180]

There are also some important economic incentives provided small-scale electricity systems. The Nepalese Government through ADBN provides soft loans for the mini-and micro-hydro power plant installations as well as subsidies for the electrification units for the micro-hydro plants (add-on or stand-alone).[181]

[177] ICIMOD; Our Mountains- the Hindu Kush Himalayas. A Decade off Efforts towards Integrated Mountain Development (10th anniversary brochure)
[178] ICIMOD..p. 67-68
[179] Ibid
[180] ICIMOD; Country Report on Mini- and Micro-hydro power Programme in Nepal, p.67-68
[181] Interview with Adhikhari, D. Loan Officer ADBN

### *7.5.2 Policy implications for locally managed rural power systems*

A considerable amount of money has been provided to the private entrepreneurs as well as the communities although the disbursements have not been regular. Consequently, a number of micro-hydropower plants have been installed and many private-scale manufacturing concerns have been established. However, according to the ICIMOD Country Report on Mini- and Micro-hydropower in Nepal, the implementation of such policies and rules more often than not is undertaken unamicably. A number of deficiencies and ambiguities are discerned in the government policies which has resulted in slow-down of the programmes, particularly in far-flung inaccessible rural areas, for which the micro-hydro programmes are expected to be most beneficial. There are different examples of problems related to micro-hydropower programmes. For example, the rural electrification and industrialisation is not satisfactory. It appears that the adoption of electricity for cooking is not an easy prospect. The financial returns for the manufacturers is inadequate, mainly because the volume of the businesse has declined, wherefore they are forced to diversify their manufacturing activities.[182]

In the mountain areas where fuelwood is easily available at nearly negligible costs, it can be difficult to promote the use of electricity for cooking and heating. However, there are many areas where fuel is fairly scarce and some of the people are buying the fuelwood or kerosene. In such areas, a combination of financial incentives, awareness-raising campaigns and proper technical back-up systems can make sizeable reduction in the use of wood fuel/biomass and other conventional fuels such as kerosene. According to a synthesis report on Micro-and Mini-Hydropower in the Hindu-Kush-Himalayan Region, this is not the case in Nepal, as no such government policy has been deviced so far.[183]

There are some relatively generous government policies hampering the effective implementation of decentralised electrification projects. One problem occurs when pre-feasibility studies carried out by contracted local entrepreneurs tend to be based on too optimistic assessments. In reality, the implementations of projects sometimes appear to be much more complex and expensive than initially envisaged. The reason lies in the local entrepeneurs´ own interest in realisation of the project, as this would imply employment opportunities. Non-reimbursement of loans provided by ADB-N is also common and consequently, the government will loose a large amount of money.

### *7.5.3 The Hydropower Development Policy* [184]

The Hydropower Development Policy of 1992, stresses the importance of constructing new small hydro electric projects to meet the demand of the hilly and remote Himalayan regions where the national power system has not been extended, or would not be extended in the near future.

The Policy also emphasises the necessity of extending a proper distribution system in the rural areas where electrification has not been undertaken, and also to develop the hydropower of the country by motivating national and foreign private investors in the electricity sector. In addition, the Eigth Plan envisions the ambitious target of adding 5,000 kW of hydro-electric power through the implementation of mini-and micro-hydro power projects under the Alternative

[182] ICIMOD; Country Report..., pp. 76-78
[183] ICIMOD; Mini-and Micro-Hydropower Development in the Hindu-Kush-Himalayan Region, p. 37
[184] The Hydro Power Development Policy 1992

Energy Development Programme. It further apportions the regional share of this 5,000 kW to the tune of 1,250 kW for the eastern, central and far western regions and 750 kW and 500 kW for the mid-western and western regions.

### *7.5.4 The Water Resources Act*[185]

The purpose of the Water Resources Act is to make arrangements for rational utilisation, conservation, management and development of the water resources in the country. Basically, the Act regulates the ownership and utilisation of water resources in the country. The Act also provides legal arrangements for determining beneficial uses of water resources, preventing environmental and other hazardous effects therof and also for keeping water resources free from pollution.

The private sector is allowed to generate and sell electricity to NEA. The selling rate of the electricity shall be agreeable to both parties and be based on avoided cost, cost-plus or a fixed percentage of the average selling price of NEA.[186]

Perhaps the most important policy initiatives under the Act was the de-licensing of the privately owned micro-hydropower plants up to 1,000 kW (1992). A license can be obtained for a scheme above 1,000 kW by the Ministry of Water Resources for a maximum period of 50 years.[187]

### *7.5.5 The Electricity Act* [188]

The generation, transmission and distribution of electricity in Nepal is regulated in the Electricity Act no. 2049. According to this Act, no single person is entitled to generation, transmission, or distribution of electricity up to 1,000 kW and for conducting surveys thereof without obtaining a license under the Act.

1 % customs duties is levied for the import of construction, equipment, machines, tools and equipment required for repair and maintenance as well as the spare parts which are produced and sold by local industries.

The purpose of The Tariff Fixation Commission is to fix the electricity tariff and other charges on the basis of the rate of depreciation, reasonable profit, mode of operation of the plant, changes in the consumers-price index and royalty. Anyone distributing electricity in isolation of the national grid, is entitled to fix the electricity tariff and other charges for the electricity distributed.

## 7.6 Rural Electrification in Nepal

The first hydroelectric installation in Nepal was built already in 1911, but after that, there was little further development until the 1960s. The international oil crisis in the 1970s accelerated the rate of establishment of hydro-electric projects in Nepal as a growing concern of sustainability of energy resources led to greater interest in hydro-electricity.

The rural electrification schemes in Nepal are principally comprised of systems based on the centralised grid supply and those based on decentralised generation through mini- and micro-hydro plants. The history of planned grid-

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185 The Water Resources Act 2049
186 "Mini hydro: Policy and Practice" in Hydronet, no. 2, 1994
187 "Mini hydro: Policy and Practice" in Hydronet, no. 2, 1994
188 Electricity Act 2049, 1992.

based rural electrification is relatively recent: the first effort to implement of a national rural electrification programme was initiated in 1984 with the completion of an evaluation study of the programme. In this study, the potential load centres for rural electrification were ranked on the basis of economic/ financial criteria. The grid-based rural power schemes also supply electricity to the largest number of rural consumers.[189]

There is also a growing number of isolated electrification schemes in operation. Micro-hydro power schemes are found in many remote areas of Nepal. Water power has been harnessed for centuries in Nepal to drive traditional water mills for agroprocessing. These water mills, so called *ghattas*, are still used in many villages in the hills. Most of the micro-hydro plants are owned by individuals. The most common form of isolated rural electrification is for an entrepeneur to provide his neighbours with electricity in the evenings powered by an add-on generator to his water turbine mill. It is estimated that there are more than 800 turbine-driven mills in Nepal.

Programmes to introduce modern micro-hydropower technology to Nepal were initiated in the early 1960s. However, it really started to yield good results in mid-1970s.[190] A number of private micro-hydro plants in Nepal has received assistance in terms of promotion, installation, as well as monitoring and evaluation from international aid organisations like SKAT of Switzerland, ITDG of United Kingdom, GATE/GTZ and FAKT of Germany.[191]

Apart from the micro-hydro plants, there are some isolated rural areas where rural electrification is based on diesel generation, solar power, or supply from Indian grids. [192]

A number of private turbine manufacturers has developed during the last two decades. The growth of local manufacturers of micro-hydro as well as mini-hydro turbines and associated equipment has been immense and has also led to low prices and widely spread benefits in Nepal.[193]

Despite the country's huge hydropower potential and the increasing demand for rural electrification, only about 9% (1989/90) of the rural parts have access to electricity supply. It is estimated that only about 1% of the rural households actually have access to electricity.[194]

The future plans for rural electrification will probably be based partly on a study conducted by NRECA in the beginning of the 1990s. The ten-year electrification study, initiated under the World Bank assistance, recommended policy and technical criteria as well as development strategies for a ten-year period of rural electrification efforts. It suggested that the implementation of 20 grid-based rural electrification schemes during the ten-year period. These schemes are expected to serve 231,000 customers. The facilities required consist of 232 km of 33 kV line, 61 MVA sub-stations and 2,949 km of 11/6.35 kV distribution lines. The study also suggests development of hydro plants of 2 MW capacity to serve about 22,000 consumers, and the expansion of existing micro-hydro programmes.[195]

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[189] Acharya, M. P. & Shrestha, R.M; "Rural Electrification in Nepal" in Rural Electrification Guidebook,for Asia and the Pacific p. 410

[190] Acharya, M.P. & Shrestha, R.M... p. 411

[191] ICIMOD;Mini- and Micro-hydropower Development in the Hindu-Kush-Himalayan Region, p. 15

[192] Acharya, Mahesh P; & Shrestha, Ram M, p. 410

[193] Pandey, B., ITDG; "Micro-hydropower Devlopment in Nepal based on Local Manufacture" in Hydronet, no. 2, 1994.

