4. SMALL HYDRO PROJECT RANGJUNG, BHUTAN

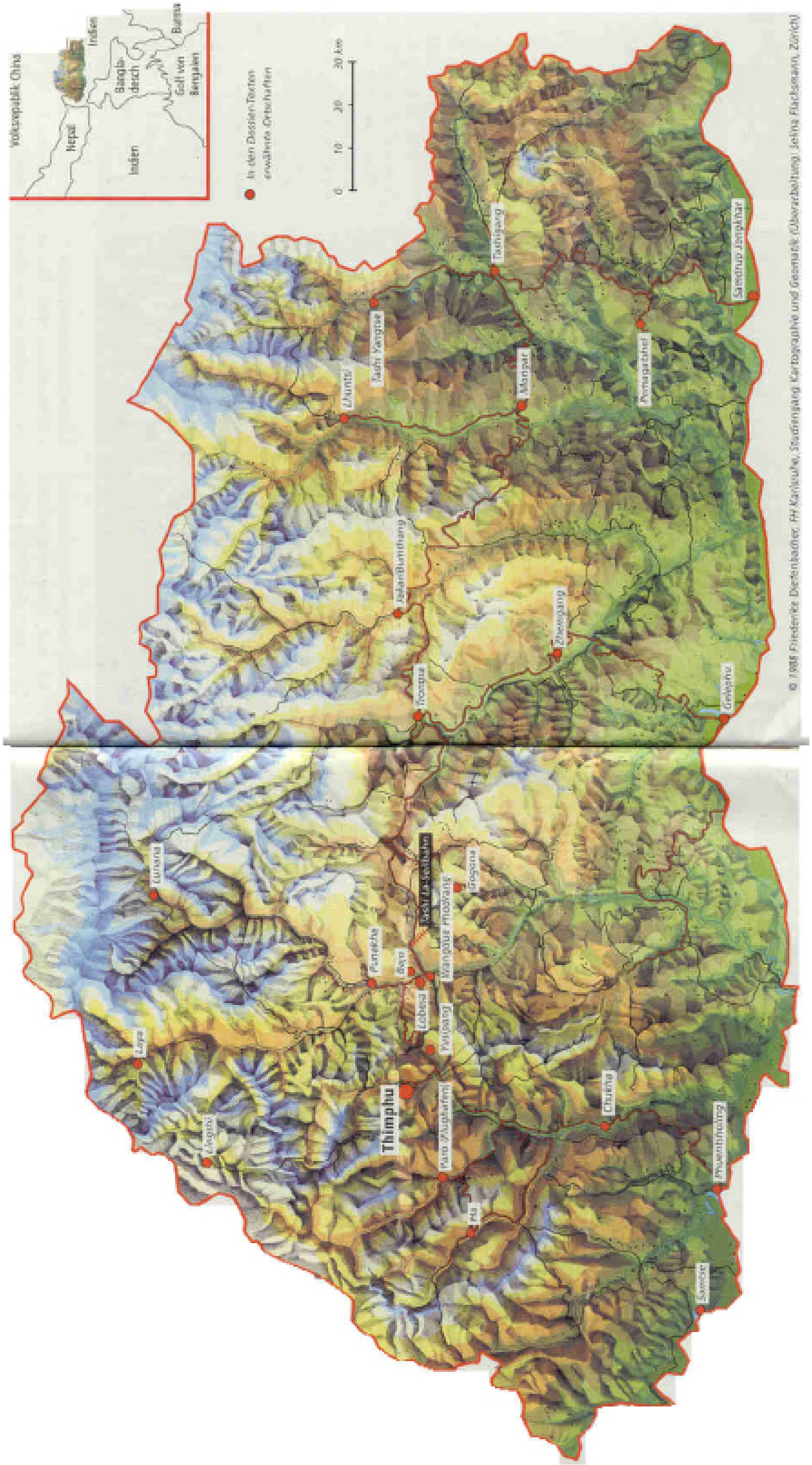

Figure 25: Relief map of Bhutan showing the Rangjung project area in the remote Eastern districts of Trashigang and Trashiyangtse.

4.1 Project History

4.1.1 Project Identification and Appraisal

The Rangjung Small Hydro Plant located in the District of Trashigang (East Bhutan) is a project of the early rural electrification strategy of the RGOB. This strategy foresaw the electrification of the remote districts through decentralised small and mini hydro-power plants and associated mini grids. The objective of the Rangjung SHP project was to stimulate economic and social development of remote Eastern Bhutan through electrification. This concept was in line with the general objectives of the Austrian Development Co-operation in Bhutan and the request for assistance in developing the Rangjung Small hydro Plant was therefore granted. Co-operation in small hydro power development between RGOB and the Austrian Federal Chancellery (AFC) began in 1986 with fact finding missions and strategic issues on how to develop the sites (turn-key versus co-operation). Studies for the Rangjung site were carried out in the late 1980s (concept study 1988, feasibility study June 1989) but the bilateral agreement between the RGOB and the Austrian Government (through the Federal Chancellery) confirming the Austrian grant aid was signed only in April 1993.

The Rangjung plant with an initial capacity of 1.1MW was to complement two existing Indian-funded mini hydro plants which energised an existing grid of limited extension in Trashigang district.

