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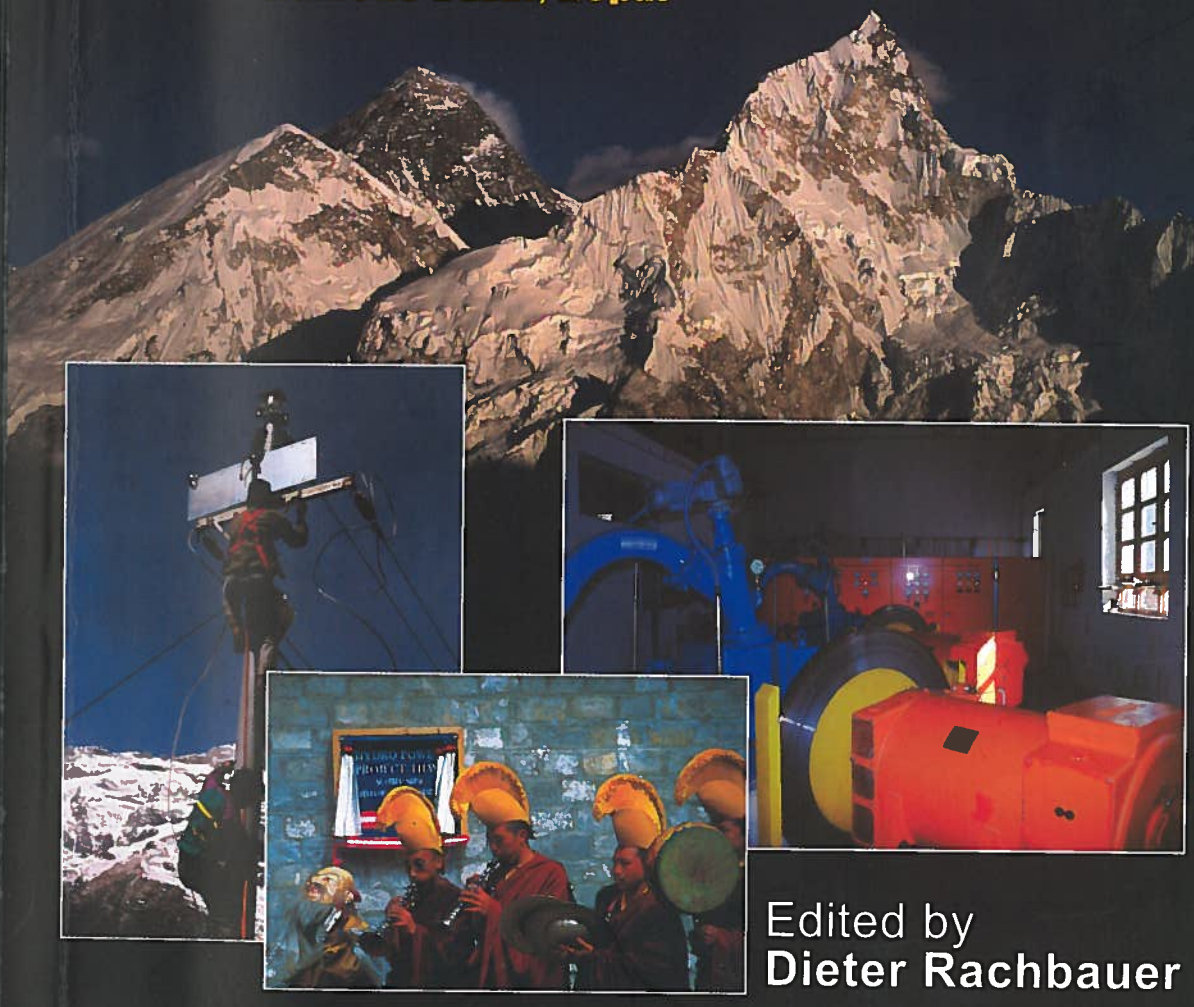
Austrian Development Co-operation

KHUMBU BIJULI COMPANY

Energy from the Top of the World

Small Hydropower Plant Thame-Namche Bazar, Nepal



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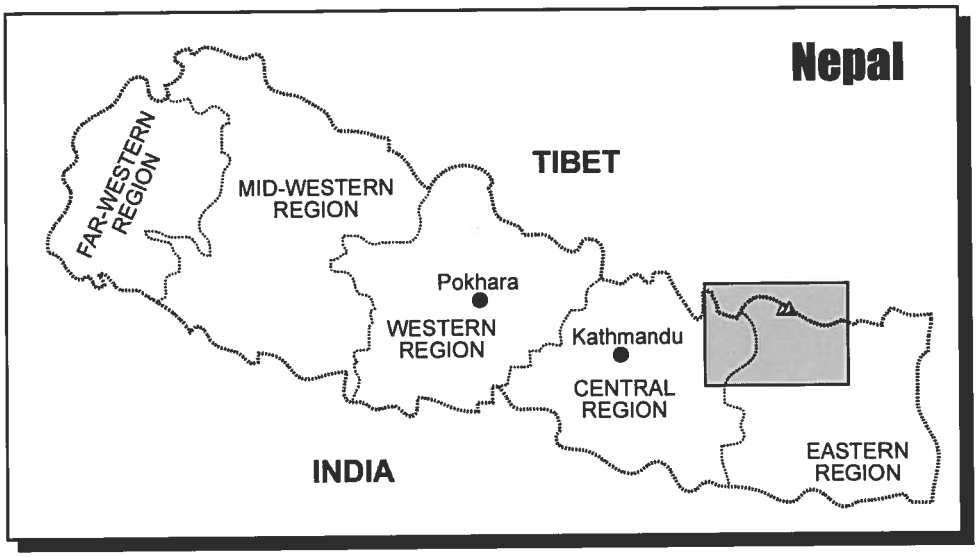
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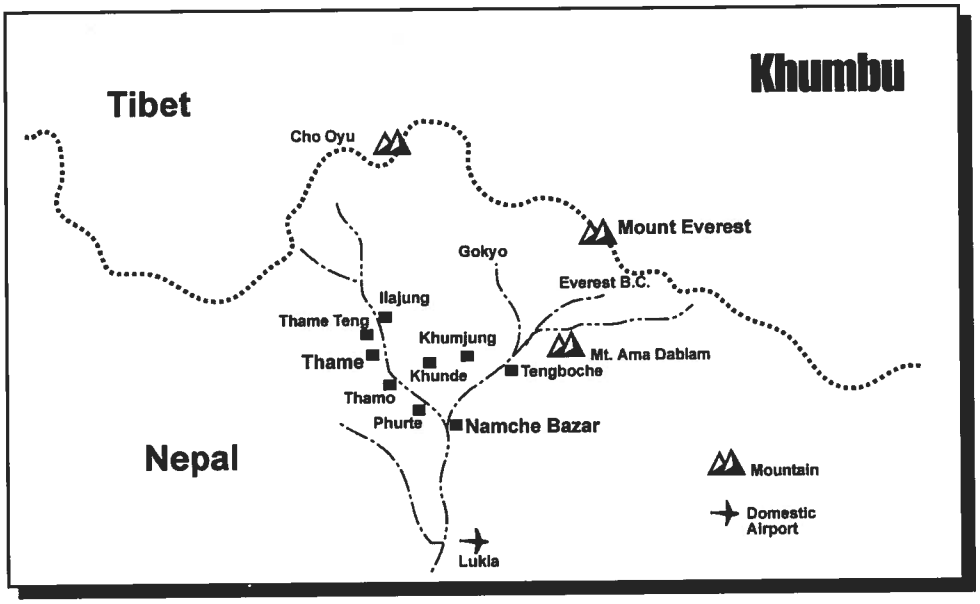
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Thamo
Phurte
Namche Bazar
Nepal
Mountain
Domestic Airport
Lukla

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Foreword

The principal aim of development co-operation is to bring about positive changes in the poorest countries of the world, and in particular, to enable disadvantaged social groups to lead a life worth living. To achieve this the following overall objectives for the Austrian Development Co-operation were defined:

- Poverty alleviation,
- Promotion of peace, in particular by strengthening democracy and good governance, and
- Preservation of the natural environment.

These objectives are supported by the following principles that should be heeded in all programmes and projects:

- Ownership/partnership,
- Appropriate technology and
- Gender - equal participation of men and women in the development process.

The Department for Development Co-operation commissioned an independent company to carry out an evaluation of the small hydro power projects in Nepal and Bhutan. These external evaluations are important instruments that help us to improve the quality of development co-operation constantly, by learning from experience. The first results of the evaluation show already that the Namche Bazar hydro power project has succeeded in addressing most of our objectives and principles.

As I have been responsible for the Austrian Development Co-operation for the past five years I am very happy that this project could be successfully completed by the end of 2000. The project, which included the construction of a small hydro power plant in a very remote area of eastern Nepal and support of the management during the first years of operation, required long-term commitment and willingness to cope with difficult circumstances like natural disasters or extremely difficult logistics. Taking into account all the difficulties we had to face when implementing the project, I would like to express my warm thanks to all the people who contributed an extraordinary amount of work and personal efforts to make this project a successful one.

— Ms. Benita Ferrero-Waldner
Federal Minister for Foreign Affairs
of the Republic of Austria

Vote of Thanks

Despite the considerable difference in the level of economic development between Austria and Nepal I have found a lot of similarities between these two countries. First of all, both of them have beautiful mountains where people are friendly and both have a long history of socio-cultural development. Vienna and Kathmandu have developed as a cross point of different histories and cultures.

I am proud that I spent my three years in Vienna from 1983-1986 as a student under Prof. Alexander Van der Bellen at the University of Vienna. My studies there have totally changed my thinking on development economics and liberal values. My studies in Austria have immensely helped me to formulate and implement liberal and open economic policies for the private sector development in Nepal.

After my return from Vienna in July 1986, I served in the government of Nepal for another 14 years in various capacities and retired as a Permanent Secretary. During my years in a leading position at the Nepal Electricity Authority the Small Hydropower Plant Thame - Namche Bazar was brought under way.

For the excellent opportunity, both for me personally and for the people of Nepal, I would like to thank the Austrian Government and Eco Himal. This is an outstanding example of successful co-operation between a developed and a developing country.

— **Bhola Nath Chalise**
Former Director General of
Nepal Electricity Authority

Small Hydropower and Rural Electrification in Nepal

Out of every 100 Nepali families, only 15 have access to electricity, and most of these live in urban centres. In rural areas, it is estimated that only 4% have access to electricity. Of these roughly half are served by the grid and the remaining receive electricity from isolated hydropower projects such as the Thame Project.

Isolated small hydropower projects[1] have an important role to play in providing electricity services to rural Nepali mountain communities. Each year around 30,000 new families are connected to the national electricity grid by the Nepal Electricity Authority, the government-owned national utility. Most of these households are in the vicinity of urban centres or along highways. However, this rate of electrification is insufficient to even supply the increase in population, which is in the range of 80,000 households each year. This means that there are more people in the country without electricity at the end of each year than at the beginning! An additional 10,000 to 15,000 families being electrified in the country each year with distributed energy options, will bridge this gap to some extent. Together with solar PV, isolated micro and mini-hydropower projects of a range of sizes serve to supply those communities that the grid will not reach any time soon.

Small isolated hydropower very often provides the most accessible and least cost option for mechanical power and electricity for communities living in mountain areas. Most mountain areas in Nepal have a very long tradition of using vertical axis water mills sometimes known as 'Norse wheels', which produce between 0.5 - 1 kilowatt (kW) for turning a stone grain-grinder. It is estimated that some 25,000 of these are still operational in Nepal. More sophisticated turbine designs

1. The term small hydropower is used generically here. However, the standard definition is micro hydro (<100 kW capacity), mini hydro (<1,000 kW), and small hydro (<5 MW to 50 MW depending on the country).

such as the Cross-flow, Pelton, and Turgo are increasingly being installed to produce electricity from small streams to meet local needs.

In Nepal, around 1500 hydropower turbines provide milling services - grinding grain, husking rice, and pressing oil - to an estimated 2 million people or 10% of the country's population while some 800 electricity plants of a range of sizes supply electricity to half a million people not connected to the national grid. While milling projects range in size from 2 kW to 15 kW, electricity-producing plants have a much larger range of 0.5 kW to 600 kW. The Thame Project is the largest hydropower project serving an isolated load centre in the country.

Milling projects constitute investment by entrepreneurs who sell services to their neighbourhood customers. Electrification projects are financed by a combination of government grant and self-investment by communities or entrepreneurs. Projects under 100 kW capacity are generally owned by the community and are constructed using govemment and/or NGO grants, bank loans, and cash and/or voluntary contribution from the users. A number of projects, especially those that sell milling services in the daytime and electricity for lighting in the evening, are owned by entrepreneurs, who have built the projects with a combination of govemment grants and self-investment. The performance of community /entrepreneur projects is varied. While the best projects have achieved a high plant factor[2] of over 50% and good revenue and have paid off their bank loans, the less well-managed ones do not generate sufficient revenue to repay their loans and some have gone out of operation.

Larger projects, higher than 100 kW capacity, have been constructed by the Nepal Electricity Authority (NEA) using bilateral and multilateral grants and His Majesty's Government of Nepal (HMG/N) resources. There are a total of 35 such projects, with nominal production of 7 MW. These projects are operating sub-optimally, being generally over-staffed with high operation cost and producing less than designed power. The tariff they follow, which is based on kilowatt-hour consumption and is identical to that for customers on the national grid, encourages high demand during the evening peak and little demand during the daytime and late at night. Most projects are heavily overloaded during three or four hours of peak load every day and are operating at a fraction of their capacity during the rest of the time. This results in plant factors ranging from 15-40%. Their revenue does not even cover the cost of operation and maintenance, much less depreciation or providing any returns on investment.

In recent years, realising that as a large centralised utility, it is not suited to operate small isolated projects, NEA has leased out eleven of these small projects to private operators. By reducing employees, these projects can now cover the cost of operation and maintenance and also generate a profit. They even pay a small royalty to NEA. However, there is little sign that services have improved or that the energy utilisation of leased projects has improved very much. The projects have all retained the tariff structure of the central grid and have not been successful in increasing the utilisation factor. The terms of the lease do not encourage lessees to make substantial repairs or make investments into project expansion.

More recent projects such as the Salleri-Chialsa (400 kW) and the Thame (600 kW) have also been funded in a similar way to the NEA projects – through bilateral grants and NEA investments. These projects are different from the normal NEA projects in some substantial ways and share many similarities with smaller community-owned projects. First, majority ownership of shares

2. Plant factor is defined as the % of use, in terms of energy produced and used, of the unit compared to its capacity.

in both projects has been transferred to the user groups with NEA retaining a minority share holding. Secondly, they maintain a different tariff from the national grid, and slightly different from each other. By providing a flat tariff that is based on wattage subscription rather than metering of kilowatt-hours, consumers are encouraged to use electricity for heating water and cooking during off-peak hours. The electricity is essentially 'free' during these times. Thirdly, substantial investment has been made in promoting productive end-uses of the electricity. And last, the construction of both projects was managed by international companies. This resulted in high cost but also in high quality. In the case of Thame, one additional factor is that significant investment has been made in training local manpower to operate the plant.

The differences between the two categories of projects are quite obvious. Thame and Salleri Chialsa have relatively high load factors compared to NEA projects. Their tariff covers the cost of operation and maintenance and also a good portion of depreciation of equipment. The plants have competent technicians and management, are technically very reliable, and are used to power a number of sophisticated commercial end-uses. Average tariff is lower than in NEA projects and yet revenue per kilowatt is significantly higher. These projects have been better able to achieve the twin stated goals of isolated power plants in Nepal - to reduce the unsustainable rates of consumption of firewood in mountain areas and to create non-farm jobs for people within their own communities.

In addition to its novel management and tariff structure, the availability of trekking tourism in the Khumbu makes the Thame project perhaps the most successful mini hydro project in the country in meeting these two goals. Electricity from the Thame power plant is clearly adding value to tourism – the major economic sector in the Khumbu. The advent of electricity has introduced some sophisticated items to the tourism menu especially in Namche Bazar - high quality pizzas and breads from its four electric bakeries, well-lit restaurants, hot showers and even a Jacuzzi bath, karaoke and snooker bars, and video parlours. With the availability of running water, as a result of electrical pumps, and electric heating, the room rates in the lodges and hotels are also going up. Clearly more can be done in both categories, but what exists is already a big improvement over status quo.

Electric cooking and water heating has also been relatively successful in the Khumbu because labour to collect firewood is relatively expensive and in short supply. By offering alternative employment to labourers, such as carrying loads or backpacks, tourism has increased their daily wages. This makes collection of firewood expensive. In addition, the regulations within the national park, where Khumbu is located, mean that supply of firewood is constrained. Experience throughout Nepal is that it is only in the few cases where both these conditions are met, that rural people will cook with electricity. The two projects in the country where the highest proportion of electricity is used for cooking are arguably the Thame and Ghandruk (50 kW) in the Khumbu and Annapurna areas respectively, the two most popular trekking tourism routes in the country.