[194] According to estimates by interviewees.

[195] Acharya, M.P. & Shrestha, R.M...p. 415

## 7.7 Local Management in Rural Power Systems

Following the scarcity of government funds devoted to rural electrification efforts in Nepal, the Government increasingly recognises the importance of promoting locally run, self-reliant electric distribution systems. Perhaps one of the most important initiative by the Government to promote locally run rural power schemes was the delicensing of electrical installations up to 1,000 kW in 1992. Another favourable policy was the provision of loans and subsidies to decentralised power systems. These incentives have paved the way for a growing number of rural electrification schemes put in by private individuals and consumer organisations.

One form of consumer organisation in the country is the Village Electrification Committee. There are a number of such committees serving power supply to rural areas. Another type is the small private company, or local small Electricity Users Organisations linked to a private power company working in the area. Common to all these actors is their contribution to the management of local power distribution. Otherwise, they may differ from one another. For example, some organisations own their equipment while others do not. Some generate their own electricity while the others buy bulky power from the national grid.

In many cases, local management has proven to be an outstanding approach to rural power generation and distribution in Nepal. This particularly holds for farflung areas, where the national electrification programmes have not, and will most likely not reach the forthcoming years.

The locally managed decentralised schemes are to a large extent provided direct support from national and international aid organisations, such as UMN, GTZ, USAID, NORAD, ITDG, SATA etc. The general success of a number of micro-hydropower project based on local management with external support has operated remarkably independent from the national government.

## 7.8 Case Studies in Nepal

### *7.8.1 Rural electrification in the Andhi Khola area*[196]

#### *7.8.1.1 General characteristics*

The project area is situated about 165 km west of Kathmandu and 80 km south of Pokhara, Nepal´s second largest town. It is located in Nepal´s mid-hills where the temperature sometimes falls below 10 °C in winter, while it occasionally exceeds 30 degrees during summer. The Andhi Khola river is one of Nepal´s many rivers with immense potential for hydropower development.

#### *7.8.1.2 Electrification of the area*

Andhi Khola Hydel Electrification Project (AHREP) was established by the United Mission to Nepal (UMN) a Christian Protestant aid organisation. Its main objective is to provide for "...development of appropriate technology and suitable methods and tariffs for rural electrification". [197] Apart from the AHREP, UMN also set up another parallell project, the Andhi Khola Project, with the aim to achieve integrated rural

[196] If not indicated by footnote, the data in this section is based oninterviews with Vinay Bhandari, BPC/AHREP, Dale Nafziger, BPC, and Michael Leane, UNM.
[197] Nafziger D. L. & Thapa, R.B. A Synopsis of Domestic-Sector Impacts at the Andhi Khola Hydel and Rural Electrification Project and their Implications for Future Butwal Power Company Rural Electrification Planning, p. ii.

development in the area. Activities like irrigation, resource conservation, drinking water and sanitation, adult literacy and non-formal education are being undertaken. These two projects operate side by side in the same area. AHREP is managed and owned by Butwal Power Company (BPC).

The construction of the mini-hydro plant within AHREP began in the early 1980s, and commercial power generation formally commenced in July 1991. Comissioning the power plant included constructing two horizontal tunnels totaling 2.4 km and a 230m vertical shaft. Three second hand pelton turbines and generators from Norway were refurbished and installed. The plant services both 'semi-urban' and rural consumers in the area, altogether about 440 consumers. Excess power is delivered to the national grid. The average coincident peak load per connection is about 400 Watt in Galyang village and its periferial areas, i.e. the 'semi-urban' parts. For the Aserdi branch though, coincident peak demand average 90 Watt per household. [198] In the prolongation of Aserdi branch, another rural area- Phoksingkhot- will soon be connected.

*7.8.1.3 Generation and distribution*

The generation capacity within the electric scheme is 5.1. MW. At times, power has to be taken from the grid, particularly when there are faults in AHREP's own power house. Most of the time though, power can be sold to the national grid as peak demand within the Galyang/Aserdi system is only about 0.5 MW. The peak demand for the 242 consumers of the Asardi User Organisation is 21.18 kW. In the year of 1994, the AHREP plant generated 32,031,400 kWh. The consumption within the AHREP network was 858,600 kWh, of which 85,605 kWh were consumed in the Aserdi branch. Power is available 24 hours a day in the whole system.

There are nine large transformers in the system. At the power plant, the bulk of power is transformed from 5.3 kV up to 33 kV in the system's largest transformer rated 6 MVA. Some though, is tapped of for the Aserdi/Phoksingkot branch and passes through a 5.3/1kV transformer rated 100 kVA. After the 6 MVA transformer follows six substations rated 33/0.4 kV, 100 kVA and one rated 0.4/1 kV, 20 kVA. The line length in the urban distribution system is up to 1.5 km. The system applies a voltage level of 400/230 V in its service lines. The voltage drop in the far end of the system is 15% of 230 V.

In the Aserdi branch, line lengths amount to 5-6 km and the tension is 1 kV all the way up to the consumer sites, rather than 33 kV followed by 400 V that is normally applied for branches of this size. A large number of small 1/0.23kV transformers are then used to serve load clusters. The advantages of the 1 kV distribution system are several: First, the system is somewhat cheaper as insulated cables designed for 400 Volts can withstand 1 kV, an outcome that would become even more significant if the area had been as scarcely populated as is typical for Nepal; Second, the 1/0.23 kV transformers are much lighter than the 33/0.4 kV and are therefore suitable for areas where equipment has to be carried by porters; Third, thanks to the insulation, the neutral needs not be grounded; And fourth, there is no need of earthing in houses, wherefore house wiring costs stay low.

The design peak load per consumer is 110 W for rural areas and 210 W for urban areas. The load growth rate is 1% for rural areas and 1.7% for urban areas.

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[198] A. Inversin, New Designs for Rural Electrification - private sector experiences in Nepal, NRECA 1995. pg. 18-19

*7.8.1.4 Technical aspects*

As discussed above, the 1 kV system is one of the alternative techniques tried out in AHREP in order to lower costs of rural electrification. Furthermore, for the house wiring and energy metering some unconventional approaches are chosen. A cheaper alternative to conventional house wiring, offered to consumers in AHREP, is the 'Tayari wiring' (ready made wiring). It is fabricated in the AHREP workshop after inspection of the house in question. Presently, there are four variants of Tayari house wiring available with two, three, four or five points respectively.

Innovative line-drawing saves the system some material costs. By taking charge of wooden poles trees and houses for supporting insulated cables in the branch line, the number of fabricated poles needed is reduced. A disadvantage with insulated conductors is the cost of piercing connectors. Currently an alternative method is used. To make a connection, a short length of insulation is removed, parallel groove clamps are secured to the conductor at this point, and the clamp is taped once the connection has been made. Dead-end clamps constructed for insulated cables are quite expensive, wherefore locally available clamps are used. These have however brought by some problems as they tend to strip the insulation and cause short cuts between conductors. Line hardware, such as supporting clamps, dead end clamps, fuse boards and clamps have been designed for local manufacture. [199]

Transmission and distribution line poles of galvanised steel have been developed locally in Nepal by NHE (Nepal Hydro and Electric Company Private Limited). These poles are used in Aserdi as they are thought advantageous to the concrete poles normally used in urban areas of the country. Their qualities mainly lay in that they are easily transported and handled. The pole is sectioned in 2,5 meter long pieces, the heaviest section weighing 40 kg. A concrete pole measures eight meters and weighs 500 kg.[200] Porting a number of these relatively fragile giants for long distances in mountainous terrain is out of question.

Instead of meters, some consumers prefer load limiting circuit breakers. In this manner, the energy control gets cheaper in terms of materials and because no meter reader needs be employed.

In order to keep costs low, some imperfections are accepted in the system. For example, the 15% voltage drop is not considered a problem. Also, rather than designing systems for twenty years, that is normally recommended, a fifteen year period is considered which reduces costs of main lines. During peak hours, a 30% overload is accepted in the 1/0.23 kV transformers, which reduces investments.