4.1.2 Project Implementation

The project holder was the Department of Power (DOP) in the Bhutanese Ministry of Trade and Industry. Following a change of Austrian consultants for planning and engineering design in 1992, the civil works were tendered locally in 1993 based on revised designs. Two civil work contracts (for two lots) were awarded by DOP to local contractors. A ground breaking ceremony marked the start of construction on 17 June 1993. An Austrian engineer was assigned to DOP for permanent site supervision and for technical assistance to the local civil work contractors and DOP. Electro- and hydro-mechanical equipment supply was tendered in late 1993. Tenders were floated in Austria only. Related contracts were signed in mid-1994.

One of the local civil contractors (from Eastern Bhutan) was unable to achieve the required output mainly due to insufficient management capacity and an insufficient number of experienced Indian contract workers complementing the local staff (mostly unskilled and semi-skilled farmers). Part of his contract (intake, weir, desanding basin) was reassigned to the other more experienced civil contractor in November 1994.

4.1.3 Re-optimisation and Re-design

Construction was already well under way when in March 1994 an increase of turbine capacity of the Rangjung SHP in view of new frame conditions was deemed necessary by both the Austrian and the Bhutanese partners (high demand growth and low output of the two existing Indian SHPs energising the local grid). While the Rangjung SHP was initially designed as the leading plant in an independent mini grid comprising Rangjung, Khaling (600kW) and Chenary (750kW) hydropower plants, the inability to supply full capacity of the latter two plants forced the DOP to rapidly look for additional capacity to meet the growing demand. At that time, the possibility of interconnecting the isolated mini grid with a new medium to large-size (storage) power plant to be built in the same region to form a regional grid was first mentioned.

In addition, the economic viability of the Rangjung project had deteriorated due to a massive increase of the foreign cost component (e/m equipment) following a devaluation of the local currency. An increase of the plant capacity showed considerable improvement of the project economics.

After consultation with the AFC, it was decided in August 1994 to double the capacity of the project from the initial 1.1MW to 2.2MW by increasing the head of the plant to 170m and the flow to 1.6m^3/s. The amendments in civil works and the change of order for the e/m equipment supply to suit the revised capacity was at that time still possible without much demolition and modification work in the field. This highly flexible response by the AFC in meeting DOP's request is proof of the good co-operation between the two parties during project implementation.

Due to the initial delays with the inexperienced local contractor and the re-optimisation and redesign work, the initial completion date of December 1994 could not be maintained. Following a tremendous effort from all parties involved, the plant was successfully commissioned in January 1996. The official inauguration took place on 22 April 1996.

Four Bhutanese technicians were trained in Austria as power station operators between 1994 and 1997. The training concept was conceived with the intention to qualify the technicians for professionally operating the Rangjung and other hydropower plants in Bhutan. The thoroughly-trained technicians were able to substantially reduce DOP's dependence on specialist input into power station operation and the reliance on foreign personnel for plant maintenance and repair. While the training exercise has proven to be very beneficial for DOP and the country as a whole, the high aspirations raised with the foreign training course were not fully achieved on a personal level: Since the technicians had not given academic qualifications in Austria, they were unable to resume the position of an executive engineer on return and have thus far not carried out higher administrative and managerial functions within DOP as they had initially expected.

4.1.4 Rehabilitation I

Heavy rainfall during the monsoon season of 1995 caused an existing geological fault to destabilise, and ground movement at the slope of the piped headrace occurred. Settlement of up to 0.40m was measured. In order to protect the headrace pipe from being damaged by further movements, a geotechnical measuring programme and a rehabilitation concept were established by Austrian consultants. The slide was rehabilitated by a local contractor involving drainage measures (with overseas material supplies), pipe bridges and site supervision by an Austrian engineer. The work was completed in the second half of 1996.

4.1.5 Rehabilitation II

Still in 1996, DOP staff had observed considerable abrasion damage on the turbine runners at the Rangjung SHP. The Austrian Consultant responsible for the planning and the design of the scheme confirmed the damage and presented recommendations on how to improve the mode of operation so that less silt would be caught in the turbine water and abrasion on the turbine would be reduced. Due to a disagreement on the real causes of the heavy abrasion, the proposed remedial measures were not implemented.

In June 1998, an independent consultancy mission fielded by the Austrian Federal Ministry for Foreign Affairs (BMfaA, which had succeeded the AFC in handling Austrian Development Co-operation) concluded that the excessive wear on the turbine runners was caused by an unfavourable design of the desanding basin and an unfavourable runner design with regard to abrasion by silt-laden water. In December 1998, it was decided to ship a replacement runner to Rangjung SHP as an emergency measure. The badly-worn runner on turbine No. I was replaced at the end of 1999 / early 2000. For improving the abrasion problem in the long run an additional desanding facility on the headrace and the procurement of two new spare runners was planned. The costs of the work was shared by the AFC (civil works, site supervision) and the Austrian consulting engineer (planning, design and tender documents) who had to accept some of the blame for the damage. He had not made the clients on both the Austrian and the Bhutanese side aware of the probable consequences of doubling the Rangjung plant capacity without a corresponding increase of the desanding facility (to suit the higher water inflow). DOP carried out tendering and contract award for the civil works. Implementation of the new desander is currently on-going.