Comparison with the NEA-owned Jomsom power plant, which is now operated by a private lessee, demonstrates that the existence of tourism alone does not mean that electricity from small hydropower will be put to value addition or to electric cooking. Although this 240 kW power plant supplies the Thak Khola area of Mustang district, another very important tourism destination, it has not been able to add value to tourism in a substantial way, other than through electric lighting, and certainly has not encouraged electric cooking or water heating during off-peak. Tariff which prices electricity at a low

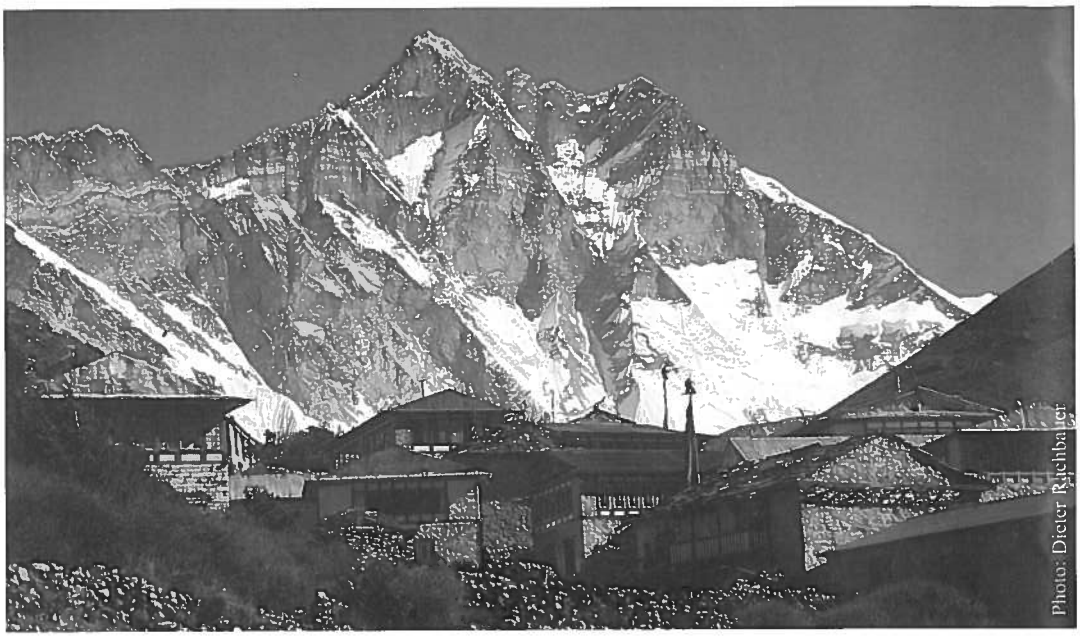
price during off-peak hours, a reliable and sufficient power supply, and a good promotion program are seen to be equally important as the existence of a strong tourism sector.

Can the lessons learned from the Thame project be replicated in other places in Nepal? One challenge is to transfer some of the learning to other mini-hydropower projects in the country that are owned by NEA. A good place to start would be the projects that are already leased to private operators. The lessees do have an incentive to increase energy sales since it means more revenue for them. In terms of new projects, the main challenge is financing – finding sums of money to build a number of similar projects in other tourism destinations such as Upper Mustang or Lukla where firewood is already or will soon be scarce. Community owned micro-hydropower projects in the under 100 kW range are being supported by part-cost subsidies[3] from HMG/N and Danish assistance. Around 500 kW to 800 kW in small projects are expected to be built in each of the coming years. The next range of projects in the mini-hydro range of 100 kW to 1000 kW has no regular source of funding. Being larger, these projects have the potential for meeting larger scale commercial and industrial uses, serving centres such as the Khumbu, that micro-hydro projects are not able to power. NEA is winding down its own small hydropower program. It would certainly be a shame if Thame and Salleri Chialsa were to be 'one-offs' whose lessons were not more widely replicated. Perhaps the challenge that should be put before the new mini-hydro projects of the future is to be able to operate commercially at no higher subsidy than what is given to micro-hydropower plants by the government.

— Bikash Pandey
Director, REPSO Nepal,
Winrock International

3. Of around US$ 1,000 per kilowatt produced plus up to $ 300 per kW for transportation for the most remote sites.

Small Hydropower Plant Thame - Namche Bazar



The Khumbu: Sherpa villages and 8000 m high peaks (Pangboche with Lhotse in the background)

Background

The hydropower plant is located within the Sagarmatha National Park in the Mt. Everest Region, which forms the northern part of the Solu-Khumbu District in eastern Nepal. The area is part of Nepal's mountainous and high altitude areas on the border to Tibet, where permanent settlements are located between an elevation of 3,400 and 4,200 metres. The valley lies to the northwest of Namche Bazar, the central market place in the "land of the Sherpa" and also the main tourist centre in the region. More than 20,000 mountaineers and trekkers visit the National Park area every year. The Sherpa people benefit from this kind of tourism as lodge owners, guides, porters, tour operators and shop owners. However, negative impacts are visible as well: increased demand for timber and fuel wood to satisfy the needs of the tourists made the utilisation of new energy resources necessary to avoid intolerable environmental stress and the eradication of the forests in the region. From this background, the idea grew to provide electricity to the lodge owners and the farmers in order to reduce fuel wood consumption, and the Austrian Government decided to finance this undertaking.

History

The history of the plant dates back to 1976 and first construction works were started in 1980. In 1985, a flood from a glacial lake outburst set an end to the ambitious plans. Thanks to the persistence and commitment of the Austrian Government a new site was identified and a new agreement was signed between the Federal Government of Austria and His Majesty's Government of Nepal. In the following years a power plant with a nominal capacity of 620 kW was built in a side valley of the Bhote Koshi at the Thame

DETAILS OF THE PLANT AND THE GRID SYSTEM

GENERAL DATA

Location:	Sagarmatha National Park, Solu Khumbu District, Nepal
Village Development Committee (VDC):	Namche, Khumjung
Area population:	Approx. 4000
Type of scheme:	Run of the river
Construction period:	1989-1994
Villages connected:	Namche Bazar, Khumjung, Khunde, Syangboche, Phurte, Samsing,Theso, Thamo, Thame, Thame Teng, Ilajung, Thame and Kyarok Gompa (monastery)
Number of customers:	632

PHYSICAL STRUCTURE

Intake (Tyrolean type weir):	Thame (3800 m)
Open flow canal (headrace):	Length 305 m
Pondage basin:	Volume 2000 m^3
Penstock pipe:	Length 970 m Diameter 450 mm
Power house:	Hungu (3600 m)
Nominal head:	205 m
Design flow:	180 litre/sec
Two Pelton turbines:	Capacity 310 kW each
11kV high voltage grid system:	Length 20 km
Headquarters "Khumbu Bijuli Company":	Thamo (3480 m)

COSTS

Construction costs:	4,500,000 US $[1]
Cost per installed kW:	7,258 US $
Management support, training, repairs:	1,000,000 US $
Grant in aid:	Department for Development Co-operation, Federal Ministry for Foreign Affairs, Republic of Austria

IMPLEMENTATION

Survey and planning:	Posch & Partners, Austria
Electro-mechanical equipment:	Fiegl + Spielberger, Austria
Turbines:	Geppert, EFG, Austria
Management support and training:	Eco Himal, Austria

1. 1 US $ = 15 Austrian Shillings (ATS),
1 ATS = 4.8 Nepali Rupees (NRs) by March 2001

Inauguration ceremony, October 1995.

Khola, and officially inaugurated in October 1995.

In 1993, Eco Himal, an Austrian INGO based in Salzburg, took over full responsibility for the technical and financial management of the power plant, including the final phase of the construction period and the training of a local Sherpa team. In May 1994, the "Khumbu Bijuli Company" (KBC) was formed and registered with the Ministry of Industry. Since 1999, KBC with its 15 local employees has been fully responsible for operation and management of the power plant. Eco Himal continued to assist KBC as adviser in technical and management know-how up to the end of 2000.

Ownership

According to the experience of hydro experts in Nepal, the reason for the failure of several similar projects was the lack of adequate training of the personnel to operate and maintain the power plant as well as the centralised management from Kathmandu. Therefore a young Sherpa team has been trained first at Balaju Technical Training Centre in Kathmandu for one year, and then for six years by Austrian technicians at the site. To transfer the decision-making process from Kathmandu to the plant itself, a bilateral government agreement between the Federal Government of Austria and HMG Ministry of Water Resources established an ownership structure unique in Nepal at this time: 85 % of the total investment was given as shares to three user groups on behalf of the respective local community, 15 % remained in the hands of the Nepal Electricity Authority (NEA) (figure 1). KBC will be managed by the Board of Directors with three elected representatives of the user groups and one representative from NEA. Since 2001, Eco Himal holds a non-voting board membership to continue the contact with its year-long partner.

KHUMBU BIJULI COMPANY — OWNERSHIP

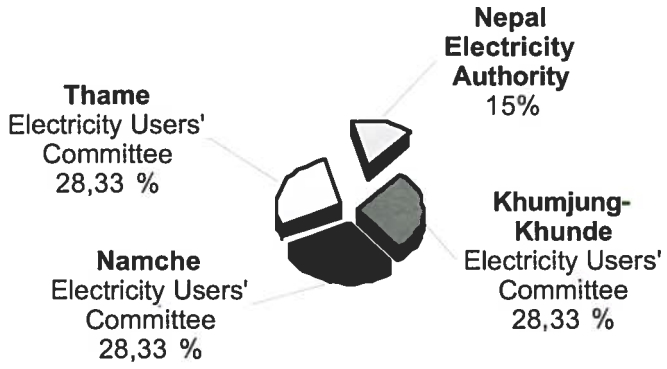


FIGURE 1

KBC TARIFF SYSTEM AND CUSTOMER DISTRIBUTION *Effective December 2000*

Level	Power	Flat Rate NRs.	Rate NRs.	Energy meter	No. of connections	% of connections
1	100 W	60.00		No	193	30.5
2	1,260 W	600.00		No	339	53.6
3	4,000 W	300.00	7.50/kWh	Yes	80	12.7
4	12,000 W	800.00	7.50/kWh	Yes	14	2.2
5	30,000 W	3,000.00	7.50/kWh	Yes	6	0.9
FIGURE 2					632	100.00

Tariff Structure

The Khumbu area is characterised by huge income differences among the population. Namche Bazar, Khunde and Khumjung, visited by many tourists, are rather wealthy villages, whereas the Thame Valley is comparatively poor due to the lack of popular tourist routes. Therefore, a socially graduated tariff system was designed to cope with this uneven situation. KBC currently applies two kinds of tariff – a social tariff with two connection levels (100 W and 1260 W) and very low fixed rates and a commercial tariff with three connection levels (4, 12 and 30 kW) with metered consumption at the current rate of NRs. 7.5/kWh (figure 2). The low energy price at the social tariff level has facilitated the quick dissemination of this new technology and has resulted in an acceptance rate of electricity connections of 100%. For customer distribution see figure 3.

Economic Viability

Since the start of operation KBC has been able to generate enough income to cover operation and minor maintenance costs. Compared to similar schemes in Nepal, this is clearly a big success. However, current revenues are not sufficient to cover depreciation in order to build up reserves for future repairs and replacements. A tariff hike in 1999 and alterations in the structure of connection levels at the end of 2000 are gradually improving KBC's income level. Furthermore, KBC management is increasingly aware of the need to adopt a more business-like attitude without compromising the original idea of providing electricity at affordable prices to poor farmers as well. At present, 84% of the customers are subscribed to the un-metered social tariff. Looking at the income distribution by region (figure 4), shows that the regional centre of Namche Bazar with

CUSTOMER DISTRIBUTION BY CONNECTION LEVEL

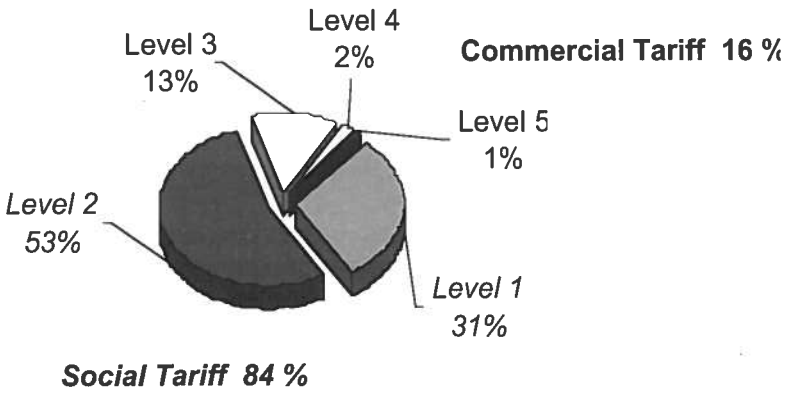


FIGURE 3

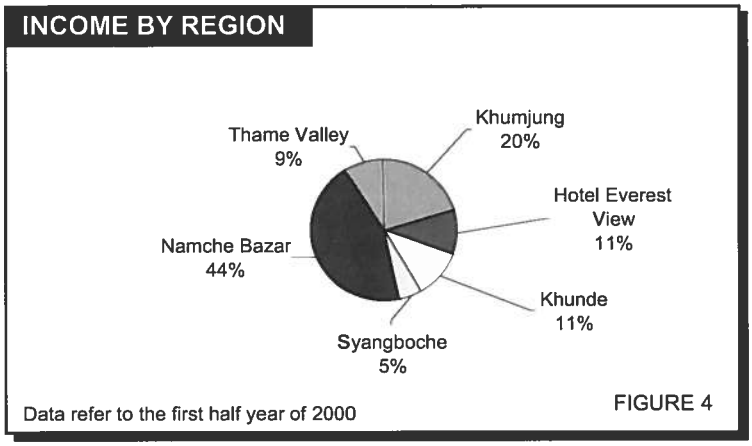


FIGURE 4

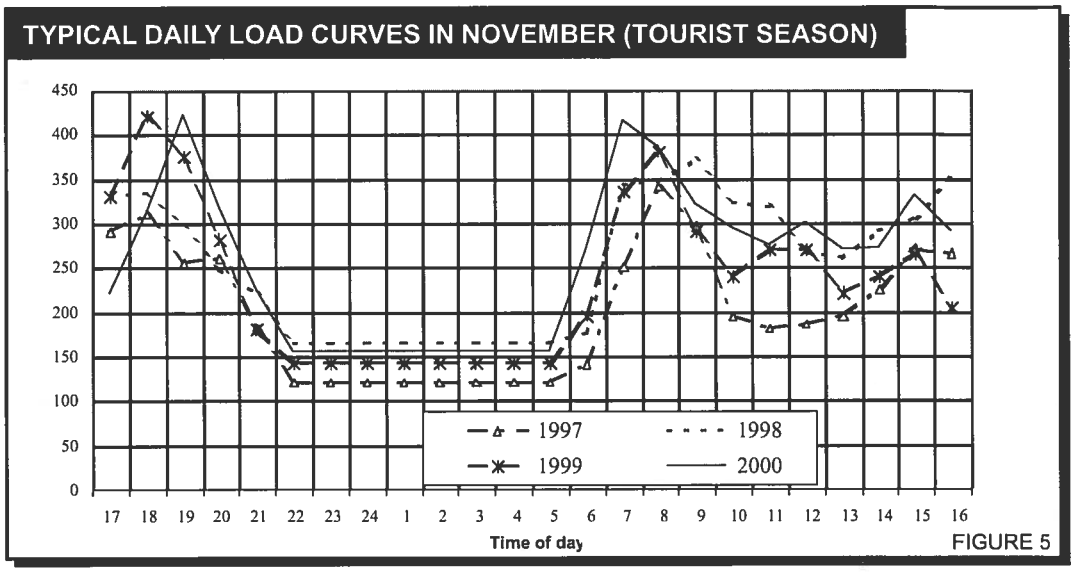


FIGURE 5

its electricity intensive services catering to the tourism industry is the most important area in terms of income. In addition, single customers like the "Hotel Everest View" near Khumjung and the "Hotel Panorama" in Syangboche as well as the bakeries in Namche Bazar and Khumjung show that KBC relies heavily on very few but "big" consumers for its main income. It also shows that the existence of a highly advanced and diversified tourism infrastructure is the financial backbone of KBC. Attempts to encourage local entrepreneurs to provide additional energy-related services to the tourists (like hot water boilers heated at off-peak hours with a lower night tariff) show first results. The recent alterations in the structure of connection levels brought down the percentage of social tariff users by 10 %, a small improvement but an important step into the right direction.