The combination of a well designed tariff structure and promotion of low wattage end-use devices helps AHREP retaining relatively high load factors in the distribution branches. Load factors are about 0.82 in the Aserdi branch and 0.46 in the 'semi-urban' branch. Cut out fuses naturally serves this aim. Moreover, industries are not allowed to operate during peak load time. The most important end use device designed for retention of high load factors is the low-wattage cooker. So far however, only 14% of those connected have bought a cooker.

*7.8.1.4 Financing the system*

The total investment in the AHREP, 5,1 MW power plant is USD 280,000. The Aserdi/Phoksingkot branch has required USD 55,000, of wich 24,000 are

[199] A. Inversin, New Designs..... pg. 17
[200] A. Inversin, New Designs..... pg. 19

investments made so as to enable extension up to Phoksingkot.[201] The distribution investment costs are increasing gradually as AHREP is in the position of expanding the distribution networks. AHREP makes profit by selling electricity to NEA. The Aserdi User Organisation does not make a profit though, although revenues cover operation and maintenance costs.

AHREP tries to get some financial support from USAID for its rural electrification activities. All of the electrification investments in Aserdi has been made by AHREP. The villagers offered to carry poles and to dig holes etc. However, they did not contribute funding. It is assumed that the contribution from villagers accounts for approximately 9% of the total project cost. They contributed 15% of the labour costs and 6% of the material costs for the project. Their labour contribution to the construction of the branch lines in the village accounted for about 60% of all labour costs. The wage for a labourer was approximately USD 1 per day, and the cost for a wooden pole was about USD 15.[202] When expanding to Phoksingkot, AHREP will get financial support from the locals apart from the labour and material contributions. With its retired soldiers putting some of their pension into the project, the Phokingsot User's Organisation will be able to contribute USD 10.000 in cash.

Apart from energy, consumers have to pay for different services in the AHREP system as listed in table 8.

**Table 8. Service fees in the AHREP system**

| Service | | Fee |
|---|---|---|
| **Application fee** | | USD 0.04 |
| **Connection fee,** | single phase | USD 2.24 |
| | three phase | USD 7.45 |
| **Temporary connetion** (max 1kW) | | USD 3.67 |
| **Capacity change,** | single phase | USD 2.24 |
| | three phase | USD 7.45 |
| **Change of place for meter/cutout** | | USD 3.26 |
| **Reconnection fee,** | single phase | USD 2.24 |
| | three phase | USD 7.45 |
| **Meter deposit,** | single phase | USD 8.16 |
| | three phase | USD 20.41 |
| **Meter rent per month,** | single phase | USD 0.31 |
| | three phase | USD 0.71 |
| **Penalty for broken seal,** | single phase | USD 7.45 |
| | three phase | USD 20.41 |

The tariff system has been designed with a view to maintain a high load factor. Consumers can have either meters or cut out fuses installed. For cut-out consumers, the monthly charge for different subscribed loads are given in table 9.

[201] A. Inversin, New Designs..... pg. 19
[202] A. Inversin, New Designs.... pg. 42

**Table 9. Monthly charges for consumers with cut-outs in AHREP**

| Capacity | Charge per month (USD) |
|---|---|
| 25 W | 0.37 |
| 50W | 0.74 |
| 100 W | 1.22 |
| 250 W | 2.14 |
| 400 W | 3.27 |

Metered consumers are supplied from two tier meters. They are charged as given in table 10.

**Table 10 Monthly fixed charges and energy charges for consumers with meters in AHREP**

| Capacity | Demand charge USD/month | Unit charge USD/kWh |
|---|---|---|
| max. 500 W | 1.73 | 0.031 |
| max. 600 W | 2.08 | 0.031 |
| max. 700 W | 2.43 | 0.031 |
| max. 1,000 W | 3.47 | 0.031 |

Two-tier meters allow for two energy unit prices, one if you keep within the subscribed load and one if you exceed the agreed limit. In case the load exceeds subscribed demand, the extra costs is USD 0.092/unit.

Revenues from electricity sold in the Aserdi branch currently total approximately USD 1,700 annually.[203] 10% of this sum is repaid the Users' Organisation while the remaining amount covers the cost of operation and maintenance in the distribution system. Based on the approximate revenues, costs of operation and maintenance are 0.018 USD/kWh in the Aserdi branch. Figures from NEA's annual report 1993/94 reveals that their operation and maintenance expenditures amounts to 0.02 USD/kWh, considering the entire system, i.e. not rural branches exclusively.

### *7.8.1.5 Management of the power supply system*

AHREP is managed by BPC, a public company which own and manages the rural electricity system. UMN, the funding agency and initiator, has members in the Board of BPC. BPC runs the power station and cares for the electricity service.

User Organisations were also formed to provide co-ordination between the villagers and the power utility during the project's design and construction phase. They are organised on the basis of local political units in the electrified villages. The first area to be electrified through a Users Organisation was Aserdi village. It was selected because of the villager's enthusiasm and their willingness to contribute labour and poles to get power. A sign of community motivations was the previous organisation of a Drinking Water Committee responsible for construction of a water supply system in the village.

Today, there are four such User Organisations in the AHREP. They serve as communication links between the local communities and BPC and collect monthly fees from the clients and deposit them in the utility's local bank account. Thereby,

[203] A. Inversin, *New Designs....* pg. 19

the burden on the utility from operating the system is minimised. The formation of the User Organisations has reduced the costs of operation and maintenance in the distribution area.

In the Asardi User Organisation, there are no by-laws to be followed by the members. Instead, the management is steered by decisions taken at the public meetings. The leadership of the Organisation consists of one Chief, one Deputy Chief, one Secretary and seven to eight other members in the User Organisation. Out of them, one works as a Service Man responsible for replacing the fuses; for bringing any written application from the consumer, for reading the meters of the rice mill and for collecting and depositing the monthly revenue.

The revenues are collected by the Service Man within the User Organisation. He collects the money every month and then deposit it himself in the bank account of BPC. In urban areas, the consumers come directly to the office to deposit their billing amount. When costs of operation and maintenance of the branch are covered, possible remains are returns on capital investments. However, based on the present-day situation, it takes more than 20 years to get the invested amount back.

BPC staff attend the meetings where the villagers discuss the various conditions. BPC's representative observes whether the members are being properly elected or not.

BPC has hired and trained individuals on a full-time basis to familiarise villagers with all matters of electrification, such as house-wiring, safety, tariffs, and end-uses. This has contributed to a very high percentage of villagers in the area having opted for access to electricity in spite of very small disposable income.

AHREP has a group of staff called Motivators. Their role is to make house-to-house visits in the villages to be electrified with the purpose to teach and inform the villagers about safety, use of electricity, payment of monthly bills etc. They also assists in deciding to what level of electricity consumption consumers ought to subscribe, and how best to electrify their homes.

*7.8.1.6 General experiences and tendencies*

To some extent, the outcome of the rural electrification activities in the Andhi Khola region are determined by the fact that the Government of Nepal was committed to designing a new approach to rural electrification in the project area. AHREP itself has also developed several appropriate techniques to operate and maintain the system as smoothly as possible. The standard of living has gradually increased since the introduction of electricity in the Andhi Khola area. There is, however, still low awareness of electricity and its uses tends to prevent potential consumers from maximising the benefits they might derive from it.

Asardi User Organisation has been operating since 1990. There are 11 rice/flour mills, one milk chilling centre, one ice cream factory, one bakery two furniture industries and four welding machines in AHREP. The Asardi User Orgnisation has contributed to the local development by setting up one of the rice/flour mills. Aserdi User Organisation has successfully carried out its responsibilities and the concept of User Organisation has gained considerable attention throughout Nepal. The formation of Aserdi User Organisation has contributed to low construction and administrative costs of the scheme and decentralisation of rural electrification operations and maintenance.

Four User Organisations have been formed so far. It still remains to be seen when additional User Organisations are to be established in the project.

AHREP has also placed emphasis on teaching people about productive uses of electricity to enhance their economic conditions. So far, the community motivation programmes has yielded successful results.

AHREP has also taken innovative approaches in the design of the distribution system. A major innovation is the 1 kV three-phase distribution system. Since the consumers are scattered over a large area, the 1 kV system can reach a distance as far as six times further than that possible with the conventional 400 V system.

With respect to future plans, BPC is in a position of getting a license for selling electricity to its own consumers. AHREP has to send its annual plan of rural electrification to the Government. As of 1996, AHREP has to send its tariff to the Government of Nepal for approval. However, the Government has not any direct link with any User Organisations in Nepal. AHREP also has plans to add 1,000 new consumers per year for the next four years.