4.2 Project Approach and Performance

4.2.1 Objectives, Results and Activities of the Austrian Intervention (Logical Framework)

A logical framework as such was never prepared to describe the project in all its details. However, sections of a logical framework matrix can be gathered from the many contracts (and associated TOR) awarded to consultants, suppliers and manufacturers. The Austrian intervention and its initial intention in the context of the Bhutanese rural electrification project is shown in Figure 26.

The Rangjung small hydro project was planned with a classical engineering approach whereby the main responsibilities for plant design, project management and site supervision and administration rested with the Austrian Consulting Engineer. Due to the limited experience of the Bhutanese partners in small hydro design and implementation, no attempt was made to delegate more responsibilities to local engineers and managers. At the time of project conception it was not yet possible to limit the Austrian intervention to the provision of advisory services and capacity building measures as would be the preferred approach today after more than ten years of Bhutanese-Austrian cooperation.

Overall Goal
Regional economic and social development in Eastern Bhutan is supported through a reliable energy supply

Output 1
The civil works of a mini hydropower plant in Rangjung, Trashigang District are implemented

Activity 1.1
Provide the financial means for local civil works contracts awarded by DOP

Output 5
Electricity is safely distributed to consumers by DOP

Activity 5.1
Build transmission and distribution grid with support from donor and funding agencies

Activity 5.2
Operate transmission and distribution grid in an efficient manner

Output 2
Electro-mechanical equipment for the mini hydropower plant in Rangjung is supplied, installed and commissioned

Activity 2.1
Award e/m equipment supply and installation contracts to Austrian companies

Output 3
The Austrian project components in the Rangjung mini hydro and RE project are professionally managed and co-ordinated with partners

Activity 3.1
Establish detailed planning documents

Activity 3.2
Define co-ordination and communication set-

Activity 3.3
Establish a programme for supporting activities (erosion control, access path, sky line) and ensure sustainability of the intervention

Activity 3.4
Provide project management services

Activity 3.5
Provide site supervision services

Output 4
Professional plant operation in Rangjung is ensured

Activity 4.1
Send four DOP staff for a four-year training to a Danube hydropower utility, Austria

Figure 26: Log Frame Matrix of the Rangjung SHP

4.2.2 Project planning and implementation set up (institutional map)

The Rangjung project set-up is characterised by a well-defined co-operation between the Austrian development aid institutions (AFC and ACB) and the Bhutanese ministerial levels for project appraisal and steering on the one hand and the more technical co-operation between the Austrian Consulting Engineer and the Bhutanese Dept. of Power (DOP) on the other. The number of stakeholders in the project is limited to five (see numbering in the Figure below). The involvement of the Trashigang Dzongkhag administration and the Department of Forest was limited to general project approval, land acquisition and forest clearance permits respectively.

In line with the Bhutanese concept of self-reliance and national execution, the co-operation with the Austrian Development Co-operation was limited to the small hydro plant and was not extended to the rural electrification (RE) component where DOP had developed its own in-house capacity. The Austrian input did not address RE policy aspects, tariff setting, and the design and the funding of line extensions in the project area (with the exception of limited Austrian funding for a number of sub-stations and transformers in Trashigang District). For the massive input in grid extension into the rural areas and to the district capital of Trashi Yangtse, the RGOB was able to allocate funds from on-going national rural electrification programmes supported by donor and funding agencies (SNV, Netherlands, 1995 to 1999 with 1325 new connections in the project area for close to Nu 40 million; ADB Manila under RE I loan from 1995 to 1998 and the RE II loan where implementation is about to start).