If we look at a typical daily load curve during the peak tourism season (figure 5), we see a picture quite common for isolated power systems: High loads in the morning and evening when electricity is needed for lighting and cooking purposes, significantly lower loads during daytime due to the absence of an urban-type industrial and commercial structure and slack night-time hours. This

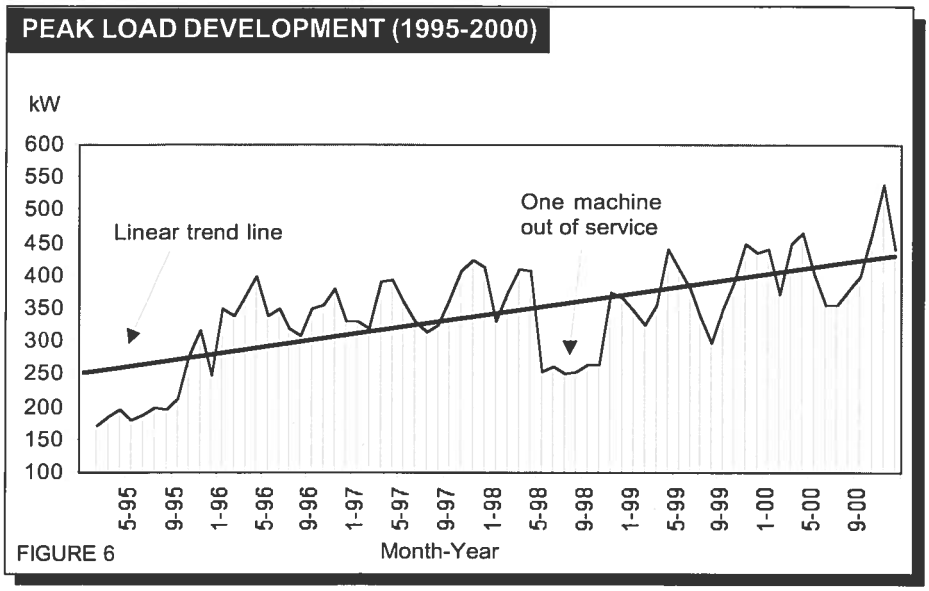


FIGURE 6

results in a sub-optimal plant factor (percentage of energy consumed compared to installed capacity) of around 35% in the year 2000.

Peak load development (figure 6) shows a gradual increase over the last 5 years of operation as well as the seasonal variation due to the character of the tourism season with peaks in March/April and October/November. Peak load problems will occur in the coming years, however, KBC is equipped with a remote control load switching system and therefore able to tackle this problem with proper load management.

Daily and seasonal consumption patterns represent the situation of isolated power systems in rural areas and the seasonal nature of tourism in Nepal, hence a structural problem and difficult to rectify by KBC. In this respect KBC's strategy to increase revenues from energy sales should be three-fold:

- Promoting energy use in off-peak hours by providing tailor-made solutions to individual entrepreneurs
- Linking the tariff system to the Nepal Electricity Authority (NEA) and adding a surcharge for the significantly higher general price level of the Khumbu region
- Gradual reduction of the percentage of social tariff users without abandoning the idea of providing affordable electricity to the poorest fraction of the population as well

Drinking Water and Sewage System Namche Bazar

As part of the hydropower project the construction of a drinking water system in Namche Bazar has been facilitated. Besides the objective to provide the major village in the area with safe drinking water, the attempt to develop KBC into a regional public utility company with diversified income opportunities was the prime motivator for pursuing this project. The innovative joint effort in terms of financing can be seen in figure 7.

Grid Extension to Lukla

Since 1996, Eco Himal has been considering the extension of the electricity transmission line into the buffer zone of the Sagarmatha National Park towards Lukla. The original rationale behind the plan was to increase the revenues of KBC, to reduce firewood consumption in a wider area and to implement an integrated electricity scheme for the

WATER SYSTEM NAMCHE BAZAR — FINANCING MODEL

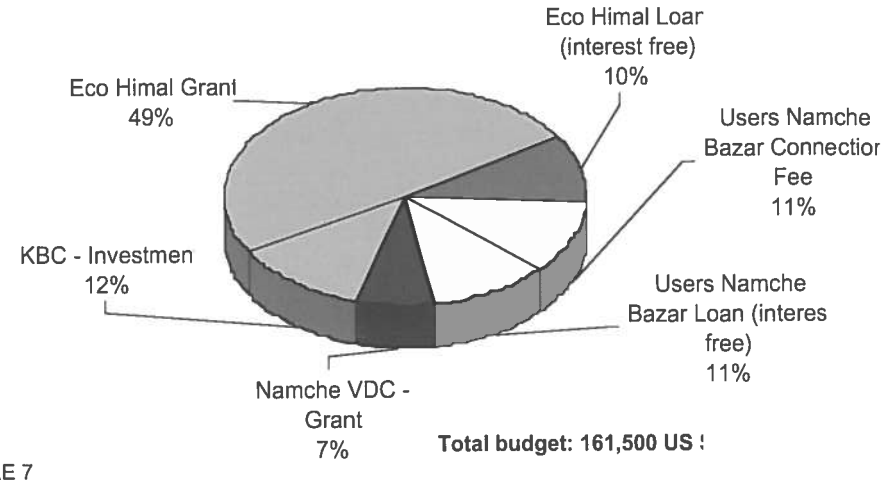


FIGURE 7

Khumbu region. In 1998, the planning phase was completed and the plans were officially presented. An approximately 15 km long 11 kV high voltage power line from Namche Bazar to Lukla and the 400 V distribution system was intended to connect the villages on the way. Concerns as to the economic viability, future demand development and lack of financial means made it necessary to put the plans on halt.

Energy and Development

The initial rationale behind the construction of the power plant was to reduce fuel wood consumption in the Sagarmatha National Park. A study conducted in 1997 and an additional survey from the year 2000 show that due to the widespread use of electricity for cooking purposes fuel wood consumption has been reduced by 30%.

Due to the availability of electricity, intensive diversification of tourism-related services took place. Figure 8 (next page) shows the various commercial or non-household end-uses by region. Figure 9 shows the different electric appliances being available in a typical lodge. Differences per region/village represent the different income levels of the area as well as differences in the distribution of tourism-related infrastructure. From figure 8 it can also be seen that the availability of electricity did not contribute towards the diversification of the economic structure of the Khumbu area itself. Almost all commercial electricity users cater to the still expanding tourism market.

In autumn 2000, an external evaluation commissioned by the Austrian Federal Ministry for Foreign Affairs attributed the project major achievements in reaching developmental goals including positive effects through electricity on health, education and reduction of women's workloads. Cultural transformations as a result of the introduction of electricity are clearly visible and generally positively perceived by the local people.

Looking back at the experience of the last 12 years a wide range of factors can be identified which contributed towards the success of the project:

Technology

- State of the art and reliable technology
- Appropriate stock of spare-parts to avoid supply-disruptions
- High safety standards
- Reliable power-supply to build trust in the new technology and to avoid

COMMERCIAL OR NON-HOUSEHOLD END-USES

1. Namche Bazar

- ❒ 3 Bakeries: Everest (2 ovens each 13 kW), Hermann's (2 ovens, 3 kW, 4 kW), Namche (2 ovens each 4 kW)
- ❒ 2 Internet Cafés
- ❒ 1 Sauna
- ❒ 2 Laundries
- ❒ 2 Bars
- ❒ 2 Pool table halls
- ❒ 32 Lodges
- ❒ 50 Tea shops
- ❒ 1 Cinema
- ❒ 2 Mineral water bottling plants
- ❒ 2 Meat processing mills
- ❒ Pizza Hut with one oven 4 kW
- ❒ Offices: Sagarmatha National Park Administration, Sagarmatha Pollution Control Committee, Police Office, Nepal Telecommunication Office, Border Administration Office, Post Office, Commercial Bank, Village Development Committee
- ❒ Health Post, Dental Clinic, Tibetan Medical Centre
- ❒ Namche Primary School
- ❒ Army Barracks
- ❒ Airlines agents: Skyline Air, Yeti, Shangrila, Gorkha
- ❒ 35 Shops

Thriving business in Namche Bazar.

2. Khumjung and Khunde

- ❒ 16 Lodges
- ❒ Hotel Everest View
- ❒ 7 Teashops
- ❒ 1 Bakery
- ❒ 1 Hospital

Bakery in Namche Bazar

3. Syangboche

- ❒ 3 Lodges
- ❒ Hotel Panorama
- ❒ 2 Teashops
- ❒ 2 Shops
- ❒ Airline agents: Asian Airlines, Hotel Everest View Office
- ❒ Livestock farm

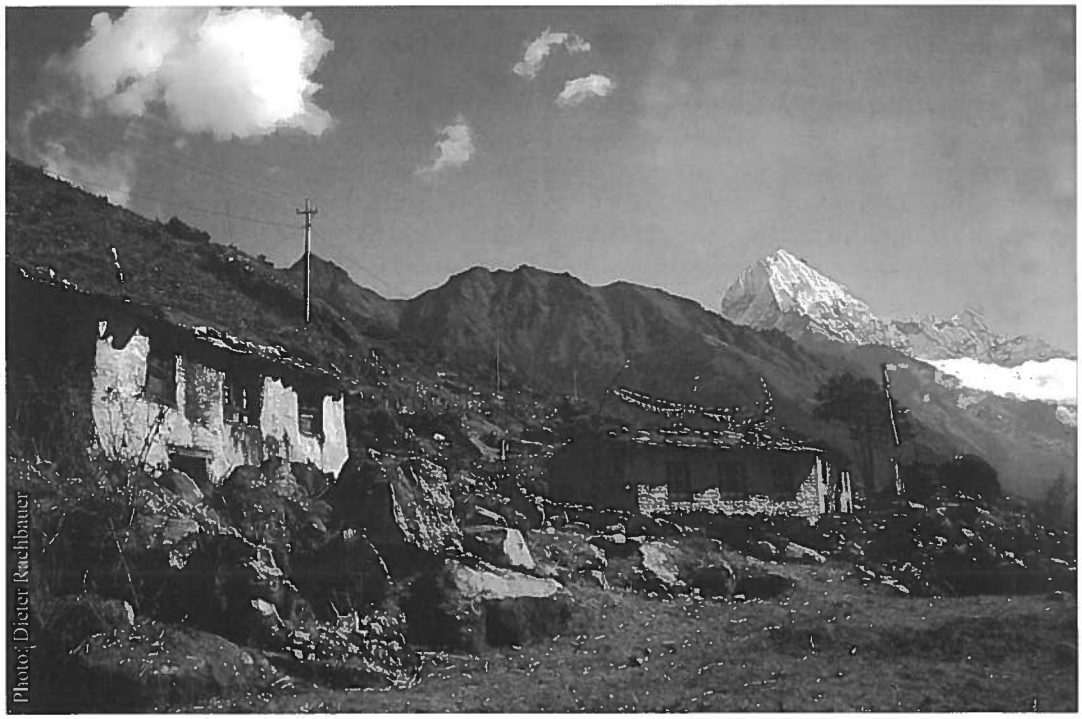
4. Thame Valley

- ❒ 8 Lodges
- ❒ 22 Teashops
- ❒ Army Sub-office .
- ❒ Border Police Check Post

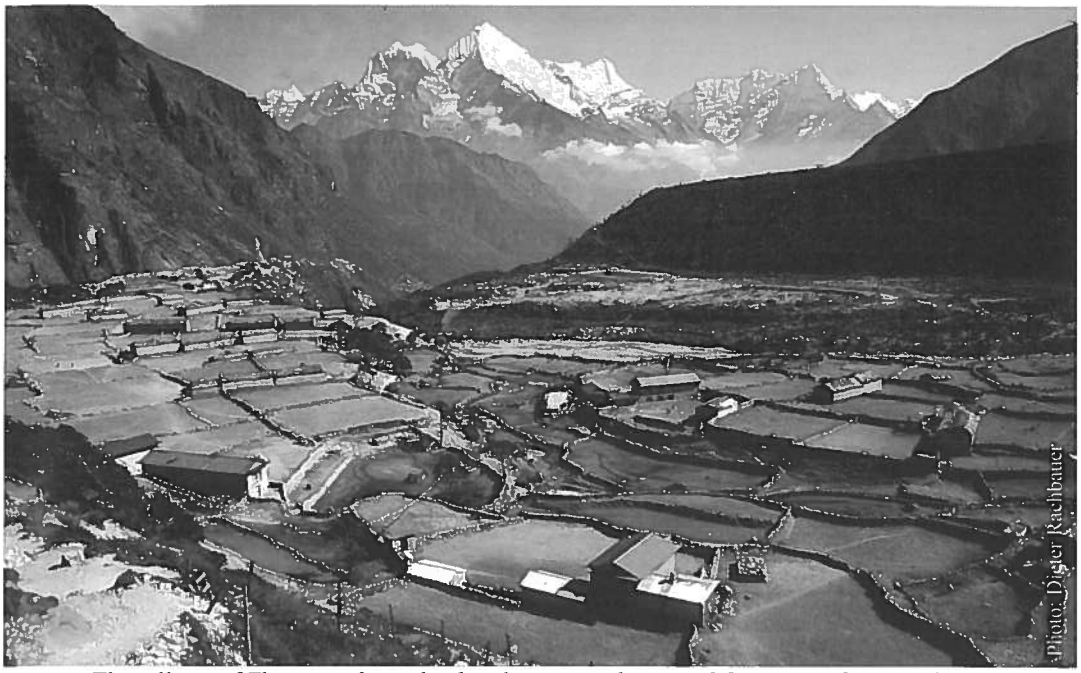
FIGURE 8

ELECTRIC APPLIANCES IN A TYPICAL LODGE — FIGURE 9

	Thame Valley	Khumjung	Namche Bazar
Light	✓	✓	✓
Electric Cooker	✓	✓	✓
Mixer	✓	✓	✓
Tape Recorder	✓	✓	✓
Battery Charger	✓	✓	✓
Television	✓	✓	✓
Video Recorder		✓	✓
Refrigerator		✓	✓
Vacuum Cleaner		✓	✓
Water Purifier		✓	✓
Micro-wave Oven		✓	✓
Boiler		✓	✓
Toaster		✓	✓
Coffee Machine			✓
Room Heaters			✓
Iron			✓



Electricity transmission through the Thame Valley



The village of Thame with intake, headrace, pondage, and first part of penstock line (right bank of Thame Khola).

continued income losses

Ownership and Training

- ❒ Local ownership of the power plant which increases commitment and accountability to the users
- ❒ Local personnel which reduces turn-over and loss of trained man-power
- ❒ Appropriate electrical and mechanical training of the staff
- ❒ Year-long on-the-job training through qualified personnel
- ❒ Provision of training and advice to the user groups and the board of directors of the power company

Economy

- ❒ Low energy costs in an initial phase to encourage acceptance, dynamic demand development and firewood substitution
- ❒ "Commercialisation" of the power system in a second phase and move towards a more business-like approach to increase the level of income of the power company (not yet fully accomplished)
- ❒ Sufficient purchasing power available in the supply area

Regional Development

- ❒ Integrated approach to link technology with training, management, institutional set-up and development through a non-profit organisation committed to a wider regional development approach
- ❒ Long-term commitment of the donor and willingness to support accompanying projects like the Village Development Project Thame Valley and the Mountaineering School Thame, both projects implemented by Eco Himal

—Dieter Rachbauer
Project Co-ordinator Nepal,
Project Manager, Eco Himal

The Early Days

Origin of the glacial lake outburst flood (Dig Tsho Lake) which destroyed the first site.

The small hydropower plant in Thame - Namche Bazar has a long history. Already in the early 70s a Norwegian study was carried out to find possibilities to produce electrical energy for the National Park area. It seems that the whole area between Lukla and Namche Bazar was explored without finding an ideal site. Finally the engineers reached Thamo where the valley of the Bhote Khosi opens up between two narrow stretches. The area was big enough to propose a small hydropower station with an installed capacity of 650 kW, designed as a run-of-the-river plant with six Francis turbines to be installed. A representative of an Austrian company producing equipment for hydropower stations somehow got hold of the study in New Delhi.

From then on the activities also become a mirror of the history of the Austrian development co-operation. In 1978, the Austrian Department for Development Co-operation was still part of the Department of State Owned Industries. Therefore it was quite clear that the detailed planning and the equipment supply should be done by state-owned industries. It was intended to build the small hydropower plant Thame - Namche Bazar as a showpiece of Austrian export industries. The first negotiations for a bilateral agreement between Nepal and Austria started with the intention that Austria would only supply the equipment and the engineering services and Nepal should finance all the construction costs. During the lengthy negotiations Nepal insisted that it could not finance all the construction costs. In the end Austria reduced the planned six turbine units by two and added some construction costs instead. Finally on August 6, 1980, an agreement was signed between the Federal Chancellor's Office of Austria and the Ministry of Finance of Nepal. The project was to be implemented by the Small

Hydropower Department (SHPD), which was integrated later into the Nepal Electricity Authority.

When the agreement was signed, the project planning was already finished and SHPD had already started minor work. By the end of 1984, construction work had reached a stage where invitations to tender for the equipment were sent out. During the summer of 1985, the final quote had been selected and the contract for the electromechanical equipment was about to be signed when by middle of August the news spread that a flood wave caused by a glacier lake out-burst had swept away the civil works.