### *7.8.2 Rural electrification in the Annapurna Conservation Area*

#### *7.8.2.1 General characteristics*

The project area is situated in the Annapurna region of the Nepalese Himalayas. The altitudes in the region range from 900 m to 4,000 above sea level. The Annapurna conservation area has traditionally included three systems, i.e. hunting regions, national parks and reserves. The area is the home for 441 species of birds and 100 species of orchids. The region covers 7,600 square meters and has a population of about 45,000 people. However, the number of tourists visiting the region is about the same number as the population, implying that about 90,000 people/year are using the natural resources of the region. There are about 20,000 households and 1,000 tourist lodges and tea shops spread over the area. The average income-level is rather low, and the bulk of income comes from the tourism sector.

*Annapurna Conservation Area Project* (ACAP) is the largest conservation project in Nepal. The idea of ACAP emerged from the recognised need to minimize the stress on the natural resources and wildlife in this ecologically vulnerable area. Since 1986, ACAP has undertaken an innovative approach to natural resource and tourism management in the Annapurna region. The project practises a multiple land use method of resource management, combining environmental protection with sustainable community development and tourism management.

#### *7.8.2.2 Electrification of the area*

ACAP runs five programme components within its scope of activities, one of which is an Alternative Energy Programme (AEP). The energy use was already initially considered as one of the critical issues in the Annapurna conservation area. The intensive use of fuelwood has resulted in deforestation and soil erosion. In addition, most settlements in the Annapurna region are remote and far off from the existing grid, making grid extensions uneconomic . AEP aims to minimise environmental degradation by introducing technologies that could help to replace fuel wood consumption and reduce the use of forest products in the area.

Micro-hydro electrification is the largest component in the programme. The commercial operations of the Ghandruk plant started in 1992. The Siklis plant has been running since 1994. In mid-1994, 810 consumers in the Annapurna region were benefitting from the Ghandruk and Siklis micro-hydro plants. 25 lodges are relying on power from the schemes. At present, five additional micro-hydro schemes are under construction or in the pre-construction phase. With a total of an additional 110 kW generating capacity in prospect, the number of consumers is estimated to be around 1300 in mid-1996. In Annapurna conservation area, 80% of the power is used for heating water, even if AEP promotes electricity use also for cooking.

The following discussions on generation, distribution, technical aspects and financing, concerns primarily Ghandruk power system and the Village Electrification Committee connected to it.

*7.8.2.3 Generation and distribution*

The Ghandruk plant, being the AEP's oldest, has a generating capacity of 50 kW. The electricity is distributed in 380/220 V lines from the power house. There are both single- and three-phase lines installed in the village.

The power plant is overloaded during peaks in demand. The load factor is approximately 50% and is generated 24 hours a day except for some winter months when black-out are frequent.

*7.8.2.4 Technical design*

The techniques used are chosen or developed with respect to the special aims of ACAP and are in that context not necessarily those normally applied in Nepalese rural electrification schemes. Installation of the Ghandruk plant was made in May 1992 with assistance from the contractor D.C.S. Butwal. The technical design of the scheme is made by Asea Brown Bovery.

Special devices are installed at the premises to limit the maximum power connected at one time. The aim is to solve the problem of sharp peaks and non-uniform usage. The consumers have electronical cut-out circuit-breakers, or "Police Boxes" which assures that the electricity automatically goes off after a certain amount of energy consumption agreed upon. Furthermore, light sensors are applied to control automatic switches in households that have subscribed electricity during daytime only.

ACAP has focused on the promotion of the use of locally adjusted technologies to satisfy the energy demand of the area. This includes not only electrical end-use devices but other solutions related to the energy situation in the area. Besides micro-hydropower electrification; kerosene depots; active and passive energy solar technologies are being promoted. The low-wattage cooker, originating from AHREP, is also promoted.

*7.8.2.5 Financing the system*

The total cost of the AEP programme is about 20% of the total project cost, i.e. USD. 482,000. The construction of the Ghandruk scheme required USD 70,000 and was made possible through funding by the World Wildlife Fund, the Government of Germany, ACAP, *Overseas Development Agency* ODA of United Kingdom, CCO of Canada etc. The residual capital costs were made possible through a bank loan from ADBN. The Village Electrification Committee in Ghandruk had to contribute 30% of the capital costs for construction of the scheme. 15% was covered by a bank loan of USD 18,750 with an interest rate of 18%. Of this loan, USD. 1,030 was given as a grant. ACAP provided USD 8,335. The remaining money was provided by local people´s contributions. Total investments per consumer in the Ghandruk system are USD 277.

Ghandruk power system generates monthly revenues in the order of 540 USD. The system is not profit-making but there are funds available to sustain the activities. Expenditures are mainly salaries and spare parts. The number of staff is kept low (three persons in charge) in order to bring down the expenditures. Salaries accounts for about USD 134 per month, USD 100 are devoted for future use and the remaining is used for repaying loans. The Ghandruk project is expected to repay all the loans within six to seven years from 1995.

In Ghandruk, a flat tariff system for billing is adopted. Domestic consumers are charged USD 0.01 per Watt per month of the connected power, whereas commercial consumers pay USD 0.015 per Watt and month. These consumer groups are allowed permissible power levels, the lowest being 25 Watt and the highest 1,000 Watt. Some of them have chosen to have electricity during day-time only and pay half the monthly bill. The electricity is then switched of at dawn with the help of an automatic, light sensor controlled circuit breaker. An energy meter based system is being introduced for commercial/industrial consumers, who are allowed to use electricity during day-time only. They are charged a fixed rate of 0.0025 USD per Watt (1-10 kW), and also USD 0.025 per every kWh used. A power cut-off device is installed in the connection to switch off power if the prescribed limit is exceeded. In the occurrence of non-payments of bills, the consumer is obliged to pay fines. The first connection is free, while a reconnection cost amounts to USD 2.

A rough estimate of costs for operation and maintenance in the Ghandruk systems gives 0.013 USD/kWh$_{sold}$[204], to be compared with 0.018 USD/kWh$_{sold}$ for Aserdi Users' Organisation and 0.02 USD/kWh$_{sold}$ for NEA's entire system. According to estimates made by the Officer-in-Charge of ACAP´s Alternative Energy Programme, the costs of the electrification system in Ghandruk is 60% lower than a comparable NEA programme would have been.

For all the electrification projects within AEP, the initial total investment cost per consumer is in the range of USD 425. The schemes do not require any external funding and are sustainable at their local levels. Electricity tariffs are just within the socio-economic parameters of the poorest. The revenues collected are sufficient to meet all recurring costs including operation, maintenance, repairs, debt service (if any) and capital replacement. The annual cost of the schemes is about 8% of the capital cost. Funding is available up to 1995/96, and includes construction of five additional micro-hydro schemes. About USD 825 are set aside every month for future investments.[205]

#### *7.8.2.6 Management of the power supply system*

Micro-hydro electrification is one of the largest components in AEP. Decentralised, small-scale (micro) hydro projects is pursued by ACAP, as this alternative energy option suits their nature conservation policies at large. Further reasons are that: first, sparsely populated areas and great distances between villages requires higher investment in transmission lines especially with larger schemes; second, local

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[204] 50 kW, 24 hours and 30 days, the load factor being 50% gives 18,000 kWh /month at a cost of USD 134 for sallaries and USD 100 for future use.

[205] Communication with S.L. Viadya, Alternative Energy Officer, ACAP. Letter dated 10 May 1995.

management is easier in cases of micro-schemes; and third, it is easier to arrange financial support for micro-projects.

ACAP has a grass-roots philosophy, and involves local people in all aspects of the project management. This is also true for the AEP. The ACAP staff are facilitators, not implementors in the AEP project. The AEP is managed locally by the Village Electrification Committees in Siklis and Ghandruk.

The Ghandruk plant is owned by the community under guidance of the Village Electrification Management Committee. The local people run the rural electrification system, although they receive some advice from ACAP personnel. There are no by-laws guiding the Committees, but there is a uniform Committee Law for all kinds of Development Committees in Nepal.

The Ghandruk Village Electrification Management Committee has 17 members. They meet regularly to plan and discuss the AEP activities in the village. Mass Meetings are also held in Ghandruk, where all members should attend. Most of people participate, as the meetings are compulsory. During these Meetings, the Committee attempts to motivate the villagers to use electricity productively (for example by encouraging people to establish local industries), and to promote maintenance of high load factor. They also discuss and try to resolve general problems that may arise.