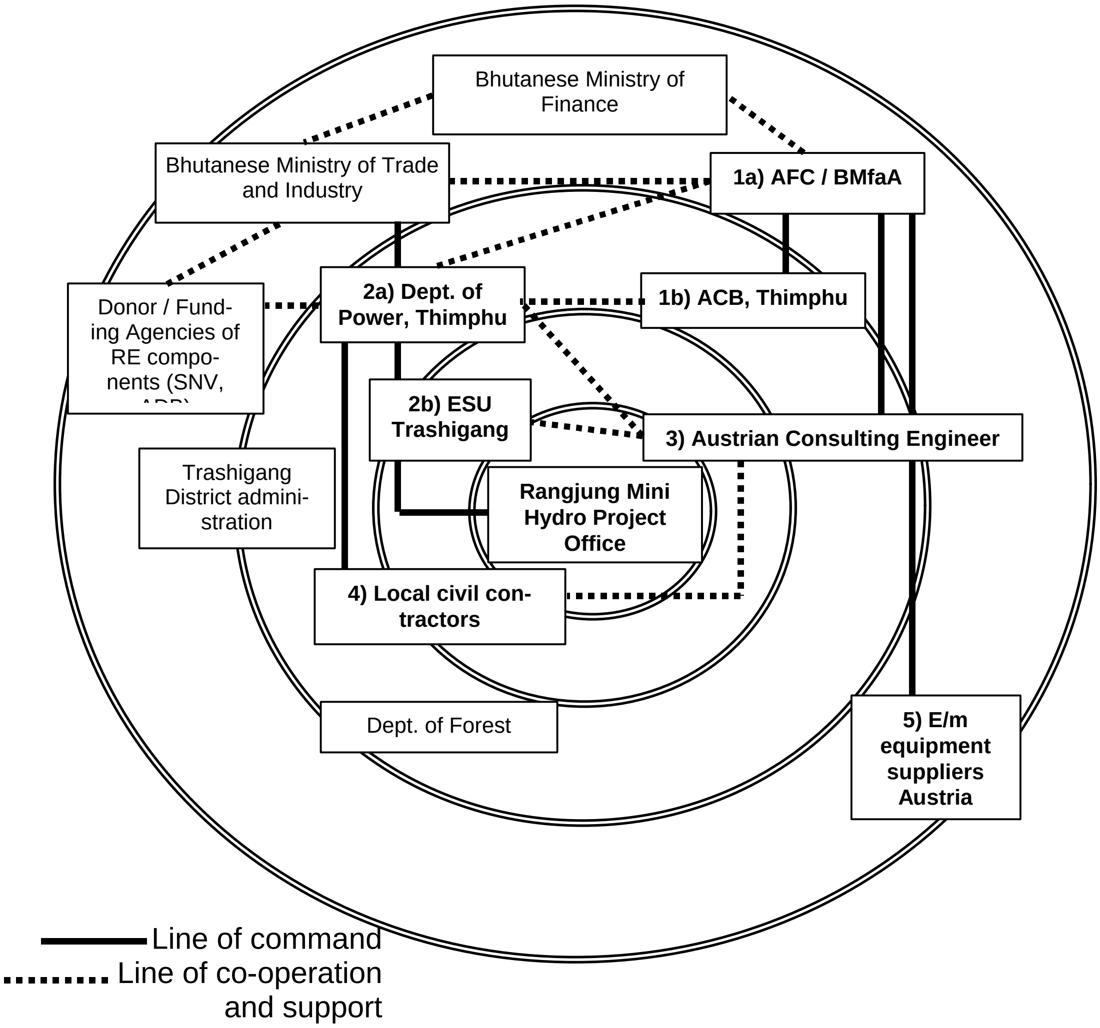

Figure 27: Institutional Map of the Rangjung Small hydro Project

The participation of the local beneficiaries of the power supply was not sought in the Austrian project set-up but were catered for under the line extension projects with ADB loan inputs (RE I) and the Dutch funded Sustainable Development Programme. These funding programmes requested DOP to obtain written agreements from beneficiaries that they will provide their own contribution to the house connection in cash and in kind as well as agree among neighbouring beneficiaries to have a number of community members trained for electrical installation and maintenance tasks.

Limiting the co-operation to the small hydropower plant, the Austrian intervention benefited from short and efficient communication channels within the technical actors involved both on the Bhutanese and the Austrian sides. The project set-up is a fine example of how the RGOB managed to keep the project simple and straightforward despite the fact that it required inputs from more than one donor or funding agency to make it happen. Co-ordination for the various inputs was handled by the RGOB and not by one of the contributing donors. The success of this approach proves the validity of the Bhutanese NEX (National Execution) concept which has been introduced to limit

Bhutanese dependence on foreign inputs and to gain self-reliance. The limits of this approach are discussed in section 4.4.2 under "Donor Co-ordination".

4.3 The Present Status

4.3.1 Waiting for Kuri Chhu

Since plant commissioning in January 1996, the electrical load of the 2.2MW Rangjung small hydro plant has grown rapidly and has reached its capacity limits during the evening peak hours in the dry season when the stream flow in the river is insufficient to meet the demand. Annual load growth is averaging 20% for the period 1996 to 2000. Since the dry season of 1999, ESU Trashigang has been forced to introduce load shedding as the other two mini hydropower plants connected to the Eastern Bhutanese mini grid (Khaling and Chenary) are not fully operational. The 600kW Khaling SHP is not providing full output (currently max. 220kW) due to technical problems (sudden pressure drop in penstock when flow increases) and insufficient stream flows during the winter months. The 750kW Chenary SHP has been under repair since several years following headrace instability and delays with the construction of a new headrace tunnel carried out by a small Indian contractor[19].