During a site visit, months before the big flood, another possible, even better site further upstream in the Bhote Khosi valley had been spotted. But of course, at this time it was only of theoretical interest with construction work well underway. After the disaster, however, the site became important. But first of all it was necessary to convince quite a number of persons that the project should go on. With a history of more than eight years, some thought that this would be a good time to drop a project that had already lost its charm as a showpiece for Austrian industry. Convincing the Austrian chiefs was the first, still easier part, holding them to the moral obligation Austria had undertaken by signing the agreement.

Looking back on the structure of the official Austrian Development Co-operation at this time it may be understandable that it was still not possible to talk about the real foreseeable cost of what is now the Khumbu Bijuli Company. The agreement covered only the construction of a hydropower station, without mentioning a distribution system or problems of subsequent operational management. Nevertheless, it was the biggest single project of the Austrians.

After getting permission to go ahead with the redesign the real headache began. I will never forget my experience with the Nepalese administration at this time as far as negotiations and decisions were concerned: sitting with my counterpart of the Ministry of Finance in one of the old Rana Palaces in the humid heat of Kathmandu for hours and days to amend the existing agreement without reaching any conclusions. But somehow we got things settled or worked alongside the lines to make this project happen.

The problems where not over after an amendment to the agreement was signed in October 1986. According to Nepalese regulations, a contract had to be awarded to the lowest bidder. So we found ourselves with a contractor on site who had calculated the prices in Kathmandu without knowing the high cost of the tourism-spoiled Namche area. Taking over part of his duties by and by was the only option to avoid more setbacks in the timetable than had already occurred. On the other hand, one has to admit that it was quite a challenge to work at an altitude of 3800 metres where a bag of cement had to be carried for 14 days to reach the site. And it was not only cement that had to be carried but also steel, pipes, cables and all small items. Only heavy equipment like turbines, transformers, etc. where flown in by helicopter. This was another factor limiting the project, even more so because at that time only one company existed for transportation and they had the say!

With all the experience gained during the years of construction, it was clear that the Nepalese Electricity Authority would not be very much interested to run a small hydropower station and an isolated grid in this adverse environment. Therefore new negotiations started to find a better set up for the years of operations hopefully to come. At this point help came through our neighbours (in a double sense): Switzerland had financed a small hydropower project in Salleri Chialsa and was also looking for a model of local ownership. So we could profit

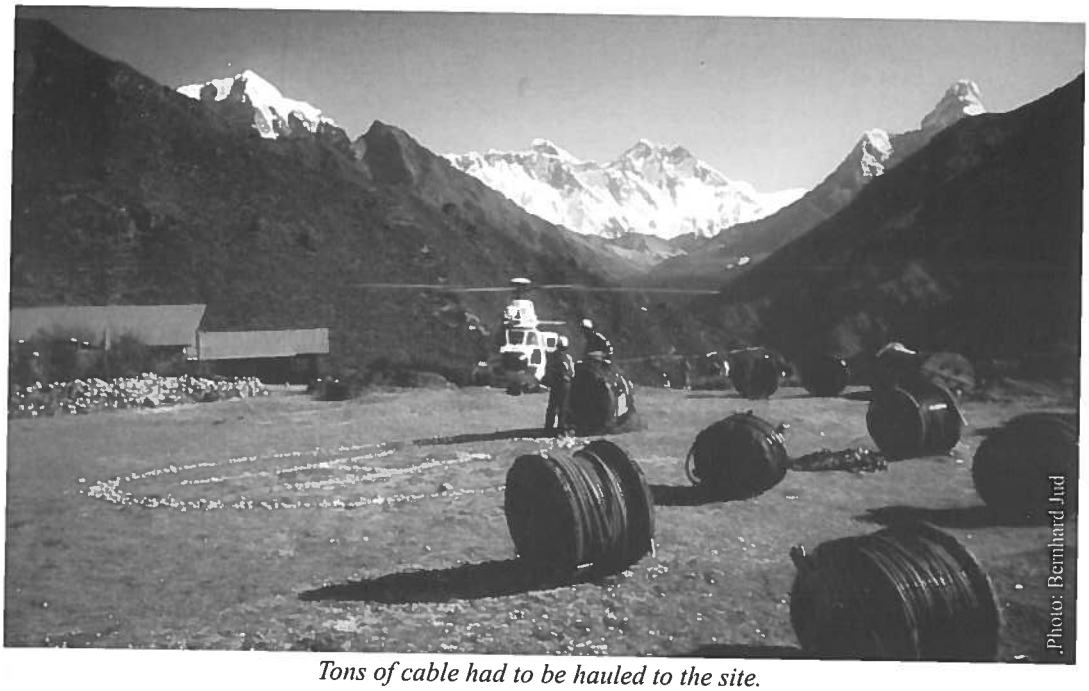
Transport to the site.

from each other's efforts - and the fact that Nepal had to open up its power market to attract private investment and narrow the supply gap. Earlier on, a group of young Sherpa had already received training in Kathmandu to work as operators. To improve their knowledge they also had worked together with an Austrian engineer during the construction period.

So what had started out as an export promotion project in the end became a user owned utility corporation, what once was intended to create employment in Austria created better living conditions for the Sherpa (even against protests of some Austrian environmentalists who wanted to keep electric distribution lines out of their sights).

— Hans Danninger
Dept. for Development Co-operation,
Federal Ministry for Foreign Affairs, Austria

The Construction Period



Tons of cable had to be hauled to the site.

I started working at the Small Hydropower Project Thame – Namche Bazar as a trainee in spring 1990. By that time, the construction of the hydropower plant had just begun. *Posch & Partners*, an Austrian company from Innsbruck, was the main contractor responsible for the survey, planning, execution and commissioning of the project. *Fiegl & Spielberger*, another Austrian company, specialised in power generation was the subcontractor for the supply and installation of the electromechanical parts of the hydropower project. Both companies had to work in co-operation with the Nepalese *Small Hydro Power Plant Department* (SHPD) under the *Nepal Electricity Authority* (NEA). SHPD's part was to complete the civil construction works by contracting local contractors under the supervision of the Austrian companies.

[1] Nepali for "Electricity"

The hydropower project was a big sensation for the Khumbu inhabitants. Tons of "strange" electromechanical equipment were transported to Khumbu and there were so many helicopter flights. Although the project construction phase had just begun, people were very curious to know when the power plant would be finished. The first question they always asked us was, "When will *Bijuli*[1] come?". We had to explain to the people that "Bijuli" would not come until the power station at Hungu and the transmission lines to the villages were completed. We always told people, "Bijuli comes in two years, if everything runs as swiftly as planned". And everyone was sighing, "Two years! So long!" However, more patience was necessary.

At the beginning of the construction phase the power house building and the helipad at Hungu were started. The helipad was

Excavations for the penstock.

essential as no other means of transportation was possible to reach this remote location. The civil construction works like intake at Thame Khola, Tyrolean type weir, head race channel, etc. had also begun. There were more than 10 SHPD staff at the present KBC office in Thamo, with a civil engineer as chief of the project on SHPD's behalf. A local contractor with more than 30 labourers was engaged for the construction of the power house building and the helipad in Hungu while another contractor with more than 40 labourers was working at the intake area and with earth excavation works for the penstock. Later on three more local contractors, each having more than 60 labourers, were engaged for the construction of the village transformer stations and laying out of 11 kV lines as well as the 400 V house connection lines.

The transportation of the electromechanical equipment to the site started in autumn 1990, using helicopter flights from Kathmandu. Smaller equipment and the cables were transported by truck from Kathmandu to Jiri and further by helicopter to the project site. Many of the materials were also transported by a military aircraft from Kathmandu to Lamidanda and then by helicopter to Khumbu. All electromechanical equipment, tools and other materials were shipped from Austria in sea containers which first arrived at Bombay port in India and then hauled by truck to *Balaju Yantra Shala* (BYS) in Kathmandu.

The turbines and generators were installed in autumn 1991 by the Austrian company *Geppert*. At the same time it was found that the electrical welding of the steel plates for the penstock (which were shipped from Austria) by BYS did not meet the required technical standards. It meant a major task had to be repeated at the site, re-welding of all penstock pipes. Welders and welding equipment from BYS were flown to the site. The main difficulty was that the welding apparatus did not work properly at the high altitude. The second problem was that the heavy steel pipes were already placed all over the hill between Hungu and Thame and work had to be done under very difficult conditions. The main tasks completed in autumn 1992 were the erection of the panel boards of the control units, installation of the high voltage switch yard as well as the transformer station. I was involved mainly with laying 400 V distribution lines in different villages. More than 160 labourers were engaged for this job under three local contractors. In autumn

Work at the transmission line.

High voltage underground line.

1992, we had some problems with SHPD staff regarding the 400 V distribution lines in the villages. The work proceeded very slowly and the way they laid the cables contradicted the principles of the Austrian engineers. The cables had to be laid in the shortest possible way in order to save cable and time. However, the contractors on site were paid per metre of cable laid and the SHPD chiefs received a certain percentage of the total amount paid to the contractors as a commission. We realised that we had to supervise this work in order to save money and around one kilometre of expensive cable from Austria, a decision which did not please SHPD. To lay out the long cables in the ditches properly was quite a strenuous job because none of the labourers was skilled in this sector and none of them had ever seen an electric cable in their life. The present KBC technicians joined us in autumn 1992 after completing two years of training at *Balaju Technical Training Centre* (BTTC) and soon after the distribution lines were finished.

In autumn 1993, the villagers sighed, "Bijuli will never come". Everyone realised that it would still take at least a year longer than planned until the power plant would be ready for operation. Finally, in autumn 1994, the lights went on.

I left the hydropower site in June 1993 and came back to Salzburg in order to study at a technical engineering college. In April 1999, I returned to Khumbu as Eco Himal's project manager for the Village Development Project Thame Valley.

Electrical installations at a transformer station.

Everybody involved in this hydropower project, for a long or short time, has his or her own story to tell. If we were to gather all the stories of all the people, we would end up with a very thick book. The construction of a hydropower plant in such a remote area and at this altitude is certainly a big challenge and I think that this project has a very special place in the history of Khumbu as well as in the Austrian Development Co-operation.

— Mingma Norbu Sherpa
Project Manager, Eco Himal

Napataune Khola Le Sango Bagaunchha

"A tame-looking river can wash out a bridge" is a common Nepali proverb that expresses the sentiment that the small can do mighty things. This also reminds us that even the quietest of Nepal's mountain rivers can be potentially destructive. This lesson is often ignored when planning large hydro projects.

High waters at intake.

In 1976, a team of Austrian and Nepali engineers came to survey the Namche Hydel Project site on the Nangpa Khola (Bhote Koshi). At that time I was working for the National Park Service to establish Sagarmatha National Park in Khumbu. A hydropower project in a national park is not an easily reconcilable idea in many parts of the world, and Khumbu was not an exception. Park planners were particularly concerned about the possibility of ill-designed transmission lines and structures destroying the aesthetic beauty of Khumbu. Gordon Nicholls, the New Zealand advisor and I decided to be proactive and visit the engineer's camp to share our concerns. The engineer told us that underground wiring would be costly and may be impractical in a mountain terrain. Upon seeing the site plan, my concern shifted from the potential ugliness of overhead wires to the long-term safety of the power station itself. I pointed out that the river often produced major floods. The engineer assured us that technicians had surveyed the headwaters and that the river was considered safe. The construction work began and for nearly a decade progress was made at a snail's pace. Local people were getting discouraged and saw it as nothing more than pouring money into the river.

Park managers anticipated the negative impacts of the construction phase - the increased use of fuel-wood, illegal hunting, and landscape damage. However, it was assumed that the long-term potential benefits were likely to offset the short-term impacts. Being both a local and a park official, I was aware that the park's legal protection and the hydroelectric alternatives were both essential to conserve Khumbu's forests. Differences were resolved with the hope that the completion of the project would eventually contribute to conservation.

One fine afternoon in August 1985, a glacial lake outburst flood (GLOF) came down from Dig Tsho, as feared. It not only swept away many bridges but also destroyed the construction work on the hydro project, disappointing many. Fortunately, the donors decided not to give up. Site was relocated upstream to a safer tributary and construction work began all over. The installation was completed in 1994 and the *napataune khola* generated 600 kW of much needed electricity for Khumbu. All major villages of Khumbu were ready to be hooked up with electricity for cooking and lighting.

The challenge then was to develop long term operation and management of the system. At this point, Eco Himal stepped in to help setup a local management system. It initiated

The Thame Valley (bottom left: Remnants of the intake of the first site)

local consultation, formed power user groups; trained locals as technicians, restored damaged landscapes, and funded community projects in affected areas. Now, Eco Himal is phasing out their participation, leaving the management in the hands of the local Khumbu Bijuli Company (KBC). Khumbu residents have therefore considered the "Bijuli"[1] as a "Bideshi"[2] project. Now, the local users must take over responsibility. Are the users ready to take on the challenge? This will depend on the capability of the elected KBC Board. The technical aspects of KBC may be sound but the financial and decision-making system may need to be strengthened. The local users must take a greater interest and support the KBC to make it a functioning and business-like company. Sherpas have created successful businesses in trekking, tourism, and trade at individual and family level. KBC needs to build on this experience and develop the company into a community-managed business. Khumbu residents have enjoyed the use of undisrupted electricity and all that comes with it for nearly seven years. Research has proven that electricity has had positive impacts on forests. Local opinion shows that there have also been positive impacts on health, education, and economic productivity. The community is grateful to the donors and Eco Himal for developing this asset. The users can no longer afford to ignore hydropower management. The KBC must be strengthened. If a tame-looking river can wash out a bridge, the unassuming KBC can also rise to the occasion and manage the "Bijuli" system.

— Lhakpa Sherpa
Project Manager,
Chomolungma Conservation Project,
The Mountain Institute

[1] Nepali for "Electricity"
[2] Nepali for "Foreigner"

Development through Technology ?

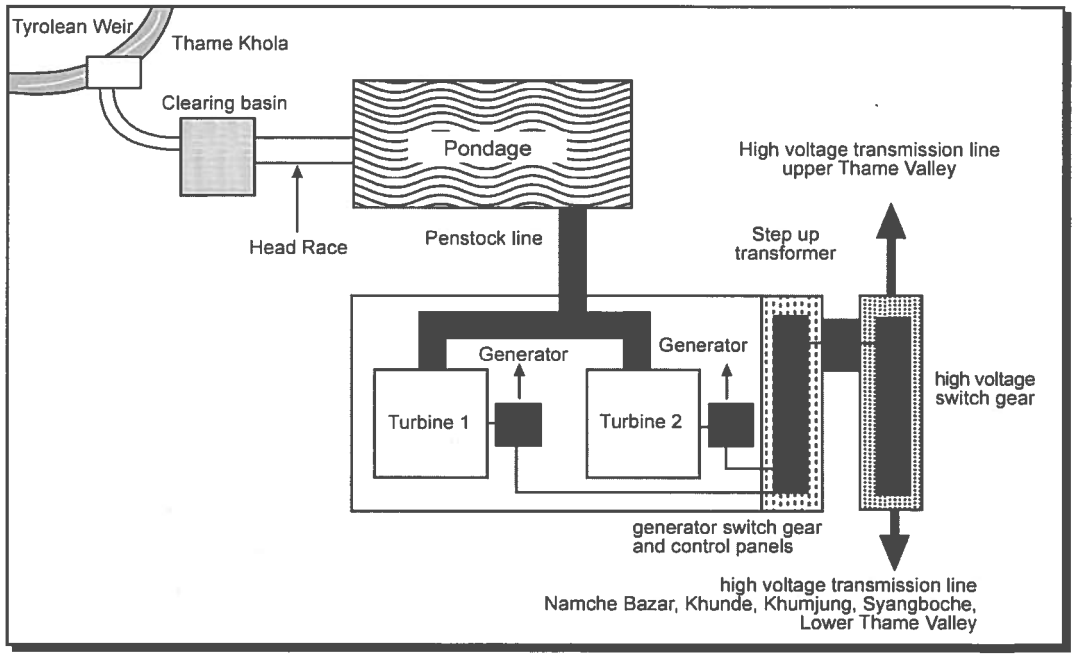
Technical Aspects and Recommendations for Successful Implementation of Small Hydro-power Projects in the Himalayas

Experts have already described the hydro-power plant Namche-Thame as one of the "most successful small hydropower plants in the Himalayas". In the following brief summary a former technical manager of the hydropower project analyses its method of functioning and which preconditions similar projects should fulfil in order to be just as successful.

Technical Overview of the Power Plant and its Transmission and Distribution System

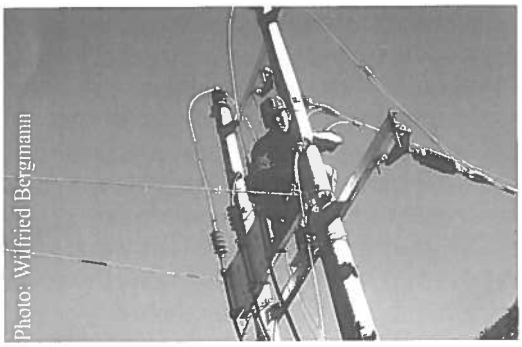
The small hydropower plant in Thame generates its energy by utilising the high water pressure, which is produced by an altitude difference of approximately 200 m. The water is brought to the turbines by a penstock line of 1000 m with a nominal diameter of 45 cm. The key components of the power plant are two pelton turbines with a combined output of 620 kW. The generators, which convert the turbine's mechanical energy into useful electrical energy, are directly coupled to the turbine shafts. Both units can be operated individually as well as parallel and are monitored and controlled by a central electronic controlling system.