The Committee also sets the tariff locally with respect to the costs of the system. Another task is to provide training and education facilities to enhance the management capacity of the local staff.

The Manager is responsible not only for operation and maintenance of the power plant, but also for issuance of the bills and collection of the revenues. Revenue collection is carried out the first week every month. Money is collected directly from the households.

Technical assistance and equipment is provided by ACAP. Technical backstopping is provided by ITDG Nepal, which also conducts evaluation studies of the micro-hydropower schemes. Initial education was carried out by ACAP in Butwal. Daily routines of the operators include maintenance, such as checking of pipelines and headline work on shift. Very few technical incidents have occurred where outside expertise has been required.

#### *7.8.2.7 General experiences and tendencies*

The micro-hydroelectric schemes of ACAP are the most sought-after programme in terms of versatility, ability to rapidly address all kinds of energy needs of a village, cost and sustainability. It is clear that the micro-hydro electrification scheme is a relatively viable option for meeting the rural energy requirements in Nepal. Other alternative energy technologies are also introduced as a package at the time of micro-hydro electrification to complement the principle of energy conservation inform of storage cooking. Meanwhile, it reduces the use of fuel wood as much as possible.

The Ghandruk micro-hydro stand-alone electrification unit is a good example of a successful micro-hydro power scheme from economic and financial point of view. In 1993, ICIMOD reports that the plant generates an income of USD 4,900 a year, is managed by the local community, and has one of the best managements and account keeping systems. [206] According to the Energy Officer, it is estimated that the 500 tonnes of fuelwood are saved annually from the electrical

[206] ICIMOD; Country Report on Mini- and Micro-hydro power Programme in Nepal, p. 20

energy of the plant. The reason for the high consumption of fuelwood was mainly that hotel owners previously used a much higher amount of fuelwood. This was because they boiled water and kept it hot all day to attract tourists longing for a hot shower, particularly during the cold season.

The grass-roots strategy, local management under the guidance of Electrification Committees, has also proven to be a sound approach to rural electrification in this remote area with a scattered population. It has resulted in relatively reliable electric supply at low cost, self-reliance, and increased awareness of sound use of electricity.

The power supply activities of the AEP is expanding. Another five plants are under construction, and the energy demand is increasing significantly. Herewith, new Village Electrification Management Committees are likely to be established.

NEA also recognises the advantages of Village Electrification Committees as an option to local management of rural (generation and) distribution systems. In fact, the view has been expressed that the Government should aim at encouraging the formation and organisation of additional Committees in the future.

There are, though, some challenges to be met by the local management in the future of the AEP programme. Notwithstanding hydro electrification being the most economical among all alternative energy sources, financial arrangement with respect to paying capacity of the rural poor is still a difficult task for the project leaders. The financing structure, operation and management and end use promotion style in the Annapurna conservation area is typical in many ways and has indeed set examples to be followed in the future. The problem lies in not being able to justly appraise the benefits accruing from improvement in the quality of life, improvement in forest cover, income generating opportunities etc.

Appropriate value needs to be put on fuel wood and softer financing terms applied to develop micro-hydro schemes, in order to be able to provide alternative energy to the rural poor at their opportunity cost.

Challenges lies also in defining and introducing new forms of end uses to increase the load factor of the plant and make it financially more viable.

### *7.8.3 Rural electrification in the Salleri Chialsa area*

#### *7.8.3.1 General Characteristics*

The area is situated in the district of Solukhumbu in the north-east of Nepal. The region is mountainous, with rugged terrain and poor infrastructural networks. The local inhabitants are mostly Tibetans. The reason is that many of the Tibetan refugees who fled their country in the beginning of the 1960s settled down in the Solukhumbo region.

Like in other remote areas of Nepal, the local population is relatively poor. The majority of the people is engaged in the agricultural sector, but there are some small industries based on carpet handicrafts. Most of the income is generated from the wool-dyeing industry.

#### *7.8.3.2 Electrification of the area*

Already in the beginning of the 1960s, the Government of Switzerland, through its Swiss Development Cooperation decided to electrify the handicraft centre in Chialsa. However, it was not until March 1987 that, finally the first electrically-dyed wool left the newly built dye house in Chialsa Tibetan Settlement (refugee camp). Since then, two electric dye vats, proposed and installed by ITECO Switzerland have been operating with remarkably high efficiency. From the Salleri Electrificity Utilisation Project (SELUP), a shareholding company, SCECO, has emerged. They run the 400 kW isolated hydro power scheme which serves 4,000 consumers. This plant is owned by its shareholders, of which a majority being local people, and is managed by a professional team of eight locals. The small-hydro power station was constructed between 1982 and 1986 on the Solukhola River. [207]

Today, about 4,000 people has access to electricity from the SELUP plant through approximately 680 connections. The number of consumers is increasing steadily. About 10,000 people are actually benefiting from electricity from the SCECO-run plant.

### *7.8.3.3 Generation and distribution*

The electricity supply system was designed and implemented by ITECO. The power plant, situated on the Solukhola River, is a classical run-of-river scheme, designed for 400 kW hydraulic gross capacity. The two 210 kVA generating units are driven by two crossflow turbines. The nominal power output (net) capacity amounts to 360 kW, whereas the transient output rises to as much as 410 kW. The hydraulic layout is such that the plant can run at full capacity all year. The firm electricity generation is in the range of 3,000,000 kWh/year. The average availability of the plant since its start-up is 98%.

The high voltage transmission line length is 20 kms. The total step down capacity in the distribution transformers has grown from 475 kW in 1989 to 1150 kW in 1993. From each transformer, a distribution line goes to the main distribution box and ultimately to the sub distribution box. From this box, service drop-cable to each house is laid down. Load controlling switches are installed at the sub distribution box. The load controlling switches gives the load a customer is entitled to draw, according to request.[208]

During the fiscal year 1993/94, SCECO generated 949,734 kWh and the maximum peak was 255 kW. Running time for the plant reached as many as 8,646 hrs which is 98.7 percent of the year. The plant run at peak load 42.5% of this time. The station factor for the period was 30%.

### *7.8.3.4 Technical design*

The technical design is of unconventional type, in reference to most of NEA's rural electrification schemes. Most of consumers are not metered, but have individual load controller switches placed in the houses. The meters installed are the property of the company. They are installed and maintained by SCECO.

The 20 kms long 11 kV high voltage transmission lines and the low voltage underground distribution system, with cables totalling more than 50 km, were built step by step between 1987-93 with considerable amount of local labour and components imported from Asia (India, Nepal and Thailand). The distribution cable has made safer and cleaner energy delivery to the customers.

Meter calibration is carried out periodically by company staff, by means of a standard Watt hour meter. Pilferage problems are avoided by having the low tension distribution line system underground.

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[207] Neuhaus, M; Salleri Chialsa Project. In Water Power & Dam Construction- Salleri Chialsa Project. pp. 1-2
[208] Thapa, R.S; New Approaches and Activities -Viability and Desirability of Micro- and Mini-hydropowe. p. 3

In case of over-load or short circuit in a house, a common solution used is to let the load controlling switches corresponding to the customer only get tripped. As a result, he/she is temporarily disconnected. However, following payment of a small reconnection fee electricity is again supplied. With the help of load controlling switches and micro-circuit breakers, the balance between customers' consumption and power availability is easily maintained.

*7.8.3.5 Financing the system*

According to a presentation of the project written in 1994[209], the overall expenditures for all project activities in the ten year programme amounts to approximately USD 7-8 million. Of this, about 45-50% has been provided by SATA and the remaining from the SDC-Nepal. Half of the total cost is invested in turn-key activities i.e. procurements; construction; testing and commissioning of generating plant; high voltage transmission lines and low voltage distribution facilities and engineering. The power plant per se cost USD 1,900,000 in round figures, and it is estimated that the cost might have been brought down to USD 1,200,000 had the works been carried out in one go.

At later contacts with ITECO, figures have been somewhat adjusted. Total project costs in July 1995 amounts to USD 9,5 million. SCECO runs an expanding activity, the reason why investments sometimes are not justified by the present load but rather by future plans. As of July 1995, investments in the Salleri Chialsa scheme totalled USD 4,100,000, the major posts being civil structures (26%), electro-mechanical equipment (25%) and HT-lines and switch yards (24%). Low voltage lines accounts for only 15% of the investments, while the rest is invested in offices, office equipment and storage buildings. ITECO estimates that investments, without expansion in mind, would have totalled approximately USD 2,500,000, which gives a per consumer investment of USD 625. With the actual investments, and still only 4,000 consumers, the per consumer investment totals USD 1,025[210].