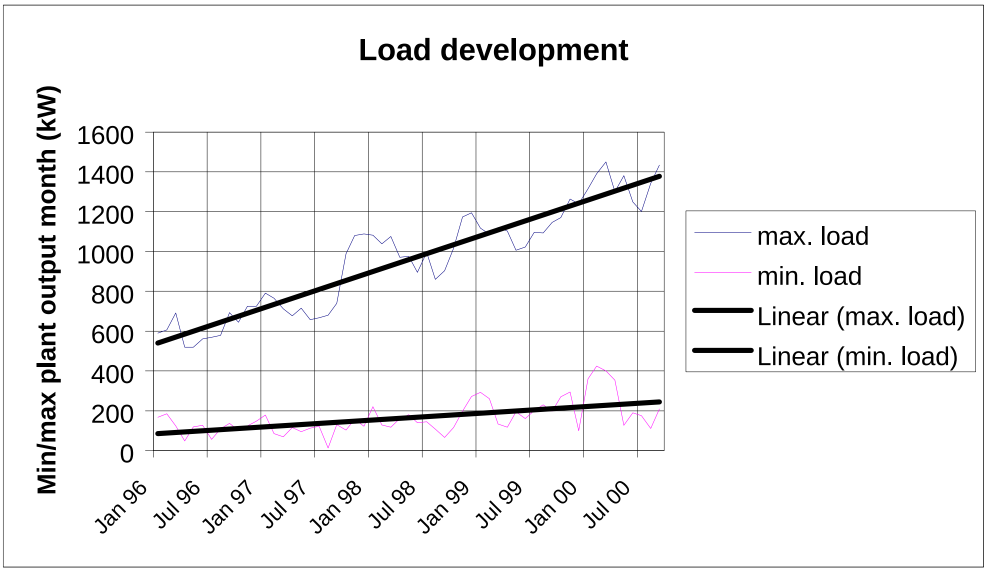

Figure 28: Load development of the Rangjung Small hydro Plant since commissioning in Jan. 1996. Note the seasonal peak load variations with rapidly increasing peak loads during the winter seasons and the somewhat reduced peak loads in summer (July, August, September).

Load shedding has been introduced by DOP in order to be able to keep up generation during peak demand periods. As load shedding is not an acceptable solution for many consumers, four new diesel generators have recently been installed in Chenary and Trashiyangtse (two each, 380kVA) to cater for the peak load requirements and to bridge the supply shortfall until the arrival of power from the 60MW Kuri Chhu hydropower plant currently under construction in the neighbouring Mongar district (commis-

[19] During a brief site visit at Chenary SHP, the evaluation team learned that the tunnelling work will not be completed before December 2002! There are currently 100 Indian workers engaged on the construction of the new 584m long tunnel in difficult geological conditions.

sioning expected for Sept. 2001). The diesel generators are currently awaiting commissioning.