The power plant itself is located in the Hungu Valley below Thame at an altitude of 3600m. The intake area, consisting of Tyrolean type weir, clearing basin, headrace and pondage, is located in the Thame village at an altitude of 3800m. This area is connected to the power house via penstock line. During Monsoon season the power plant is supplied with spring water, which is free of sediments and available in the intake area in a sufficient amount, instead of river water from the Thame Khola.



Basic functional scheme of intake area and power house

The power plant is designed to work in an island operation mode, that means that only the amount of energy, which is required by the consumers, is generated and distributed via a high voltage transmission and a low voltage distribution system. The high voltage transmission system is 20 km long and presently connects 11 villages, including the monasteries of Thame and Kyarok as well as the large hotel "Everest View". It consists of a 11 kV overhead line as well as high voltage underground cables. In each village 11/0.4 kV substations are located. The customers are connected by low voltage underground cables. Inside the villages all energy distribution is realised by underground cable systems for reasons of landscape protection. At present 632 households are connected to the grid.



Work at the high voltage overhead line.

Experiences and Success Factors

How can a technically oriented development project become a long-term success? Due to the general character of such projects, success or failure is mainly determined by the way "hard" technical factors are combined with organisational, social factors and adapted to the special local situation. The experience gained during the operational training of the local staff showed that a number of general success factors can be identified, which are absolutely applicable to other power plant projects.

Should the power plant project succeed, special attention must be given to the following areas:

- Technical and design quality of the plant
- Education & training of the local staff
- Project duration.

Technical and Design Quality of the Plant

The key components of the power plant – turbine, penstock pipe, electrical, mechanical and hydraulic equipment – must fulfil the highest quality standards regarding life-time and reliability (this precondition should not only apply to western power plants!). The demands on the material in the Himalayan region are tremendous due to the extreme site conditions: high altitude, weather conditions, glacial processes, landslides. During Monsoon season the rivers carry large amounts of sediments which expose the material and the plant components to extreme physical stress. A poor material quality leads to a shorter life-span, therefore savings on the first investment will result in later additional investments which were not initially calculated. If plant components of an inferior quality are used, the power plant will fail in the long run and its operation cannot be guaranteed under the extreme conditions in the Himalayas.

Furthermore, procuring spare parts is rather time and resource consuming due to the mostly remote location and difficult accessibility. Therefore, planning a generous stock of spare parts from the tender stage of the project onwards must be considered as an important success factor. Plant shutoffs due to a lack of spare parts directly result in income losses as well as in losses in confidence by the customers. Because of the social situation in the project area, the earnings of the power plant are usually much lower than in western power plants of the same size. Therefore sufficient financial reserves must be made available for key components throughout the entire operation period.

All components should not only fulfil sufficient quality parameters, but also comply with

western safety standards. The plant must be state of the art, whereas the degree of automation can be limited to a certain level. Experience has shown that forced outages are dramatically reduced, if as many components as possible have an option for manual operation. But, a certain degree of automation is necessary to reduce the human error factor and to protect the operational staff.

KBC staff.

Education and Training of the Local Staff

Apart from the "hardware quality", human resources are one of the most prominent success factors. Supposedly, one of the most important lessons learned in the power plant project is that it is unavoidable to intensively train and support the future operational and administrative staff for a number of years. Educating and training the staff should in principle be seen as a continuous process which should already start at the installation and system start-up phase at the beginning of the project. This aims at making it possible for the local staff to "grow" into the project and strengthens their understanding of the larger operational context. Integrating the local team as equal co-workers instead of "cheap" labourers in this initial project phase helps to develop motivation and identification. Furthermore, I suggest training and supporting "key personnel" with "key competences" in order to achieve a certain amount of continuity.

Duration of the Project

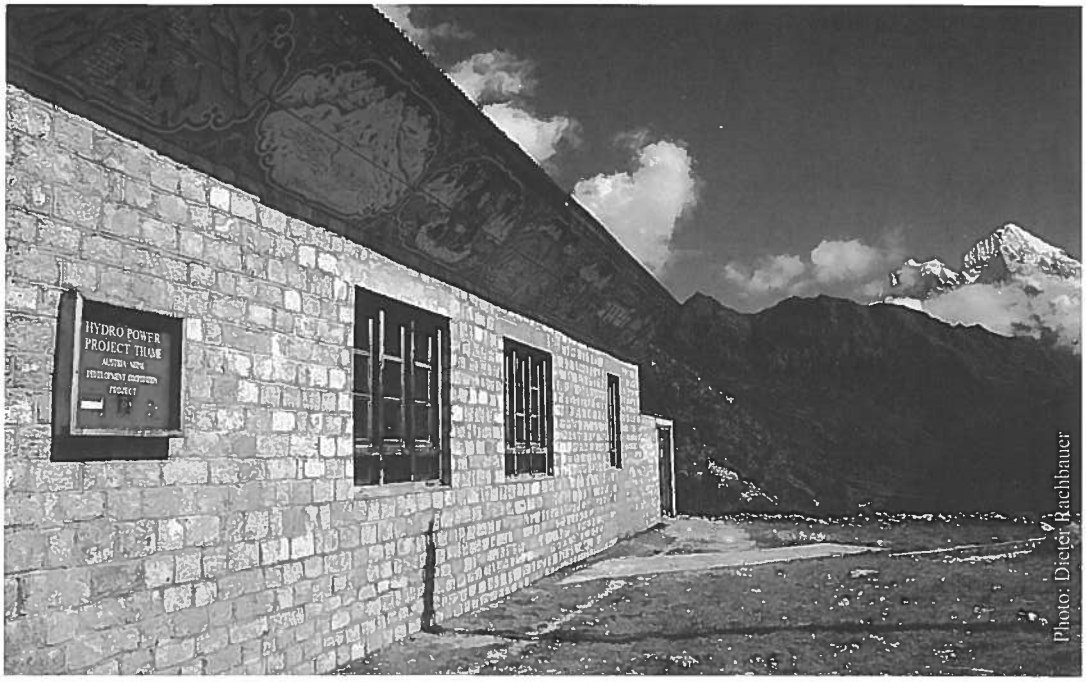
The complexity of small hydropower projects with large transmission and distribution systems demands a sufficient project duration. Generally, the project support should last until the power plant works technically and economically well and can be operated independently. The small hydropower project Thame-Namche Bazar, for instance, was entrusted to the local owners after a 12-year erection, training and support phase. This requires a large portion of patience, specially financially. Continuity and patience are always necessary, whether in matters of training, finances or acceptance by the customers.

In conclusion, "soft" organisational and social factors must be taken just as seriously as "hard" technical factors when working with small hydropower projects. In this, the development aid workers play an essential role. They have to meet multiple requirements: They must give an impression of credibility and build up a relationship of trust with their "students".

If the above mentioned factors – high technical and design quality of the plant, intensive training for operation and maintenance, continuity and a sufficient project period - are taken into consideration, it is highly probable that the power project will succeed in the long run. Financing and designing institutions should avoid implementing solely standard solutions which are successfully tested and work well in western countries. They should always stay open-minded and continuously improve and adapt their support according to the local requirements.

— Wilfried Bergmann
Electrical Engineer

Project Design & Technical Experiences



Summary
The demand for energy in the developing countries increases rapidly to build up their economical structures. In order to meet the demand, fossil fuels and wood are used mainly; this eventually leads to aggravating environmental problems. The development of hydropower, particularly the decentralised installation of small hydropower plants (SHPs), represents an option for these countries. The Thame small hydropower plant which is located in the extreme region of the Himalaya is an excellent example – technical features and experiences are presented.

Technical Features of Thame SHP
Thame SHP is designed as a high-pressure power plant. Water is diverted from the Thame Khola by means of a bottom sill and an intake structure erected on the right bank of the riverbed (Tyrolean type weir), furthermore a desilter basin with flushing devices is provided. An open flow canal of approx. 305 m in length is used for conducting the turbine water to a small storage basin of approx. 2,000 m^3 net volume. This enables the power plant to operate for approx. 4 hours at full load without feeding from the river.

A pressure pipeline of about 970 m in total length connects the storage basin and the powerhouse; it is led completely underground and made of welded steel pipes (nominal diameter 450 mm). The length of the sections was rather short with respect to transportation by men. Along the first section the pressure pipeline crosses a slope which caused some problems with landslides. Subsequently, it goes down to the powerhouse and ends in the bifurcation from where both turbines are fed.

The powerhouse is situated in a further side valley of the Bhote Kosi and was designed in the typical Nepalese style. It houses two generating sets, the indoor low and high-voltage switchyard, control equipment and auxiliary facilities. Near the powerhouse there is another building, the so called operator's house, for accommodation of the staff. Two identical generating sets are installed, each consisting of a Pelton turbine and a synchronous generator, which are coupled by means of a flexible coupling with integrated fly-wheel.

Generating set.

Main design features of a generating set:

Turbine:
Twin-nozzle Pelton turbine with horizontal shaft

nominal flow	Q	= 0,18 m^3/s
nominal head	H_n	= 205 m
nominal speed	n	= 1500 min^{-1}
nominal capacity	P_n	= 310 kW

Speed controller: combined electronic and hydro-mechanical system, acting on the jet deflector; positioning of the nozzles by means of electric servo motors; emergency shut-off equipment: spring-loaded butterfly-valves

Generator:

nominal voltage	U_n	= 400 V
nominal frequency	f	= 50 Hz
nominal capacity	P_G	= 380 kVA
power factor	cos φ	= 0.8

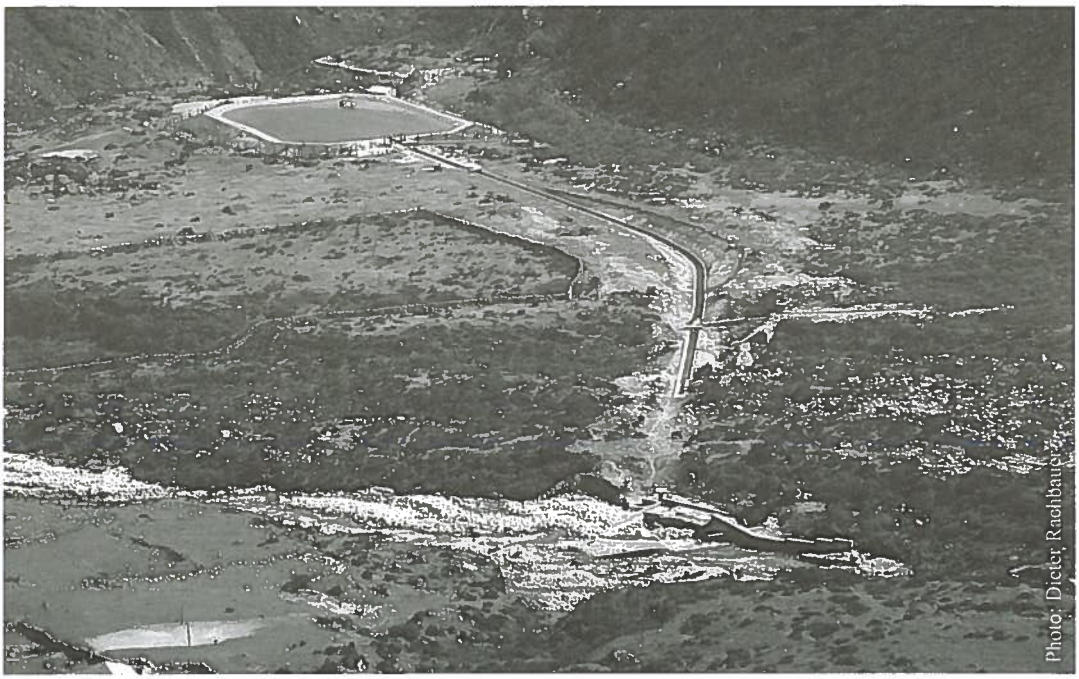
Transformers: 0.4 / 11kV

Mode of operation
The power plant supplies electricity to an isolated network at the 11 kV level. The most important process variable is the frequency which has to be constant; for frequency controlling a mechanical – hydraulical speed controller is used, where the speed setpoint is provided electrically by the electronic power plant automation system. The speed controller is acting upon the jet deflectors which are able to deflect the rated flow even for longer periods. The tailwater walls are lined with steel plates to prevent washout of concrete.

Pondage.

Another important process variable is the water level in the storage basin. It is measured by means of a capacitor type level-transducer; whenever the level is low load has to be reduced to avoid sand being soaked into the pressure pipeline. Load sharing operation is organised with the help of an electronic remote controlling and switching system. The nozzles of the Pelton turbines are closed so far that the load sharing requirements are met to save water.

Level control is realised by the power plant control system. It consists of two programmable logic controllers (PLC´s) which are interconnected by a Bus-System. Start-up and shut-down of the generating sets is going on automatically; the first set started is the leading one (master) while the second set (slave) is started automatically if the load is exceeding a predefined limit to provide base-load. The master set provides frequency control. Besides the fully automatic operation manual operation is also possible.



Intake, headrace & pondage.

In case of a technical fault an emergency shut down procedure is initialised, opening the circuit-breakers, turning in the jet deflectors by force due to gravity and closing the butterfly valves.

Operational experience

The variations of flow rate in the rivers of the Himalayan region are extremely wide. Therefore floods often occur during the monsoon period and the rivers are transporting enormous loads of materials (gravel, silt). Desilting basins are often designed to minimum dimensions due to lack of space and also due to financial restrictions. In that case, the desilter would be filled up in a very short time and usually suspended material will be drawn into the pressure pipeline. This abrasive material will cause considerable damage on the runners, nozzles, jet deflectors, etc. Desilter chambers should be designed to meet the conditions mentioned above, i.e. all dimensions should be chosen generously. When lots of gravel and silt are transported by the river it is useful to operate the desilter with short flushing intervals or even with continuos flushing. Also a twin chamber design of the desilter is very useful because it allows alternating operation desilting/flushing and moreover power plant operation will not be interrupted in case of maintenance works. Furthermore, all components of the power plant in contact with water should be protected against abrasion. The original monobloc Pelton runners suffered considerable abrasion wear during the first years of operation; they were replaced by new runners of interlocked modular technology, equipped with drop-forged chromium steel buckets and runner disks. In the case of Thame SHP, fortunately a spring originating near the headrace canal is now utilised for providing rather clear water during the monsoon season; its capacity is high enough to meet the comparably low power demand at this time.

The Thame Khola shows clear tendencies to shift its bed when floods occur, as many rivers in the Himalaya do; for stabilisation of the riverbed effective protective measures are necessary. The pressure pipeline crosses a steep morainal slope on a large stretch. The heavy monsoon rain caused dangerous landslides. Local

High voltage transmission line.

knowledge of the dry wall building (without cement) were used in order to stabilise the slope. Further aspects are the necessary afforestation and the avoidance of cattle step.

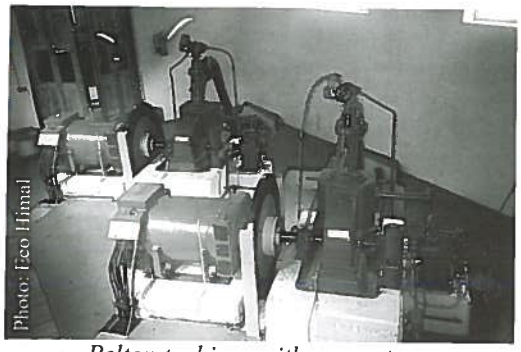
On account of the high altitude electric facilities caused some troubles, e.g. at the circuit-breakers; generous dimensioning is to be recommended, too. A very important fact for the success of the project was comprehensive training of the staff, both in technical matters and operation of the power plant, grid and household installations, as well as in commercial affairs.

Conclusions and Future Prospects

Lots of experiences were gained with the realisation of the Thame hydropower project. Its success rooted in patience and persistence of all persons involved. Of course it is necessary to provide adequate and most of all reliable technology with regard to the remoteness of the area. Increasing energy demand due to prosperity of tourism will require additional power sources. Small hydropower utilisation is ecologically desirable, it helps to reduce the consumption of firewood. Some investigations on tributaries of the Bote Kosi and Dudh Kosi were carried out to find possible sites for an additional power plant– and perhaps in future the grid system will be extended to further villages in the region.

—Wilhelm König
Consultant Engineer

Pelton Turbines



Pelton turbines with generators.

Functioning

Pelton runners are that part of high pressure power stations that convert the energy of water into electricity. Two sets of Pelton turbines, each of them with two jets produce approx. 620 kW of electric power with a net head of 205 m and a water discharge of 360 l/s. Both turbines work in island operation mode. The rotational speed is controlled by mechanical hydraulic governors which work on the jet deflector of the Pelton turbine. The water level is controlled electronically by means of electro-mechanical speed drives, attached to the respective jets. The time fluctuations in power demand and the resulting load steps of the various villages are regulated by the jet deflector. An overriding automatic timing device on the jets controls the activation of the jet deflectors to reduce wear on the machinery.