In 1994, SCECO made a profit of USD. 4,500, after covering the running costs plus provisions for depreciation compensation of equipment and infrastructure. [211] Their expenditures were USD 23,238 for personnel (53%), administration (20%), management (5%), construction, maintenance and repair (22%). In addition, linear depreciation requirements amounted to USD 15,845. Incomes for the same period totalled USD 43,588, of which 83% were from sales of electricity. Due to internal consumption, system losses and energy for street lights, only 90% of the generated energy is delivered to the consumers. Depreciation excluded, the cost SCECO has per sold energy unit amounts to USD 0.027/$kWh_{sold}$. Comparable costs for other Nepalese case assessments are USD 0.018/$kWh_{sold}$ for AHREP, USD 0.013/$kWh_{sold}$ for Ghandruk and USD 0.020/$kWh_{sold}$ in NEA's entire system.

The connection fee varies between USD 5 to 20 for domestic consumers (level 1 to 3) while the industrial category is charged USD 30.24. Along with the connection fee, the applicant is entitled to be connected to the distribution grid of the company and to claim electricity as per tariff (and according to the technical possibilities at the tap-off point).

[209] ITECO, Water Power & Dam Construction: Salleri Chialsa project. September 1994
[210] Communication with Martin Neuhaus at ITECO.
[211] SCECO: Budget Report 1994/95

The customers are divided into five consumption levels. Level 1 and 2 are not metered but pay fixed tariff rates. They are entitled to 100 W and 500 W only respectively. The other categories, 3, 4 and 5, are metered and pay as per consumption. Level 3 can use maximum of up to 2,000 W and level 4 up to 8 kW. Industries are only day consumers. During peak demand (07.00 to 09.00 and 17.30 to 21 hours) they are reduced to level 1, 2 or 3. Timers help to achieve adjustment. The tariff structure is also divided into different levels. Every tariff has to pay a fixed rate, which reflects partly the cost of stand-by power and partly the fixed investment cost related to every connection. SCECO tariffs for 1993/94 are give in table 11.

**Table 11. SCECO tariffs 1993/94**

| Level | Admitted power | Fixed rate (USD/month) | Exempted (kWh) | Further (kWh) | Price per unit (USD/month) | Further (kWh) | Price per unit (USD/month/kWh) |
|---|---|---|---|---|---|---|---|
| 1 | max 0.1 | 1.02 | all | - | - | - | - |
| 2 | max 0.5 | 4.08 | all | - | - | - | - |
| 3 | max 2.0 | 4.29 | 55 | 65 | 0.061 | all | 0.025 |
| 4/1 | max 4.0 | 7.14 | 70 | 90 | 0.061 | all | 0.025 |
| 4/2 | max 8.0 | 14.29 | 75 | 95 | 0.061 | all | 0.025 |
| 5/1 | max 10* | 4.49 | 50 | all | 0.018 | - | - |
| 5/2 | max 10* | 6.12 | 75 | all | 0.018 | - | - |
| 5/3 | max 10* | 10.20 | 120 | all | 0.018 | - | - |

* Only during off peak hours. During peaks, these categories fall under level 1,2, and 3 respectively.

The billing is done by computers. A customer Data Base Programme has resulted in a rapid, efficient and error free billing system. Failing to pay the bill continuously for three months lead to disconnection. About 70% of the customer pay in time while others clear their bill with an additional fee for delayed payment.

*7.8.3.6 Management of the power supply system*

The Nepalese and Swiss Governments agreed to bring into existence a shareholder company, Salleri Chialsa Electricity Company (SCECO) through SELUP. The structure of a shareholder company was considered to be more suitable to achieve the intended goals than any other legal form of organisation: It offers financial stimulus to the shareholders and permits differentiated economic activities (reinvestment, diversification etc) in the longer term. The holders of ordinary share, representing the decision-making body of the company, are the local people, so-called "domiciled householders" (no government offices) who hold 37%. NEA and SDC has 31,5% each of SCECO´s shares. The preference shares (investment) are held equally by NEA and SDC.

SCECO was formally registered by the Ministry of Industries in 1991. The shareholder company took over the management of the scheme while SELUP monitors and assists in the development of the company. SELUP provides the prospective entrepreneurs with technical guidance on the efficient utilisation of electricity. SELUP also informs the customers about the availability of efficient electrical appliances, such as heaters and low wattage cookers.

Training has been promoted within the SELUP activities. For example, the Technical Officer has been trained by the manufacturers of the installed equipment on the operation and maintenance of the power plant. He runs the system, carries out faults analysis, replacement of the faulty parts, and ordering of the spare part. The damaged parts are not being repaired, but are replaced by similar ones. Therefore, SCECO has to keep parts in good order and in some numbers.

Reading and billing are directly entered in the statistical computer record. The consumer has to pay his electricity bill and any other charges (e.g. reconnection fees, and late payment surcharges etc) during the first 15 days of the following month. Otherwise, SCECO will charge a late payment fee, which increases as time goes on. Those wishing to have electrical connection to their house or premises have to submit a written application to SCECO.

Ad hoc Committees have been formed at all sites in the power distribution area. Though these Committees are of no legal relevance they help bridge the information flow between the people and SCECO. Effective utilisation of electricity, company standards (wiring, earthing etc) and policies, safety measures and other matters are being discussed with the Committees.

Several measures are taken by SCECO to offer better electricity service to the clients. To offer prompt reconnection service to people in remote places, reconnectors have been nominated at the presence approval of the people of that area. The reconnectors volunteer to give this service without taking any renumeration from the company. Safety measures are also always taken to avoid accidents and damages to the equipment. Pre-planning of work (labour arranging, collecting materials to be used) is well considered before initiating the work.

Daily inspection of the electro-mechanical equipment is done and recorded as per the observation. SCECO also closes the plant for a week a year for annual maintenance. Finally evaluation of work is done for improvement of similar work and better management in future.

From its bimonthly bulletin, SCECO informs all customers about the company's activities during the reporting period. Consequently, the local people are regularly made aware of the company's activities.[212]

*7.8.3.8 General experiences and tendencies*

The need for an appropriate coherent tariff and connection policy became urgent at an early stage of the operation. The initial framework of such a policy was clearly not comprehensive enough to avoid bad exception, unacceptable privileges and spontaneous rules that could lead to unforeseen problems in the future. Subsequently, frequent upgrading and downgrading in tariff levels, late payments; short (one day) notice periods; extensive and expensive service drop installations without any cost participation by the consumers were frequent. This business also kept the SCECO team too busy to attend to the policy development needed to break the vicious circle. SELUP´s tariff policy has become innovative in Nepal.

The project has been innovative in terms of its organisational structure. The close but open relationship between the SCECO and the Ad Hoc Committees has made the implementation of new decisions easier. Contacts, discussions and exchange of views are encouraged. The bimonthly bulletin has proven to be a successful instrument of outreach to the consumers.

SCECO has become a rather successful shareholder company, according to the Project Manager and one of the Swiss experts of ITECO. The access to electricity in the Salleri-Chialsa region has reduced the stress on the adjacent

212 Thapa, R.S. pp. 3-4

forests. The generation of 4 million kWh of electricity in a few years has contributed to firewood savings for cooking half a million tons (4,000 kubic meters) of dry firewood.[213]

The SELUP project has augmented the industrial production in the area and increased people's living standard. In 1990, the lighting and lamps accounted for 26% of the total installed consumer capacity, whereas in the end of 1994, it was approximately 15%. However, further productive use of electricity still needs to be promoted by SCECO.

The distribution proceeds are climbing. The growth of the total consumer distribution consumption of 63% in four years is comparable to a growth rate of 13% per year.

There are some issues of major concern from the company's side. In the near future, SCECO aims to reach excellent time availability to ultimately improve the station factor further. To attain maximum possible time availability SCECO focuses on bringing about regular maintenance and repair work, well trained operators, unity and high moral among the staff to provide quick service and good management to lead the organisation to achieve SCECO´s objectives.

Close contact with the local population is of great concern for SCECO, according to the Swiss ITECO representative who has been involved since the inception of SELUP. However, the understanding of the complex technical and financial processes is rather slow, wherefore commitment and effort ought to be long-lasting. His experience is also that the Board of Directors should be continuously trained in decision-making. Prior to the transfer of experience and know-how from one place to another, an assessment of cultural, ethnic and socio-economic environment is of concern.[214]

## 7.9 Conclusions of the Nepal Study

With its abundance of hydro resources (about 15% of the world's hydropower potentials) it is not surprising that most of the grid-based and decentralised power generation in Nepal is based on this renewable source of energy. A majority of the rural electrification projects are micro- and mini-hydro plant installations which are used for agroprocessing and electricity generation.