4.3.2 Rapid line extensions into the rural areas

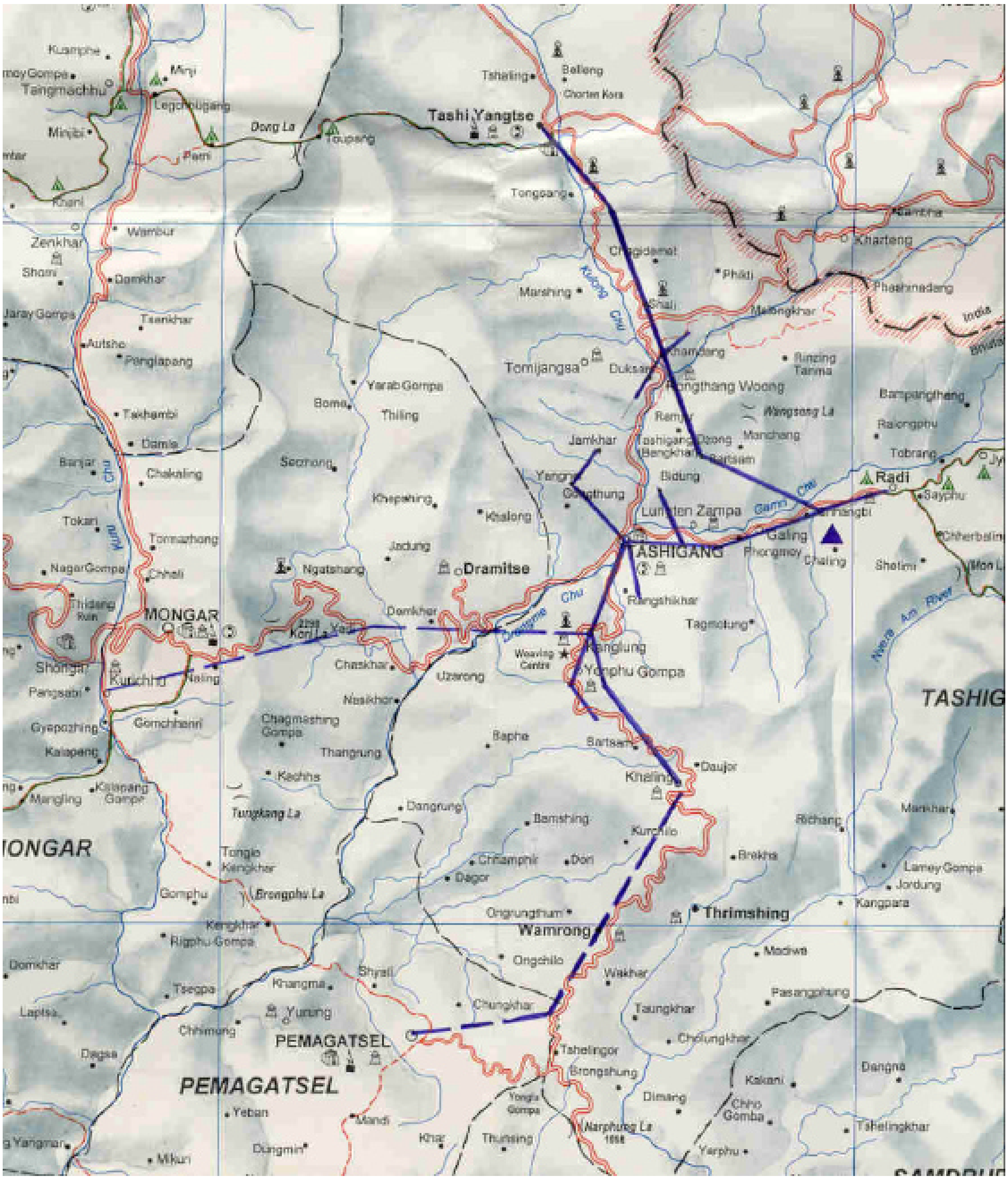

Figure 29: Supply area of the Rangjung MHP. Only the major transmission lines are shown, distribution and short spur lines are not shown. The mini grid to Pemagatsel is currently not interconnected with Rangjung (at Khaling). The line from Kuri Chu (Mongar District) is under construction (dashed line).

The rapid load development of the mini grid energised by the Rangjung SHP is basically a result of the ongoing line extensions into the rural areas under Bhutan's Rural Electrification Programme (PW06 of the 8th Five-Year Plan). When Rangjung SHP was commissioned in January 1996, the total number of consumers was just below 1500 (excluding those connected to the Khaling SHP). Now, almost five years later, the total number of consumers has more than doubled and stands at around 3500 and the figure is rising daily as new connections are being established mainly in the rural areas.