New Technology

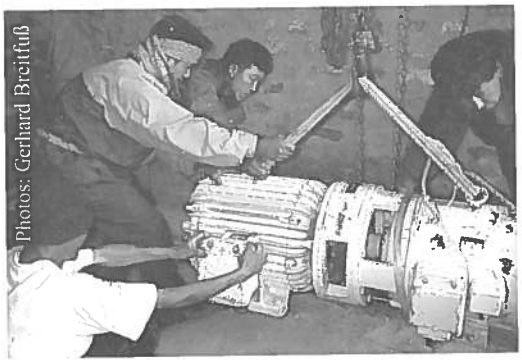
In 1999, Eco Himal Austria commissioned an exchange of the two Pelton runners. The existing cast monoblock runners showed considerable wear and tear as well as pores on the buckets, which meant that safe and reliable operation was no longer guaranteed. Fortunately, clean spring water was discovered near the intake area for operating the plant which meant that only a small portion of the abrasive water from Thame Khola river was still required. This will increase the life-span of the new equipment considerably.

A design of specially shaped, modular parts that lock onto each other is the secret behind the Pelton runners built by the Austrian company EFG. This method is called the "Interlocking Structure Pelton Wheel" and permits the design and production of a whole runner in a more controlled and efficient way than conventional runners ("Monoblock-casting"). This design enables application of precision die forging for disks and buckets which is worldwide a novelty. The application of this design proved very successful in situations where high power and abrasive water are putting heavy load on the runner.

In addition to the advantage that individual buckets can be exchanged when worn out, the decision to purchase this design was also affected by the fact that the runners can be disassembled into smaller units and carried by porters from Lukla to the powerhouse at Hungu. This saves costly helicopter transports. In the powerhouse the two wheels were assembled and installed according to the instructions of our engineer while at the same time training of KBC staff took place.

— Matthias Viertler, Werner Goldberger
EFG-Turbinenbau

Energy Management in the Heart of the Himalayas



Assembly of the generator.

Parts of the finished system.

The initial scepticism among the population of Solu Khumbu towards electricity has disappeared since its introduction in 1994. Meanwhile, the benefits of electricity have entered all the Sherpa homes in the supplied area. Thus, washers and driers as well as refrigerators and other appliances were sighted below the peaks of the sacred mountains. The resulting increase in power consumption, however, will soon bring the small power station close to its capacity limits. The magic word for coping with this problem is load management. The technical requirement is a remote load control switching system (TRA– "Tonrund-steueranlage") which ensures that each individual household can be switched on or off at the power station as required. At the appropriate time a signal is emitted and e.g. the hot water boilers start to heat up with cheaper energy. In European households this technology is used to control night current.

Bewag, an Austrian power company, has donated a TRA system to Eco Himal free of charge. This system dating from 1960 is still fully functional and perfectly suited for use in the Himalayan region since at that time very few electronic components were built in. 4000 kg of material were transported from Austria by plane, truck and helicopter up to an altitude of 3800 m in Thame. The long and rough transport caused some damage to certain parts. Still, after minor repairs all parts were ready for use. Due to a lack of high voltage testing equipment, the functionality of the system could only be tested in real operation. After an assembly and installation period of four weeks which was handled completely by the Sherpa company staff, the great moment had arrived. The system worked without a hitch from the start and will gain even greater importance when the peak loads reach the capacity limits of the power plant.

— Gerhard Breitfuß
Technician, Eco Himal

Cleaning of the Penstock

As the last phase of the power plant project the interior wall of the penstock was cleaned in October 2000. This had become necessary because of the increased friction losses in the pipes due to heavy encrustation caused by the chemical composition of the water used for operation.

Cleaning under process.

One interesting method of mechanical penstock cleaning is a system whereby cleaners with various types of exterior design (plastic profile, spiral-shaped wire brushes) are run through the pipeline. In order to realize this plan, several structural changes at the beginning and at the end of the penstock were necessary. A bypass with feed lock was welded to the pipe at its beginning. Once the cleaner is in the bypass, water from the reservoir tank is pumped into the pipe, causing the cleaner to start moving and cleaning the pipeline mechanically. In order to catch and remove the cleaners before they reach the powerhouse, a bifurcation with butterfly valve and catch pipe must be integrated into the penstock. The speed of the cleaners is controlled on the one hand by the amount of water pumped from the reservoir and on the other hand by a controlled flush pipe at the bifurcation directly before the powerhouse.

In view of all the technical details and despite having planned this procedure ahead of time, the actual work on site frequently required improvisation and carefully weighed decisions to complete the procedure successfully. We found that the performance of the emergency power generator and the pump was reduced by almost 50% at an altitude of 3800 m, which means that pumps had to run much longer and pressures were greatly reduced. Exposing and severing the penstock facing the mountain slope for inserting the bifurcation put both ourselves and the KBC team to a severe test with respect to technical safety.

Task jointly accomplished.

The successful cleaning of the penstock resulted in a capacity increase of approx. 30 - 35 kW. KBC staff was trained to repeat this cleaning procedure on their own whenever necessary and provided with the necessary technical equipment.

— Matthias Viertler, Werner Goldberger
EFG-Turbinenbau

Drinking Water and Sewage System Namche Bazar

The Austrian public utility company *Salzburg AG* contributed its know-how on water to a development project in the Himalayan region: Construction of a piped water supply system at 3400m elevation in Namche Bazar in the Mount Everest area. There is no shortage of water in the glacier regions of the Himalaya, however, drinking water in the mountain villages is sometimes severely polluted by sewage. This is why in 1999 Eco Himal initiated the construction of a piped water supply system based on the planning by the head of Salzburg AG, Centre Water, Mr. Heinrich Gernedel and chief chemist Mr. Eckart Hitsch. In May 2000, Mr. Hitsch inspected the completed facility on site and found it to be fully operational.

Until 1999, all the water had to be carried in containers to the houses.

Mr. Hitsch conducts water tests in Namche Bazar.

European Standard of Water Quality in the Himalayas

The water in Namche Bazar is being treated by means of a slow sand filtration process which has proved to be effective in Europe for over a hundred years. It works without chemicals and requires a minimum of maintenance. "The water is used to supply the village centre, the National Park administration and the army barracks. Each household connected to the system is fitted with a water meter", reports Mr. Hitsch. Together with the water supply, a simple sewage system was installed to collect household waste water. The new water treatment plant was built by staff of the local KBC power plant who also took over operation of the facility.

Three Fourths of all Homes Connected

The meter readings in the first half of 2000 confirmed the success of the project: of 131 buildings in the service area, 102 had been connected by mid-April 2000. "This large number of connected households equalling 78% has greatly surpassed our expectations. We expected 50% after 10 years", Dr. Hitsch enthuses, but he also knows the reasons: Only two years ago, all the water in the tourist village Namche Bazar, which depends mainly on trekking-tourism for a living, had to be carried in containers from the spring below the village along steep paths into the houses. All the sewage seeped into the same ground and resulted in inferior water quality causing many diseases. The construction of the water supply system meant an enormous improvement in the quality of life for the local population.

— Heinrich Gernedel, Eckart Hitsch
Centre Water, Salzburg AG

Economic Viability of Khumbu Bijuli Company

A private limited liability company named Khumbu Bijuli[1] Company (KBC) was established in May 1994 to give the Small Hydropower Plant Thame – Namche Bazar a corporate vehicle. Conventionally, a plant like this, erected with a foreign grant in Nepal, is handed over to Nepal Electricity Authority (NEA) – the only electric utility in Nepal – for its operation. In this case, NEA ownership was limited to 15% while the remaining 85% of the shares in KBC were equally distributed amongst three users' groups from the area in accordance with an Agreement between His Majesty's Government of Nepal and the Federal Government of Austria, signed on May 23rd, 1994. There are 632 users altogether that belong to one of these three users' groups.

The Austrian government spent around US $ 5.5 million[2] on this project. However, only about Rs 138 million (equivalent approx. to US $ 2 million) have been capitalised in the Company's books of account as fixed assets of the company, resulting in understatement of the Austrian government's contribution to this plant. This eases the burden of depreciation on KBC and may enable it to show profit on paper sooner. But charging a smaller amount of depreciation also means the institution will have siphoned off lesser amounts for future replacement of the plant.

The ownership structure of KBC has created an anomalous situation as far as the "Shareholders" and "Users" are concerned. Shareholders being owners of a specific company would like to see that the company is making an adequate level of profit. In order to attain this objective, they would do whatever is necessary to raise more revenue. It is slightly different in the case of KBC. On one plane both the users and shareholders are one and same. But the shareholders are not the true owners of this company as they are not entitled to share in the profit, even if the company were to make some profit. Because the Agreement signed between the governments of Nepal and Austria specifically stipulates that "the profits of the Company shall be reinvested in the Company for replacements and system expansion." Therefore, KBC shareholders look at themselves more as users than owners. Primarily due to this reason the company has not succeeded so far in collecting revenue from its users commensurate with the investment and the operating cost. The point that should be made here is that while the revenue is not even commensurate with the "capitalised" investment (US $ 2 million) plus operating cost, it is a far cry from matching the actual investment (US $ 5.5 million) plus operating cost.

In 1998 KBC earned total revenues of Rs 3.4 million while the total annual cost of its day to day operation amounted to around Rs 2 million, not including the cost of regular repairs and maintenance. In 1998 alone, the Austrian government spent ATS 3 million, equivalent to about Rs 14 million[3]. This means that the current level of revenue cannot operationally sustain the plant. The challenge that KBC is facing at the moment is to be able to at least run the plant in such manner that it is operationally sustainable. In other words, it should be able to generate the necessary funds for regular repairs and maintenance without having to rely on the Austrian government's largesse to defray these costs throughout the life of the plant.

[1] "Bijuli" in Nepali means electricity.
[2] 1 US $ = 15 ATS (Austrian Shillings), March 2001
[3] 1 NRs = 0.21 ATS, March 2001

The question KBC is struggling with at the moment is the sustainability of Thame Small Hydropower Plant. Till the end of preceding fiscal year, the weighted average rate of the tariff it charged its users was Rs 2.08 (equivalent to US $ 0.03) per kWh, whereas NEA charged slightly under Rs 6.5 (equivalent to US $ 0.09) per kWh. After some vacillation on the part of KBC Board and Management the tariff was increased effective from the beginning of fiscal year 1999/2000 in order to have KBC move towards self-sustainability. Compared with the power plants constructed with financial and technical assistance of UNDP under its Rural Energy Development Project that charges Rs 1 per watt or Rs 1,000 per kW, a KBC consumer subscribing 1,260 watt pays only Rs 600 per month under new rates. Another micro-power plant on the way to Namche at Phakding charges Rs 250 per month for 18 watts.

Another way to appraise the sustainability is to compare anticipated revenue for the current fiscal year with budgeted expenditure. With the change in the tariff KBC is expected to earn revenue of Rs 4.9 million during the current fiscal year whereas its operational expense is forecast to amount to Rs 3.2 million. Even if the plant is expected to have an economic life of 25 years, the depreciation will amount to Rs 5.5 million because it is worked out on the basis of understated (undercapitalised) value of the plant. This shows that KBC has a long way to go in terms of being sustainable at the rates of tariff it charges to its users.

Another impediment to this plant becoming self-sustaining is the fact that it is highly under-utilised. Although its installed capacity is 620 kW, the highest loads are rarely close to capacity and restricted to the tourist season. However, such peak loads would last only during peak hours of the evening and early morning while night-time and daytime (off peak) loads were quite low even in these months.

In conclusion, it must be noted that the users' groups who own 85% of the outstanding shares of KBC would never have been able to invest the required amount to own such a large chunk of the Small Hydropower Plant Thame-Namche Bazar, if not for the financial and technical grant of the Federal Government of Austria. So the plant is an Austrian gift to the populace of the Khumbu region.

Initially, the recent small increase in the tariff was resented and resisted by the users. The acid test will take place when KBC will be impelled to implement another tariff increase necessary if KBC aims at operating the plant without having to be spoon fed by external agencies. In order for KBC to attain both corporate and institutional development while achieving operational sustainability as well as being prepared to replace the plant at the end of its economic life, the Board of Directors and Management needs to develop both vision and ability to lead the Company with firm hand in the appropriate direction.

— Ratna Sansar Shrestha
Program Consultant,
REPSO, Winrock International

Quality of Life through Electricity ?

Directing Ecological and Socio-economic Impacts of Small Hydro-power Projects towards Sustainability

Can small hydropower projects contribute to reducing firewood consumption and improving the living conditions of villagers in the Himalaya-Region? A participant of the hydro-power project Thame-Namche Bazar (between autumn 1995 and winter 1997) and author of an accompanying socio-economic research report pursues this question and analyses the effects of the power plant on saving the forest, improving the standard of living and finding new income sources.

Reducing Firewood Consumption

Since February 1995, approximately 600 households in Upper Khumbu are being supplied with electricity 24 hours per day for lighting and cooking purposes. The prevailing household structure is clearly reflected in the structure of the electricity connection levels[1]: 23% of the households use a level only for lighting purposes, 71% use a level for cooking and lighting and 6% use a level for mainly commercial purposes. This means that 77% of electricity use is directly relevant to firewood substitution.

The result of electrification is that two thirds of the electrified households use electricity in addition to firewood and dung for cooking purposes and only a small fraction rely solely on electricity. Most foods are now prepared on an electrical oven ("clay cooker"), whereas firewood is still the main heating medium in winter. A comparison of the amount of firewood burned before 1995 with the amount burned after electrification shows overall reductions of up to 35%, whereby consumption varies considerably according to household size, composition and characteristics of the firewood or season (reductions in spring, summer and autumn are higher than in winter). Altogether, around 2000 tons of firewood were saved in one year.

Electricity consumption data show that the lower level users (mainly private households and teashops) consume approximately 70% of the overall electricity provided, whereas the higher level users (mainly lodges and hotels) consume around 30%. Within the frame of the current household structure the potential for reducing firewood consumption therefore rests on both, private households as well as the tourism business.

The results of the 1996 survey show that, at that time, electricity acceptance and firewood reduction on the level of private households were good, mainly due to the graduated electricity tariff system, which was adapted to the economic situation of the customers. In the first phase of power distribution not only the bulk of customers but also the greatest part of the company's income came from the mass of economically weaker users. Although the situation has changed now, a social tariff system must be seen as an essential factor both for economical reasons as well as for the objective of user acceptance in the initial phase of power distribution.

In 1996 a large potential for change was still laying at the lodge and hotel level. While the incentives for private households to switch to electricity were fairly attractive (social tariff, low-priced electrical appliances and cookers), the settings for lodges to rely on electricity instead of firewood were at that time unfavourable. Using firewood was

1. The data used in this article mainly refer to the year 1996 and represent the situation in the first phase of power distribution.

Firewood collection.

mainly determined by the rather low cost of firewood-collecting servants, which made using electricity a more costly alternative. Using electricity on a larger commercial scale would, under those framework conditions, therefore be economically unwise for a lodge owner – not because electricity is too expensive, but because firewood is too cheap!

Incentives for optimising the commercial use of electricity in the Himalayan Region must therefore focus on offering a framework that makes electricity-use and firewood-saving economically sensible, e.g. by internalising the ecological costs into the firewood price (suitable fees for firewood), paying adequate rewards for firewood-collecting services or cutting down the commercial use of firewood in areas where electricity is available. (In the Khumbu National Park this is already the case for trekking groups but not yet for lodge owners.)

Improving Living Conditions and Strengthening Local Economies

Doubtlessly electricity means a great leap forward towards a higher quality of life. Electricity is a central pillar of the infrastructure and supports a "modernisation" of everyday life. It has a positive influence on the rhythm and organisation of village life. This is especially true for lighting through electrical lights: it indirectly facilitates education, intensifies social cohesion and makes the use of modern communication media (radio, television, fax) possible. Electrical lighting prolongs the day, making reading and other occupations (e.g. conversations, common meals, taking care of the livestock) possible outside times of daylight. Apart from that, utilising electricity for cooking purposes means that especially the women and children, who are mostly responsible for collecting firewood, can spend the time usually needed for this demanding occupation on other activities (e.g. taking care of the children, playing, spinning and other manual work). But a certain amount of diversity with regard to the used fuels (e.g. firewood and dung for heating purposes, kerosene for lighting purposes), as is customary for most customers anyway, can moderate the consequences of possible power failures due to bad weather conditions.

Electricity can help finding new income sources both in the tourism business as well as outside. Innovative additional offers for tourists, for example hot showers prepared with electricity, washing machines for washing laundry, stereo equipment, special ovens and appliances for preparing food and drink, etc. can procure income for lodge owners and create additional jobs. New fields of activity outside tourism made possible or easier by electricity are for instance processing agricultural products (e.g. potatoes) or local natural products (e.g. juniper berries, drinking water, herbs).