Most of the decentralised systems in Nepal are locally managed micro-hydro power schemes. One form of electricity consumer organisation is the User Organisation, which works closely with local private utilities. The role of the User Organisations is to provide co-ordination between the villages and the power utility during the project design and construction, to collect bills from the consumers etc. Another form of consumer organisation is the Village Electrification Committees. The Committees are responsible for the management of the power plants and they sometimes even own the plants themselves. Another important role is the setting of tariff rates in the rural power system. Unique of its kind, there is also one shareholding power company in Nepal. However, none of these organisations are widespread in the country. Connection to the national grid is the option covering the largest group of rural electricity consumers. The most common form of isolated rural electrification is for an entrepreneur to provide his immediate neighbourhood with electricity in the evening powered by an add-on

[213] Neuhaus, M; p.5
[214] ibid

generator to his water turbine mill. Electrification schemes of this kind have generally not been performing very well though.[215]

Given that Nepal is one of the poorest countries in the world, it may be astonishing that rural electrification is as vital as it is. However, most successful rural electrification projects are isolated systems in remote areas were no involvement from the national government has been provided. Rather, these rural power schemes have received substantial external assistance from foreign donor agencies and NGOs. The modest proportion of electrified households in Nepal is estimated to only 1%, compared to 10% of the urban areas. This indicates that the national power utility, Nepal Electricity Authority (NEA) has not been very successful in bringing electricity to neither the urban nor the rural areas. A major reason lies in the Authority's poor financial resources.

There is a growing number of foreign donor agencies and national/international NGOs involved in rural electrification in Nepal. In fact, these organisations are operating remarkably independent from the national government. The Small Hydro Development Board (SHDB) of NEA is at present leasing out its isolated micro- and mini hydro systems to entrepreneurs. While NEA focuses on electrification of the urban centres through extension of the national grid, the aid organisations normally focus on bringing electricity into remote areas of the country. Weak state bodies on the one hand and strong small-scale projects on the other has resulted in national policies being highly flavoured by policies of such individual projects.

There are some innovative government policies promoting locally managed rural electrification projects in Nepal:

- delicensing of small scale electricity installations up to 1,000 kW. For installations over 100 kW up to 1,000 KW, the applicant has to inform the Energy Development Centre of the Government;
- the Nepalese Government through Agricultural Bank of Nepal provides loans and subsidies on mini- and micro-hydropower projects: the loans cover up to 80% for the costs for rural electrification schemes. In addition, 50% subsidy is being provided for electrical equipment; and
- to stimulate the national production of water turbines and generators, the government promotes local manufacturers by imposing high taxes on such imported equipment.

At times, the more generous government rural electrification policies hampers the implementation of decentralised electrification projects. According to ADBN, a problem occurrs when pre-feasibility studies carried out by contracted local entrepeneurs tend to be based on too optimistic assessments, while the implementation of the projects turns out to be much more complex and expensive than estimated. The reason lies in the local entrepreneurs' interest in realisation of the project as this implies employment opportunities. Non-reimbursement of loans provided by ADB-N is also common and consequently, the government looses a large amount of money.

One project that is actively promoting community owned electrification schemes is the Annapurna Conservation Area Project (ACAP). There are two isolated schemes under the project, both of which are managed by the villagers

[215] New ERA, The Techno-economic Performance of Water Turbines in Rural Communities of Nepal. August 1993

themselves. ACAP's activities are divided into five sub-programmes, one of which is the Alternative Energy Programme. Among other things, the programme aims at replacing firewood for cooking with the use of power from mini- and micro-hydro schemes.

The Salleri Chialsa isolated hydro power scheme is run by a shareholding company, SCECO. The Salleri Chialsa Electrification Project (SELUP) was set up in the beginning of the 1960s. In SELUP, both staff and consumers are encouraged to become shareholders of the power scheme. This can be seen as an incentive for strong management of the project, as there is an economic interest among the members to manage the electricity system properly.

A third decentralised power scheme with local management is the Andhi Khola Hydel Power Electrification Project (AHREP). The 5.1 MW small hydropower scheme of AHREP is run by United Mission of Nepal (UMN) like a utility managed scheme for rural electrification. To satisfy the local people's need for water within the agricultural production, AHREP also harnesses some of the falling water for irrigation purposes.

Some unconventional technical solutions are being applied in Nepal's distribution systems such as 1 kV distribution lines and Single Wire Earth Return (SWER) [216] systems. Other electric equipment used in the rural areas are bundled conductors in low voltage systems and low wattage devices that helps retaining a high load factor even in areas with mainly residential load.

[216] SWER is tried by NEA in an area close to Bhaktapur.

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## APPENDIX

### List of Interviewees

Acharya, M. P. Planning Engineer, NEA. Kathmandu, Nepal 23/2 1995

Adhikhari, Devendra P. Engineer, ADBN. Kathmandu 23/2 1995

Anand, I.S. Monitoring Chief, REC. New Delhi, India 7/2 1995

+ X Bajracharya, Siddharta B. Project Director ACAP- KMTNC. Pokhara, Nepal 14/2 1995

Bakthavatsalam, V. Managing Director, IREDA. New Delhi, India 7/2 1995

++ X Bhandari, V. Assistant Electrical Engineer, BPC; and AHREP Planning-in-Charge, Galyang, Nepal, 11-13/2, 1995

Dungana, Arun K. Managing Director, ITECO Nepal Ltd. Kathmandu, Nepal 24/2 1995

Elder, Eduardo. Planning Enginner CRE. Santa Cruz, Bolivia 20-24/1 1995

Gemio, Fernando. General Manager, ELFEC S.A.M.- Cochabamba, Bolivia 17/1 1995

Gurung, Hum B. Conservation Officer & Officer-in-Charge, ACAP. Ghandruk, Nepal 17/2 1995

Gurung, Jagang, Head of Women, Conservation & Development Programme of ACAP. Ghandruk, Nepal 16/-18/2 1995.

Haderspock, Fernando. Coordinator of Special Projects, NRECA/Bolivia. La Paz, Bolivia 16/1 1995

Hoda, M.M. General Secretary, ATDA. Lucknow,India 8/2 1995

X Junejo, Anwar A. Project Coordinator, ICIMOD, Kathmandu, Nepal 23/2 1995

Kittelson, David A. Productive Uses Specialist & Technical Training Assistant, NRECA/Bolivia. La Paz, Bolivia 13/1 1995

Kamra, S.N. Chief Project engineer, REC. New Delhi, India 7/2 1995

Kreudler, José. General Manager, CRE. Santa Cruz, Bolivia 20/1 1995

Lama, Phuri. Project Manager, Salleri Electricity Utilsation Project. Katmanu, Nepal 24/2 1995

Leane, Michael. Assistant Director, UMN. Kathmandu, Nepal 24/2 1995

Lucero B. Federico. Technical Manager, ENDE-Cochabamba. Cochabamba, Bolivia 17/1 1995

Lemaitre, Julio. Manager, Engineering Department, COBEE. La Paz, Bolivia 21/1 1995

Mercado O. Fernando; Rural Electrification Specialist, NRECA/Bolivia. La Paz, Bolvia 13/1 1995

Mukherjeh S. WAPCOS. New Delhi, India 7/2 1995

Ekonom X Nafziger, Dale L. Rural Electrification Planner, BPC. Kathmandu, Nepal 17/2 1995

Natarajan, Bhaskar. Director, EMC. New Delhi, India 9/2 1995

X Neuhaus, Martin. Head of Division "Energy & Water Power", ITECO Switzerland. Kathmandu, Nepal 24/2 & 13/5, 1995

policy + X Pandey, Bikash. Programme Manager, ITDG- Nepal. Katmandu, Nepal 19/2 1995

Parmar, L.K.S. Director, ATDA. Lucknow,India 8/2 1995

Portugal, Ramiro. Treasurer, CEY. Los Yungas, Bolivia 14/1-15/1 1995

Prado, Julio, Manager, Labor Management and Municipal Reinforcement of CORDECRUZ. Cochabamba, Bolivia 24/1 1995