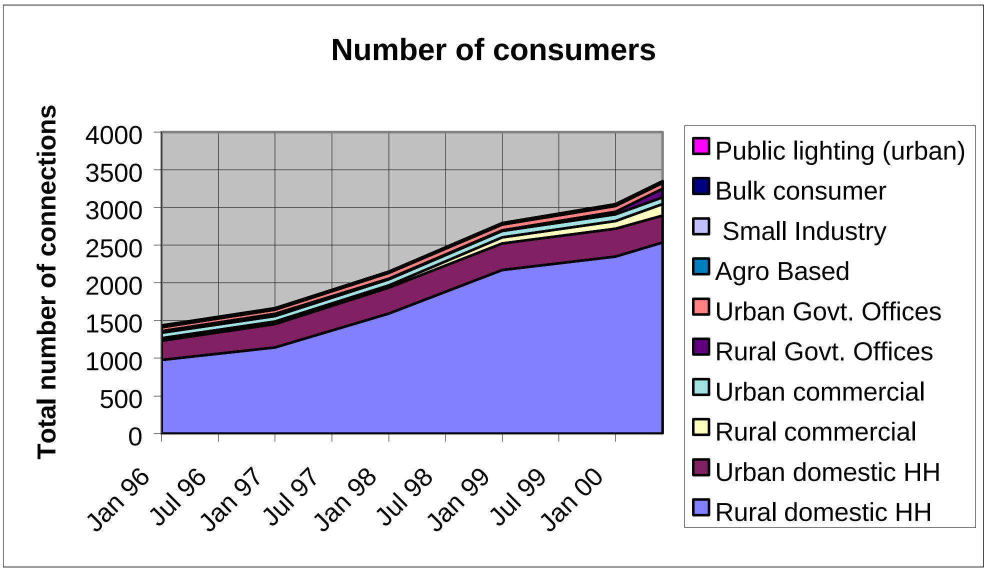

Figure 30: Growth of number of consumers since commissioning of the Rangjung SHP

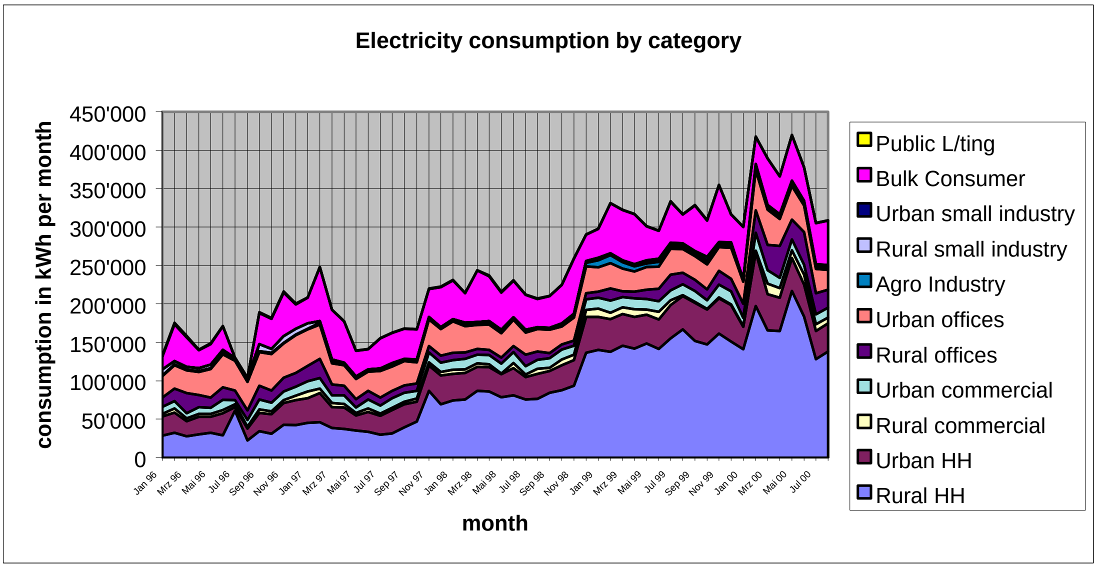

Figure 31: Growth of electricity consumption since commissioning of Rangjung SHP

The amazing load growth of the Rangjung SHP is caused on the one hand by the expansion of the consumer base (1500 new rural connections in less than five years) but on the other hand also by an increase of the individual monthly energy consumption per household and establishment. While a rural household consumed 29kWh per month in January 1996 (mainly lighting loads), the average rural household consumption in June 2000 was over 70kWh. This increase in individual household consumption is related to the increasing use of rice cookers and water boilers as observed during the household surveys.

4.3.3 Ongoing Plant Modification and Rehabilitation

When the excessive wear on turbine parts due to inadequate desanding facilities of the Rangjung SHP came to light, remedial measures were taken up, firstly, by modifications on the existing sand trap (by DOP) and secondly by building a second desanding facility on the headrace. The construction of the double-basin desanding facility is still on-going (see Figure below). Completion is slightly delayed but is expected to take place in early 2001.

Due to the late completion of the new sand trap, the two replacement runners for the Pelton turbines have not yet been delivered to the site. So far, only the runner of turbine No. 1 has been replaced. Although the desanding efficiency of the existing sand trap has been improved, the runner replacement of turbine No.2 is withheld in order not to expose this vital piece of equipment to the abrasive action of the silt-laden water. The second turbine unit is thus still operated with the first runner which is said to be worn out and be limiting the efficiency of the machine to some extent.

Figure 32: The double-basin sand trap under construction in December 2000

4.4 Specific Questions and Main Findings

4.4.1 Programming

Agreement with Austrian Development Co-operation Philosophy

Question Q1: How far do conception, implementation and results reflect the chief objectives of Austrian development co-operation, such as poverty alleviation, democratisation / ownership development, ecological concerns and gender equality?

In a first attempt to evaluate whether the Rangjung project was in line with the current Austrian development co-operation philosophy, project documents (feasibility study, TOR for project management) have been screened in search for specific objectives, activities and budget allocations related to the above issues. With the exception of ecological concerns, none of the above issues had specifically been mentioned during conception and implementation of the project. It was implicitly assumed that the provision of a secure electricity supply would be beneficial for the poor, the ecology and gender-balanced, democratic development. There were no detailed investigations undertaken in regard to the incidents of poverty, social imbalances and ecological problems (forest degradation due to wood fuel gathering and logging) prior to project implementation. However, the absence of such investigations does not mean that the project results and impacts were not contributing in one way or another to poverty alleviation, ownership development and gender equality in the project area. Since impact assessment is the subject of the evaluation question Q6, these potential impacts are evaluated in the respective chapter below.

Ecological concerns have been the only issues which were specifically addressed in the project planning documents. However, the issues were limited to the mitigation of impacts during construction such as erosion control on slopes and reduction of unwanted access to the forested areas through project roads. The project went to great lengths in fulfilling these prescriptions:

- Extensive drainage and slope stabilisation measures were undertaken along the headrace and penstock alignments; at places, innovative slope stabilisation measures were implemented using bio-engineering methods (living construction materials such as brush mattresses, willow branch cuttings, etc.).
- Such measures were not only undertaken to preserve the natural environment along the plant. The chief motivation was to protect the water ways from landslides and scouring effects.
- Construction of an access path from the powerhouse area to the headrace and intake structures was prohibited according to the Austrian project conception. All equipment and materials had to be transported by porters and mules or by a sky line (cable crane) specifically installed along the penstock alignment by the project.

More than five years after construction, the “wounds” created by the construction activities have practically disappeared with the exception of the access path which has gradually been widened by the local people who now use it as the main access to their villages. The extra cost incurred to the project for forcing the civil works contractors to use alternative means for transporting equipment and materials and to make do with a narrow access track was not justified. A temporary access road (wide enough for tractors) built during the construction phase some 6 to 7 years ago for the purpose of motorised transportation along the first steep slope would probably look very much the same as the “improved” mule path looks today.

Figure 33: The transportation path along the penstock alignment has been widened by the local population to become their main access track

Environmental concerns beyond pure plant construction activities were not addressed during project conception. Conservation of aquatic life in the by-passed river section through prescribing residual flow concepts or limiting the sediment concentration in the river following sand trap flushing operations were not considered. Similarly, no auxiliary measures were defined to assist electricity consumers in switching from extensive fuel wood use to cooking and space heating with electricity in order to mitigate pressure on the forests around the settlements.

During the initial negotiations between representatives of the BmfaA and DOP, project measures and follow-up interventions to improve productive end-use of electricity in small and medium enterprises were considered but due to budgetary constraints on the Austrian side never implemented.

From what was defined in the TOR for the implementing consulting engineers, the Rangjung project appears to be conceived basically as an engineering undertaking without directly addressing today’s chief objectives of Austrian development co-operation such as poverty alleviation, ecological concerns and gender imbalances. However, it must be said that these concepts of development co-operation have become mainstream issues only in the early 1990s when the Rangjung project conception was already established.