But electricity can also increase socio-economic disparities. Often those social groups which profit most by tourism benefit incomparably by electricity, because they are able to invest more and have more resources for paying for electricity. In order to even out these disparities it is of utmost importance to keep open the access to electricity for all economically weaker parts of the population. An eye should always be kept on the economic balance of the power plant, which means both generating a sufficient income from electricity tariffs as well as maintaining the "affordability" of electricity for all customers. In the long run, economic, social

and ecological aims should be kept in balance.

As a result of the firewood situation in the Himalayas, a socio-cultural change is urgently needed in order to secure the energy supply for present and future times. Tried and tested ways of life and problem solving strategies that were reliable up to now must be adapted to the new facts. Electricity's proper and circumspect application can contribute towards pointing the change that is already taking place in the Himalayan region due to the impact of tourism in a direction which brings economic and social progress and at the same time protects the forest resources.

The most significant lesson learned in the survey at issue is that the socio-economic effects of technically oriented development projects must always be examined as well, in order to be able to plan, erect and run power plants according to the local requirements. This should not only be done

- in the preliminary stages of technical projects in order to assess the socio-cultural, economic and demographic framework conditions of the power plant, but also
- accompanying technical projects (monitoring) in order to improve user acceptance and to adapt to the existing needs as well as
- follow-up of technical projects in order to evaluate whether the aims were reached and to draw conclusions for similar projects.

Socio-economic surveys should ideally serve as a basis for planning, elaborating and implementing concrete technical measures in the field of development co-operation.

— Christa Fischbacher
Sociologist

Hot water boiler in Namche Bazar.

Impact of Electricity on the Social Life of Khumbu

Before 1995, Namche Bazar and Tengboche Gompa each had one micro-hydro scheme but the rest of the Khumbu villages had no electricity. Since the 600 kW small hydro-power scheme was commissioned in November 1994, it has brought about a wide variety of changes in the social life of Khumbu some of which are presented here:

Changes to the Traditional Way of Life

1. **Reduction in the use of firewood for cooking:** Traditionally, a Sherpa household has to light firewood at dawn to prepare morning tea. At sunrise, smoke from every household used to rise and fumigate the whole village. Now, almost 90 percent of the village households have an electric oven and rising smoke is rarely seen. *Mahindra*, a famous *Malla*-king in Kathmandu, would have starved in this situation. He used to take his meal only when he could see smoke rising from every household in Kathmandu valley. He did not want to eat before all his people had something. Smoke rising from the roofs signified that something was being cooked in the houses. For this purpose he built *Taleju Bhawan*, the tallest building in the middle of the valley at that time to watch the houses.

2. **The traditional *Dongmu* no longer in use:** "Su Chiya", the traditional Sherpa tea made of Tibetan tea, butter and salt is traditionally mixed in a tubular wooden structure called *Dongmu.* Now, this is done with an electric mixer that can be purchased in Kathmandu at a lower price than a *Dongmu*. In most Sherpa households, a *Dongmu* now is just an object of decoration.

3. **Meat mill:** *Momo* is one of the popular dishes in a Sherpa community. Chopping meat into a paste used to be a time-consuming job for the housewife. Now, there is a meat mill (meat processing centre) in Namche. The motor of the mill runs on electricity and people can get their meat processed within no time.

Electric grinder to make traditional butter tea.

4. **Improved health of housewives:** Most Sherpa houses have very primitive chimneys for venting smoke. As a result, cooking with firewood lead to smoky kitchens and the women used to be susceptible to pulmonary diseases like bronchitis as well as eye diseases due to smoke exposure. Cooking with electricity has helped to improve the health of the Sherpa housewife.

5. **Education:** Electric lighting has facilitated the education of children since it allows them to study and finish their homework at night. Similarly, there are adult education programs run by

Morning puja (worship).

Himalayan Trust in Khumjung and Thame which would not have been possible without electricity as kerosene lighting would have been too expensive in the Khumbu area.

6. **Enhanced communication system:** The telephone station at Syangboche now uses electricity to recharge the batteries whereas solar panels are installed just for backup. This has greatly improved the telephone service. With electricity being available, most offices now have computers, fax machines and internet facilities which have further made the world smaller both for tourists and local people.

7. **Environmental protection:** Electricity has facilitated recharging of batteries. Many locals and most western tourists now use rechargeable batteries. Consequently, environmental damage due to disposal of short lived acid and alkaline batteries has stopped in the electrified area.

Changes that Tend to Have Negative Impacts

1. **Gambling:** With electric lighting being easily available, some people started gambling the whole night which disturbs their regular duties and also family life. The two pool-table halls in Namche and the one in Khumjung take away a great deal of well earned time of the youngsters and children.

2. **Preservation of wooden structure:** Normal Sherpa houses are built with wooden framework. Smoke helps the wood to become hard and long lasting. Cooking with electricity reduces the advantages of the traditional way.

3. **Music, satellite television and video centres:** Tape recorders and music are played in the houses and frequently cause noise pollution. Satellite TV and video often take away time of the young children and housewives.

— Ang Danu Sherpa
Manager, KBC

Changes from Electricity to Khunde Hospital and the Khumbu

Eco Himal, in bringing electricity and clean water has dramatically impacted our work at the hospital and health in the Khumbu.

The Thame hydroelectric plant, in bringing light and heat enables our staff to work more easily and comfortably. Now if we have a nighttime emergency or birth we have energy at the flick of a switch. Previously one of the healthworkers had to tempt the generator into life. This was a very temperamental creature and might take 40 minutes to start by which time the baby may have delivered by torchlight! The village, however is a little disappointed to lose the generator. The noisy chugging in the night kept everyone informed of deliveries and emergencies and people would creep from their houses to see what was going on. Now everyone, except the health staff, sleeps peacefully at night!

Having electricity in the clinic has meant we can use electric powered medical equipment. Something as simple as a fridge means that vaccines can now be stored safely at the hospital, their efficiency and availability guaranteed. Diagnostically an electric microscope can function without the game of mirrors. Oxygen can now be delivered by an oxygen concentrator machine thus ensuring a continuous supply that was previously limited to oxygen cylinders carried from Kathmandu. The hospital has x-ray, ultrasound, ECG and a slit lamp. We can provide more services with greater reliability and efficiency.

There has been a noticeable improvement in the health of the villagers who now have heat and light in their homes. Many families now cook mainly on electricity. Far less time is spent by family members collecting fuel for a cooking fire, and this effort can be directed toward other pursuits for the betterment of the household. With a cleaner source of energy and better light, there are fewer coughs from the previous constant smoke irritation. And children can now complete their schoolwork in the evening hours, with the added health benefits that follow education.

More recently the Namche water project has impacted the health of the people of Namche. Many of the toilets run into the central water source causing sickness. Previously the water source in the centre of town was used which was polluted by many of the toilets. Now water is pumped from a clean source outside town directly into homes. Clean water is an essential of life. In just a few months we have seen the incidence of diarrhoea drop dramatically. Diarrhoea still kills in this part of the world; providing clean water, saves lives.

Health is woven into many aspects of development work. Eco Himal's work in the Khumbu has had a significant effect on the health and self-sufficiency of this community. The community has gained the capacity to continue these developments. Eco Himal is to be commended on the success of this long-term project that was recently demonstrated in the best possible fashion by turning the projects over to capable local people! May all of us involved in development work have the vision to follow this wonderful example.

— Jim Litch, Rachel Bishop
Kunde Hospital and
Community Health Program

A Bird's-Eye View on Thame High Altitude Tree Nursery

In the spring of 1994, Eco Himal established a tree nursery at Thame at an altitude of 3800 meters. Named "Thame High Altitude Nursery", it is considered to be one of the highest tree nurseries in the world. It produces local species such as birch, silver fur, juniper, willow and rhododendron. The land for the nursery used to be hired from a local family and it is staffed by two trained local women. Himalayan Trust, which initiated many nurseries in Khumbu, helped Eco Himal with technical aspects and training of staff. Before, trees that were brought to Thame from the Phurte nursery in lower Thame Valley at 3400 meters did not survive well. Thame high altitude tree nursery was established in order to produce nursery trees which can adapt to the altitude of Thame. The objectives of the nursery are

- to restore the land of Thame valley which was eroded due to penstock pipe, high voltage cable layout and intake,
- to plant trees that can adapt to high altitudes,
- to protect the slope from landslides along the expensive penstock pipeline from Thame to Hungu power station for a length of 1000 metres,
- to support the reforestation efforts of the Thame villagers for a sound environment.

Khumbu Bijuli Company has managed the nursery with Eco Himal's financial support until the end of 1999. The two women staff members at the nursery are employed and paid by KBC. Since the beginning of 2000, total operation and financing of the nursery has become the sole responsibility of KBC after Eco Himal helped KBC to purchase the land in the name of KBC. At the local user group meetings held in Namche and Khumjung, the villagers frequently expressed

their view that running and operating a tree nursery was not an appropriate task for KBC and that expenses incurred for the nursery were totally extravagant. However, the company management has convinced them by elaborating its objectives. Recently, a board member from Khumjung came to inspect the nursery and was highly impressed. He further convinced the users in Khumjung at their group meeting by stressing the need for environmental protection in Thame valley. For the time being, KBC has decided to continue operation and promotion of the nursery activities.

The nursery actually started transplanting trees in 1996. It produces 4,000 seedlings annually and since 1996 has planted nearly 15,000 trees in the project construction area. The penstock pipeline is fenced by modern power fencing and was restored and stabilised with trees planted from the nursery. The nursery has also distributed about 2,000 different seedlings free of cost to the local communities for planting in their respective village areas. The survival rate of the trees ranges from 60 – 80 %. In 1997, Mr. Nick Legard, a forest scientist from New Zealand came to Khumbu as Himalayan Trust nursery consultant and inspected Thame high altitude nursery. He commented that the young trees from that nursery were stronger than the trees produced at lower altitudes like Phurte nursery.

In short, the steep slope of the penstock pipeline above the powerhouse is stable and there are no landslides on the gradual slope of the pipeline from Thame which means that one of the initial objectives of the tree nursery – to protect an important component of the hydropower system - has already been achieved.

— Ang Danu Sherpa,
Manager, KBC

With Khumbu Bijuli to Cyber Sherpas

Future cyber sherpas ?

A couple of years ago, when I visited the Khumbu corridor for the first time, as a tourist among a few thousand others, a mail runner jogged down from Namche Bazar to Lukla air-strip twice a week or even more often. He delivered letters and parcels to the aircraft and picked up incoming mail and gossip from the capital for the villagers. In those days, this remote region was considered a "geography of hope" by many trekkers and mountaineers. They were fascinated by the simplicity of life, the people's hospitality, and the breathtaking scenery which provides a symphony of impressions for their eyes. Today, more than 20,000 tourists visit Sagarmatha National Park annually. The Shangri La - seekers still find a wonderful place and they also find some 120 telephone lines, more than 20 satellite dishes and almost a dozen of brand new Pentium II computers. Electronic mail, thanks to computerji, now connects the settlements on the foothills of Mount Everest with the outside world.

Electricity has brought about a technological revolution in the world's highest mountains. The Austrian Development Co-operation has played a decisive role in that by financing the installation of the hydropower plant in Thame valley. Providing Sherpa villages with electricity helps to reduce firewood consumption and improves local living conditions. A hot shower is available now in almost every lodge and eco-sensitive trekkers wonder about this sophisti-cated and high-quality tourism infrastructure. Energy from Thame power plant, therefore, is not only a considerable progress in lifestyle for the locals but also a major investment into the competitiveness of the entire region.

Of course, the villages in Sherpa county have changed with electricity and with the increasing number of tourists. While some tourists complain about the less "authentic" athmosphere, Sherpanis admire their now smoke-free houses and the youngsters feel much more

Internet cafe in Namche Bazar.

comfortable in their homeland. Thanks to electricity life has become more entertaining, small business could develop, and the Khunde hospital, highly dependent on power, can operate much better. There are much more positive than negative aspects caused by this recent innovation.

It is the modernisation process, driven by migration, education, tourism and other external influences during the past 40 years, that has led to considerable transformation in Sherpa culture. Some traditions and long-observed codes of behaviour and value systems have undoubtedly lost significance. Culture is a model of behaviour, a societal software, which is in a constant process of transformation – both, in urban centres and in remote mountain areas. The Sherpas' orientation towards the outside world has therefore modified their lifestyles, their customs and their symbolic order. As a Buddhist people, their religious festivals still provide a solid framework around which the year is structured and everyday life is orientated. In addition to religious bonds and the agriculture cycle, nowadays the Sherpas' rhythm of life is ruled by the tourism seasons.

Referring to the innovation theory, the Sherpas belong to those people of whom one can speak as "change agents". Thanks to their entrepreneurship in tourism and considerable development input from Edmund Hillarys Himalayan Trust, the Austrian side and other sponsors from abroad, the upper Khumbu belongs to the wealthiest regions in the Kingdom. It is the younger and well-educated generation that pushes the modernisation process and some of them are very much aware of the danger that Sherpa culture could disappear if core values such as the language, neighbourhood assistance, the respect for nature and religious order are not upheld.

— Kurt Luger
Chairman, Eco Himal

Khumbu Bijuli Company: An Electric Utility at the Top of the World

The Khumbu power system situated at the highest altitude of the world was developed with the financial assistance of the Austrian Government and the support of the Austrian INGO "Eco Himal" after the previous hydropower project was washed away by a heavy flood caused by a glacier lake outburst. The 600 kW power station erected on the tributary of the river Dudh Koshi feeds power to the Khumbu region in the Solu-Khumbu District of Nepal.

Management of the power plant and its associated distribution network in the valley has been entrusted to Khumbu Bijuli Company. Its board of directors is comprised of local representatives of three valley regions and one nominated member from His Majesty's Government of Nepal. The administrative set up of the company comprises about a dozen employees who take care of its multiple disciplinary activities. After all the assets of the system were handed over to the company by the donor INGO, KBC has been made fully responsible for earning its own keep and also for coping with its sustainable development in future. The company also has to face the challenge of meeting the valley's growing power demand, whereas the existing generating capacity of the power plant is expected to reach its saturation point in the near future. However, KBC has been fully able to manage its systems properly with its limited revenue resources earned from the sale of electricity. The financial assessment of the company has shown a profit in its balance sheet every year. During the last few years, the company has also been able to establish a reserve fund for maintaining its future sustainability. The board has always made a full effort for the administrative reform of the company. Introduction of new employees, financial and distribution rules in the company during the past years has helped to strengthen its administrative functioning. The new budgetary and accounting system has also contributed to the proper recording of the company's financial transactions. In 1999, the company was forced to implement the unpleasant decision to increase the electricity tariff to its consumers. However, in comparison with the high cost of other commodities in the region, the present price of electricity in the region cannot be considered unreasonable.

The isolated power system of the company, however, needs patronage from His Majesty's Government of Nepal for its future development. Eco Himal also cannot be relieved of its responsibility till the company runs on its own. The company still hopes for the continued support from Eco Himal and the Austrian Government for its sustainability.

— Shree Prakash Jang Rana
Director, Khumbu Bijuli Company

5. Voices of the Khumbu Bijuli Company

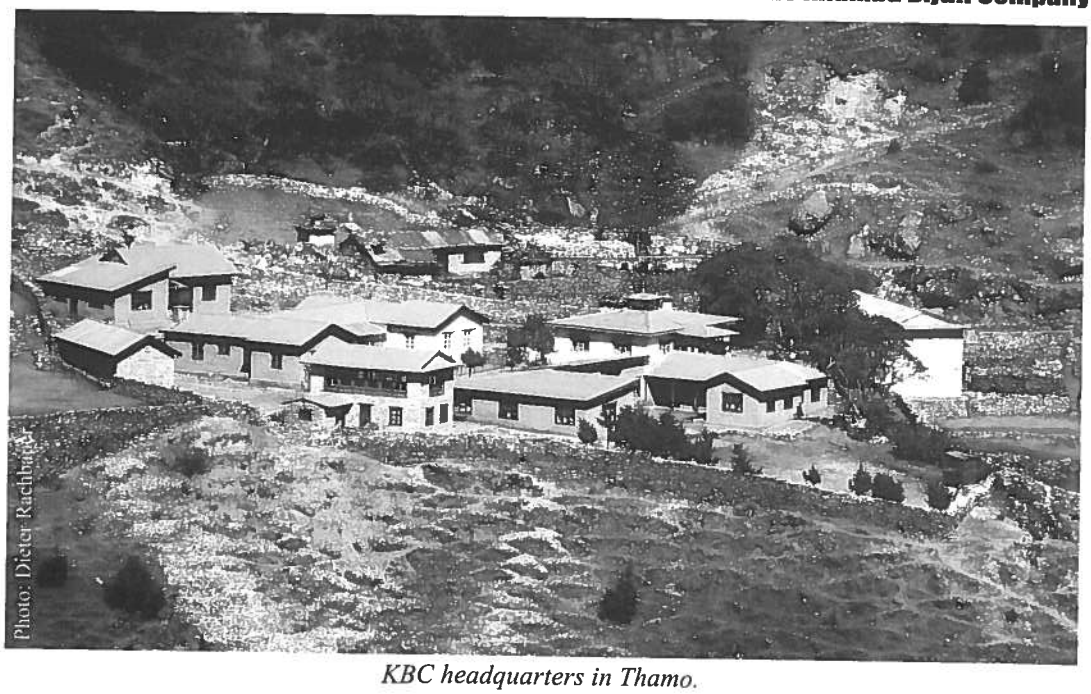
Khumbu Bijuli Company, widely connected to the contemporary development of the people of Khumbu, has been built through Austrian aid and is supplying electrical energy to the region. In the previous years, the company has been guided by Eco Himal both in managerial and technical matters. The hydropower plant is considered to be technically one of the most sophisticated small hydropower plants in the country.