Rajappa, R. Chairman & Managing Director, WAPCOS. New Delhi, India 7/2 1995

Ramachandram, M. General Manager, IREDA. New Delhi, India 7/2 1995

Rai, R.N. Chief Engineer, WAPCOS. New Delhi, India 7/2 1995

Rao, S.V.R. General Manager, (D & CP) REC. New Dehli, India 7/2 1995

Sharma, Asha. Senior Scientist, Centre for Environment, WAPCOS. New Delhi, India 7/2 1995

Sharma, R.K. General Manager, CESS. Lucknow, India 9/2 1995

Shrestha, Vijaya S. Director General EDC, Ministry of Water Resources. Kathmandu, Nepal 23/2 1995

Shrestha, Soorya B. manager, Small Hydro Power Department, NEA. Kathmandu, Nepal 23/2 1995

Swaminathan, N. Chief Project Engineer, REC. New Delhi, Nepal 7/2 1995

Swarup, Ajay. Chief Engineer, WAPCOS. New Delhi, Nepal 7/2 1995

Tudela J., Carlos. General Manager, CEY. La Paz, Bolivia 14/1 1995

Vaidya, Shankar L. Alternative Energy Officer, ACAP-KMTNC. Pokhara, Nepal 14/2 & 16/2 1995

Virreira, Victor V. President ABB/La Paz. Bolivia 25/1 1995

Waddle, Daniel. Executive Director, NRECA/ Bolivia, La Paz, Bolivia 16/1 1995, & correspondense May 1995

Zapata C, Mario. President, CEY. La Paz, Bolivia 14/1 1995

Stockholm 1995

Dear Sir,

We are happy to be invited to  to discuss rural electrification with you. When visiting you, we will seek for substantial information about the co-operative/association in question. For both your and our own convenience, we herewith send you a checklist so that you can prepare the information. You might find that some questions are not correctly formulated for your specific situation. Please excuse us for the possible inconvenience. In principal, what we would like to know is:

**1. Generation and distribution**

1.1. Is the co-operative connected to the national grid or not? If not, what kind of generating technology is installed in the system? (Diesel, Hydro etc.)

1.2. What is the generating capacity (kW)?, or: What is the contracted minimum delivery from the grid (kW)?

1.3. What is the peak demand in the system (kW)?

1.4. What is the total annual energy consumption (kWh generated in 1994)?

1.5. How is the distribution system designed? (Length of lines, Voltage levels, etc.)

1.6. What is the total transformer capacity (kVA)?

<u>Please prepare</u>: Map of grid.
Data on transformators, poles and lines.

**2. Technical design**

2.1. Is the distribution system of the conventional type, or are there any unconventional technical solutions? If any specialities: what are the advantages?

2.2. What kind of installations do the different consumers have? (house wiring, ready boards, etc.)?

2.3 What kind of cost reduction measures are applied in the design, operation and maintenance of the scheme?

2.4 Are there any technical solutions applied to maintain a high load factor in the system? if so, what solutions?

**3. Financial aspects**

3.1. Is the co-operative profit making or not?

3.2 Is there any external support provided/any donor?

3.3 What is the current financial status of the co-operative?

3.4 Who financed the implementation of the system? How much?

3.5 How much do the membership fees and shares amount to?

3.6. What kind of fees, charges and penalties exist? (Connection, disconnection and reconnection costs, etc.)

3.7. How is the tariff system designed? How many consumer categories are there?
3.8. What methods were used for designing the tariff system? What costs are included in the energy price?
3.9 Is the tariff structure designed to maintain a high load factor in the system? If so, how?
3.10. Do the revenues from energy bills cover the investment and production costs?
3.11. How are the revenues collected? (How much is collected and when? Break-even every month?)
3.12. How do the consumers pay their bills? (Cash, cash crops, etc., monthly or seasonally)
3.13. Are the consumers metered or is flat rate applied?
3.14. What kind of metering and billing techniques exist?

Please prepare: Annual accounts, if possible also from the starting period.
A clear and simple presentation of monthly incomes and expenses of the co-operative today.
Bylaws, describing members payment duties
Bylaws, describing the present tariff structure

**4. Management of the co-operative.**
4.1. According to the bylaws, what is the personnel structure of the co-operative?
4.2. Identify the responsibilities of the selected members/employees, Who does what?
4.3. What are the rights and duties of the members?
4.4. What is the time plan for meetings and elections within the co-operative?
4.5. How are the bylaws enforced?
4.6. Are the bylaws followed?
4.7. Have there been any electricity use promotion programmes/ education/ information arranged by the co-operative? If so, please be prepared to tell us about them.

Please prepare: Bylaws

**5. Tendencies in the co-operative.**
5.1. How many years has the co-operative been operating?
5.2. What have been the co-operatives major achievements so far?
5.3. What have been the main issues in the co-operatives financial history?
5.4. What is the present financial situation and the policy for the coming years?
5.5. Is the co-operative expanding or not? (Plans)
5.6 Is the current organization and management of the co-operative satisfactory?
5.7. Have there been any changes over time in the staff set up of the co-operative?
5.8. How are conflicts within the co-operative solved?
5.9. What is the tendency of number of consumers?

5.10. What is the member's general opinion about the running of the co-operative?

5.11. There might be some external factors that determine the outcome of the project and the status of the co-operative. (Government commitments or other incentives for the sustainability of the project). Are there any such factors, and if so: what factors?

5.12. What have the electricity co-operative and its services achieved in the area in terms of industrial and domestic development?

**6. The co-operatives relations to other parties**

6.1. What official agreements does the co-operative have with other parties in Bolivia (contracts)?

6.2 What type of consultation has been provided the co-operative over the past years? Who provides it?

6.3 What type of consultation is provided the co-operative presently? Who provides it?

6.4 What is the relationship between the government and the electricity co-operative?

Please prepare: Contracts with other parties

**7. General preconditions for the local initiatives**

7.1. What are the income levels of people in the distribution area, their main occupation and their level of education (General statistics)?

7.2. What industries/natural resources are there in the local area?

7.3. What is the overall infrastructural situation of the site-relations to nearby cities, etc.?

7.4. What institutions are there where technical competence in the field of rural electrification can be developed? (Schools, companies' training programmes, other institutions).

Thank you very much for your co-operation, and we look forward to having a very interesting meeting with you.

Yours sincerely,

Monica Gullberg Åsa Gerger Juma Mawenge Makala Kingu

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**Stockholm Environment Institute**

The Stockholm Environment Institute (SEI) was established by the Swedish Parliament in 1989 as an independent foundation for the purpose of carrying out global environment and development research. The Institute is governed by an international Board whose members are drawn from developing and industrialized countries worldwide.

Central to the Institute's work have been activities surrounding the Rio UNCED conference, and previous to this, the Brandt and Palme Commissions and the work of the World Commission for Environment and Development. Apart from its working linkages with the relevant specialised agencies of the UN system, a particular feature of SEI's work programme is the role it has played in the development and application of Agenda 21, the action plan for the next century.

A major aim of SEI's work is to bring together scientific research and policy development. The Institute applies scientific and technical analyses in environmental and development issues of regional and global importance. The impacts of different policies are assessed, providing insights into strategy options for socially responsible environmental management and economic and social development.

The results of the research are made available through publications, the organisation of and participation in conferences, seminars and university courses, and also through the development of software packages for use in the exploration of scientific problems. SEI has also developed a specialised library which functions as a central catalyst in the short-term and long-term work of the Institute.

**Research Programme**

A multidisciplinary rolling programme of research activities has been designed around the following main themes, which are being executed via internationally collaborative activities with similar institutions and agencies worldwide:

- ❑ *Environmental Resources*, including energy efficiency and global trends, energy, environment and development, and world water resources;
- ❑ *Environmental Technology*, including clean production and low waste, energy technology, environmental technology transfer, and agricultural biotechnology;
- ❑ *Environmental Impacts*, including environmentally sound management of low-grade fuels, climate change and sustainable development, and coordinated abatement strategies for acid depositions;
- ❑ *Environmental Policy and Management*, including urban environmental problems, sustainable environments and common property management; and
- ❑ *POLESTAR*, a comprehensive modelling and scenario-based activity, investigating the dynamics of a world with 10 billion people by the middle of the next century.

**SEI's Network**

SEI has chosen a global network approach rather than a more traditional institutional set-up. The work programme is carried out by a worldwide network of about 60 full- and part-time and affiliated staff and consultants, who are linked with the SEI Head Office in Stockholm or to the SEI Offices in Boston (USA), York (UK) and Tallinn (Estonia). SEI has developed a large mailing register to communicate to key members of society in government, industry, university, NGOs and the media around the world.

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