The Khumbu Bijuli Company team.

By the end of 2000 Eco – Himal and the Austrian Government have handed over all the responsibility to the company and the local users. I have no words to thank both Eco-Himal and the Austrian Government for their tireless effort to construct this power station and to train the local staff to steer the company. Now the time is ahead of us to experience how difficult it is to run the plant on our own. Sustainability of the company over a period of generations should be our aim. Normally user groups registered elsewhere in Nepal are established in order to fight for their rights and benefit, but the user committees of KBC are very different. We are not to fight for our rights and benefit, we are to own KBC and sustain it. The continuation of successful operation of KBC is a synonym for a bright future of Khumbu.

It is a fact that electricity is the most eco-friendly energy source for the region of the Sagarmatha National Park. The concerned government and non-governmental organisations working in Khumbu need to monitor and evaluate KBC from time to time and give their feedback. All people of Khumbu must go hand in hand in order to sustain Khumbu Bijuli Company which has become a new responsibility of our generation. At last my sincere request to the people of Khumbu: "Support KBC, respect Austrian aid to Nepal and honour Eco – Himal for its successful development with local people's active participation."

— Sonam Gyalzen Sherpa
Chairman, KBC Board of Directors



KBC headquarters in Thamo.

Before Khumbu was connected to the electrical power supply, we used to see electricity in Kathmandu only. During those days, I didn't know how electricity is produced. Now, we are the people behind the production and supply of power and the management of this company. Apart from the efforts of the governments of Austria and Nepal, Eco Himal's involvement was vital for its success. Eco Himal's objective of involving the local people in running the power plant, providing technical and management training to selected local people became an example in Nepal. They sent engineers and related experts to this area to run the power plant efficiently and to provide practical training to us. I found out that each expert who came here had a different way of thinking and attitude even though they come from the same country. However, we all worked hand to hand for more than six years to fulfil everyone's wish to make this power plant a success and a sustainable project.

— Ang Chhiring Sherpa
Technical Chief, KBC

The Austrian government did not just build the power plant but involved Eco Himal to make the power plant sustainable by establishing proper management and providing the necessary technical and legal support. They trained us in Kathmandu and provided further practical training by sending Austrian engineers to the site. Thus we became professional technicians and were prepared to run this plant by ourselves. I still think that without Eco Himal's involvement, this place wouldn't be the same.

— Karsang Sherpa
Technician, KBC

The "Khumbu Bijuli Company" will always remain as a significant symbol of Austria in Nepal. I do not find the appropriate words to thank the Austrian Government and the people of Austria for the completion of the plant to make the Khumbu bright and beautiful with electrical lights. In addition, the involvement of the Austrian NGO "Eco Himal" has been a further boon to the people of

KBC at work.

Khumbu. Eco Himal's intervention and effort to establish KBC and to set up a well-trained local staff to manage the hydro-complex is an example throughout Nepal.

We have worked with almost more than two dozen Austrian engineers and consultants in the last six years. We must admire their hard work and the capability to adapt to a totally different culture and people. We used to have minor disputes but more fun during our working time. The technical and man-age-ment skills we learned from them will continue to support our careers. One of the most significant lesson we learned from the Austrians is that time is important or "procrastination is the thief of time". Sometimes we had a dispute with our previous Austrian engineers about punctuality. In Khumbu we have no means of transport. Passing friends and Yak-traffic sometimes disturb a journey on foot and you cannot arrive on time. However, by the time when there were no more Austrians working at the hydro-complex we had achieved a certain level of punctuality and had also learned how to solve a problem by means of discussion and mutual cooperation.

— Danuru Sherpa
Senior technician, KBC

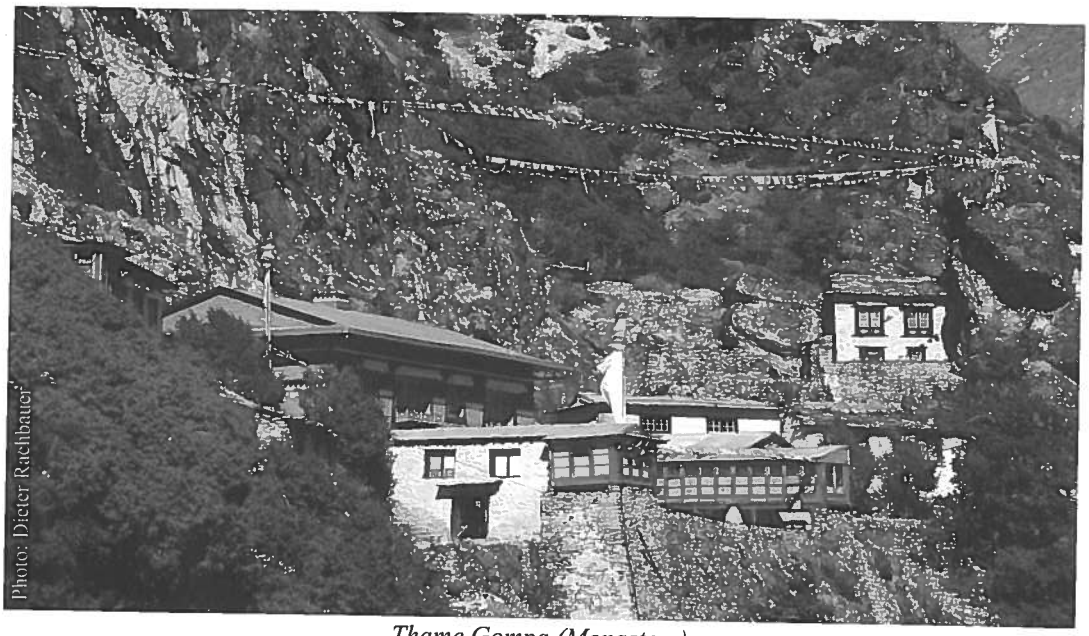
The local people are given the opportunity to run this power plant and to provide service to a maximum of users thereby preventing deforestation which protects the tourism business. It is known that micro-hydropower plants existed in the "Sagarmatha National Park" in former times but they are out of order due to lack of technical and management knowledge. Tengboche micro-hydro faced the same situation. Similar power plants in Nepal were ruined because of unskilled technicians, improper management and carelessness by the board of directors. Therefore, it is necessary to run such power plants by responsible management, skilled and trained technicians. Eco Himal's proper direction and effective guidance to KBC, as well as the staff training in Nepal and abroad has made it possible to run this company and power plant independently.

— Ngawang Tharwa Sherpa
Accountant, KBC

In 1992, I got the opportunity to get one year's training on electrical and mechanical subjects from "Balaju Yantra Shala" and "Balaju Technical Training Centre". From 1993 on, we began to work for the hydropower project in Thame-Namche Bazar along with Austrian engineers sent by Eco Himal. From these engineers we gained a great deal of practical knowledge regarding high voltage, low voltage transmission and substation. In a short period, we managed to complete all the house wiring and connections of meter boxes for every house in Khumbu. In Nov. 1994, we transmitted electricity to every household in Khumbu for the first time. We felt so proud and happy to see electrical lights in every house. It was the day the people of Khumbu had dreamed of for many years.

— Ang Tshering Sherpa
Technician, KBC

Comments from Khumbu



Thame Gompa (Monastery)

"I would agree with the opinions of the majority. The majority of the people find that electricity has made life in Khumbu much easier. I put in a great deal of effort in having electricity brought to Tengboche monastery, therefore I cannot utter any negative feelings towards electricity. Looking at it from the viewpoint of religion, we should consider everything neutral. Seeing things absolutely neutral, leaving out both negative and positive sides, is meditation in the true sense. Every beautiful thing has a bad side and every bad thing has a positive side. Therefore, I will say nothing good or bad about electricity".

— **Rimpoche (abbot),** Tengboche Gompa

"Electricity has become our basic necessity and it is almost impossible to imagine living without electricity in future. We can realise it very well, when electricity is cut off for a few days due to repair work at the power station. Being lodge owners, we can only say we have no better source of energy in Khumbu which can compensate electricity".

— **Lodge Owners,** Namche Bazar

"With the arrival of electricity in winter 1995 life has become easier."

— **Thamo Sherpani,** 23

"Electricity is equal to our eyes. If we don't have eyes, it is dark even during daytime. We feel the same. Things have become so easy due to electricity. We can work at home better and we feel more comfortable".

— **Farmers' Group,** Thame Valley

"When electricity is cut for one or two days, we feel terribly uncomfortable. We are now used to read the scripts in electric lights. Some monks in monasteries of Kathmandu opine that electric lights cannot compensate for the traditional butter lamps, that fewer and fewer butter lamps are illuminated since the availability of electrical facilities. Therefore,

electricity has brought about a draw back in religious belief, a different visual impact in the atmosphere of a monastery. We in Thame Gompa have a different opinion. Illumination is the same whether with butter lamps or electric candles. Electric lamps are cleaner and give better light. We feel simply much more comfortable with electricity".

— **Rimpoche and monks,** Thame Gompa

"Electricity has become one of the basic needs in the lodges. We cannot imagine living without electricity anymore. We have no negative opinions about having electricity".

— **Lodge Owners,** Thame Valley

"Since we have electricity Khumbu is not boring anymore."

— **Khunde Sherpa,** 22

"Light all night for those midnight emergencies and births, a warm clinic when icicles hang from the roof, X-ray and ultrasound at the touch of a switch, life-saving oxygen concentrated from air in an endless supply, contact with the outside world through e-mail and fax...and pizza fresh from a hot oven!!! This is development that is sustainable and works for this remote mountain community."

— **Dr Rachel Bishop & Dr Jim Litch,**
Kunde Hospital & Community Health Program

"If electricity is cut off for two days, we feel immediately that something is lacking. Although we have eaten, we feel like we are lacking daily meals. Above all, the school children can do their homework and learn better in electric lights".

— **Farmer,** Thame Valley

"Electricity plays a big role in modernisation."

—**Thame Sherpa,** 17

"Just a few years ago, everyone of us was asking frequently when the hydropower plant would finally be finished! When we got electricity in 1994, it was like a dream come true. Our eyes couldn't believe it, when electricity was there all of a sudden. And I found a big change in the villages ever since. Electricity was something we could only use in the city, in Kathmandu. Most of the men here spend lot of time in Kathmandu due to our jobs. When we came back to our villages, we always felt so uncomfortable the first days because in comparison, everything seemed so dark. Now we don't feel this contrast between Kathmandu and Thame Valley anymore."

— **Ang Rita Sherpa**
(10 times Mt. Everest Summitter)

"Eco Himal, an Austrian non-governmental organisation has been serving the people of Khumbu of the Mount Everest region in various ways. The electricity from hydropower which has opened the eyes of the people, helped to conserve the local forest by more than 50%. Cooking with electricity also prevented a great deal of health problems related to smoke and introduced the local young generation to modern technology of communication and computer software. Besides the hydro project, Eco Himal also joined hands with the Himalayan Trust in providing supplementary support in educational sectors like building hostel facilities for teachers and conducting adult education programs. These support activities by Eco Himal have brought tremendous changes in the life of the people of the area. I hope and wish that Eco Himal will keep these good works going for a long time in future and I extend my best wishes and compliment for its success."

— **Ang Rita Sherpa,**
Chief Administrative Officer,
Himalayan Trust

"I have visited the power station at Thame – it's an example of the best kind of foreign aid."

— **Sir Chris Bonington**

Eco Himal Activities

Eco Himal

The Society for Ecological Co-operation Alps – Himalaya is registered as a non-profit-making organisation in Salzburg, Austria and as an international non-governmental organisation (INGO) with an Regional Office in Kathmandu, Nepal. Eco Himal has been working with local grass-roots organisations in the Himalaya since 1992, and promotes development projects with primarily social, ecological and cultural focus. In line with the principles of the Austrian Development Co-operation, these projects aim to generate income and bring long-term benefits to the lives of the local population.

The Hindukush-Himalaya is one of the core regions targeted by the Austrian Development Co-operation, which largely finances the projects in Nepal. Our work in Tibet is possible thanks to sponsors, private donations and funds generated by Eco Himal's activities.

Our involvement in Nepal focuses on four sectors:

- Small Hydro-power and Promotion of Solar Energy
- Poverty Alleviation and Biodiversity Conservation
- Sustainable Tourism and Capacity-building
- Cultural Co-operation and Heritage Conservation

Poverty Alleviation and Bio-diversity Conservation

Over 80% of Nepal's population are subsistence farmers who live exclusively off their land. Population growth, soil erosion and environmental degradation, field fragmentation and low yields are increasingly impoverishing the village people. In 1994, Eco Himal has set up the Integrated Rural Development Project Arun Valley in the buffer zone of the Makalu-Barun National Park, located in the northeast of Nepal. The project area is a five to seven-day walk from the nearest road head and comprises a typical Nepali hill region between an elevation of 700 and 2,200 metres. Many families over-utilise the forest resources in the absence of additional income sources. The project's main objective is poverty alleviation through building paths and bridges, drinking water systems, improving the agricultural output, promoting additional income sources like cloth from allo-fibre (Himalayan nettle), cardamom production and fruit plantation, provision of literacy programs, adult education, awareness raising and small-scale health services. The main strategic feature is the participatory approach, i.e. planning and implementing project activities through the local Community Development Committees (CDCs) and Co-operatives, initiated by Eco Himal.

Distant Paths – Towards Sustainable Mountain Tourism

Tourism has become one of Nepal's most important economic sectors. However, the benefits brought by tourism do not always justify its social, ecological and cultural price. Eco Himal pursues a policy of promoting a form of tourism which is appropriate to the needs of the local population, the visitors, and suitable for the fragile natural environment. The Rolwaling Eco Tourism Project operates in the area south of the holy mountain Gauri Shankar in the northeast of Nepal. As in all Eco Himal projects, the local people themselves are the driving force behind the project activities. Austria's contribution is in designing a sustainable tourism by building

up physical infrastructure and providing funding, technical and logistic know-how, training and overall co-ordination.

Eco Himal puts emphasis on quality tourism by training, like the Mountaineering School Thame which provides advanced mountaineering training for trekking guides and high-altitude sherpas and a female outdoor leadership training for Nepali women in the trekking business. In collaboration with the Klessheim Tourism College, a Training For Nepalese Tourism Management Personnel has been set up.

A Flock of Sheep – Help for Tibet

Together with our Tibetan partner organisation TARA (Tibet Assistance to the Remote Areas) we conduct projects in very remote areas, which lag far behind the towns in regard to infrastructure improvements, and have hardly seen any rise in the standard of living in the last 40 years.

Eco Himal's work in Tibet is carried out jointly with its sister organisation Eco Himal Italia (Varese). Funding mainly comes from private sponsors and relies on the continued support of committed persons who care for the destiny of the people of Tibet.

Since 1992 Eco Himal is building and furnishing Tibetan primary schools in very remote rural areas (e.g. Chön Dzom, Pema Chöding, Surtsho). Each school will be provided with a flock of sheep, a traditional way of generating income for the school and providing food to the pupils. Eco Himal also supports the renovation of small monasteries (e.g. Rongbuk), a small hospital, food aid for nomads who have been hit by a snow catastrophe and lost almost their entire herds of yaks, a traditional Tibetan medical centre and the revitalisation of a traditional weaving and dying centre.

Cultural Co-operation

The Kathmandu Valley is one of the most important sites on the UNESCO world cultural heritage list. Its ancient palaces, temples and courtyards are cultural monuments and architectural gems, but sadly most of them are falling into ruins. Eco Himal – together with international and local experts - restores the Keshar Mahal Garden of Dreams, a historical garden and architectural ensemble, in the centre of Kathmandu. The key feature of the project is the utilization of a dormant resource to serve as a vehicle for capacity building in a variety of fields critical to the development of quality tourism and architectural preservation: garden conservation, eco-tourism, and cultural resource management. The revitalisation not only includes the physical structure but also the introduction of new functions for locals and tourists: cafés, restaurants, exhibition facilities. It will serve as a pleasant oasis in the heart of modern Kathmandu.

Eco Himal works with small culture groups and supports old traditions and new waves. Nepal's first independent public radio station, Radio Sagarmatha, gets technical assistance and funds for training of journalists, and a series of traditional music productions (Vanishing Culture Collection) is supported in collaboration with the Kathmandu University Department of Music.

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