Judging from the early project planning documents, the new electricity supply to be provided by the project was assumed to automatically have positive impacts on the above issues so that direct project measures in those socio-economic, ecological or cultural areas were not warranted. The impact assessments of Q6 will prove whether this assumption was correct.

4.4.2 Need-Driven Intervention

Question Q2: How far were the interventions based on the actual needs of the rural population and on priorities and development plans of the partner countries? What impact did the interventions have on sector policy development of the partner governments?

If electricity is among the top priorities of the rural population, one would expect:

- A high electrification ratio in the project area (if connection charges and electricity tariffs are affordable) and
- A high percentage of rural people expressing electricity as one of their imminent investment targets.

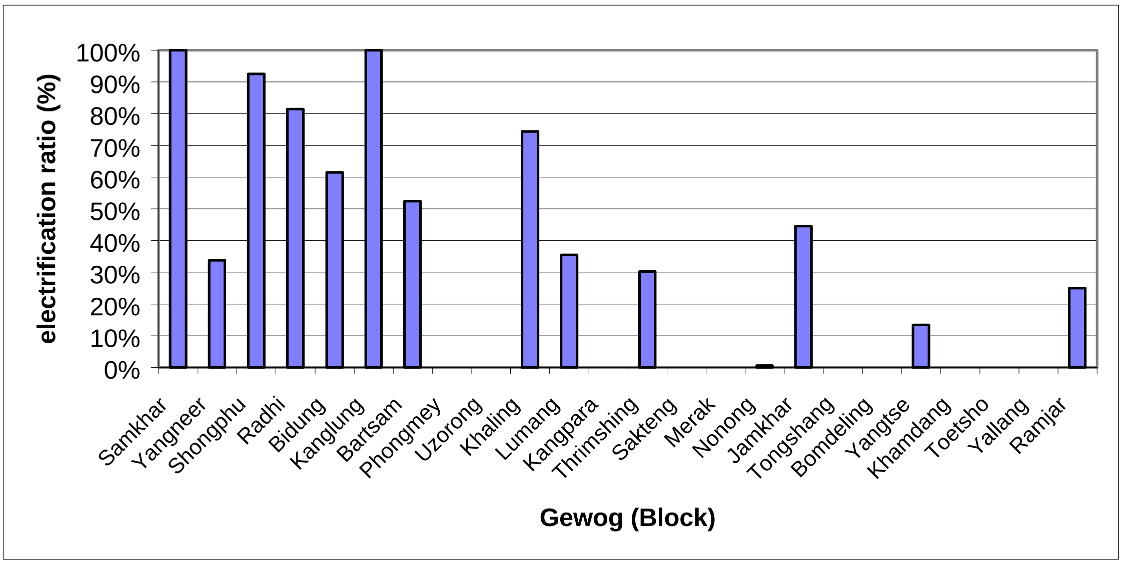

Figure 34: Electrification ratios (% electrified households to total number of households per Gewog) in the Trashigang and Trashiyangtse districts

The electrification ratio of Trashigang Dzongkhag is on average around 40%. In Trashiyangtse district it is only around 10% but increasing daily due to the ongoing line expansions. However, these relatively modest figures are not particularly representative since a number of Gewogs (blocks) are still out of reach of the electricity grid and have thus zero connections despite the eagerness of the population to get an electricity supply. From observations and data from ESU Trashigang, it can be said that there is practically no household or other establishment within reach of the grid (150m) which has ever refused to connect. In the urban areas with a dense network to all the quarters, the connection ratio is practically 100%.

Electrification ratios achieved by utilities in neighbouring countries have been reported to be in the range of less than 50% if total households per so-called "electrified" district are taken into account. In Nepal for example, rural electrification under the ADB funded grid extension project features average take-up rates of around 50% of targeted connections (all buildings within a corridor of 150m from distribution line) after 5 years from commissioning the line.

During the survey of households (structured and semi-structured interviews), the heads of the households and their spouses were asked to state their most pressing development needs. Out of 329 households responding, a majority of household heads had listed improved water supply as their development priority. The same result appears if only the spouses (women) and the non-electrified households are considered. Electricity is fifth in the overall ranking, third, if only women in non-electrified households (26% of total sample) are considered.

Ranking of development needs	All household heads	All spouses	Heads of non-electrified households	Spouses of non-electrified households
1	Water supply	Water supply	Water supply	Water supply
2	Education	Food production and preparation	Food production and preparation	Food production and preparation
3	Health	Health	Health	Electricity
4	Food production and preparation	Education	Education	Health
5	Electricity	Electricity	Electricity	Housing improvement incl. heating

Figure 35: Ranking of development priorities from household interviews (sample of 329 households in Trashigang and Trashiyangtse Districts)

- This result of the survey is quite striking. One would expect electrification to be given a higher ranking at least with the non-electrified households. However, this result should not be misinterpreted in such a way that electricity would not be important for the households in the project area. Almost 100% of households (sample size 177 households) stated that electricity was of high importance to them. None considered electricity as of low importance. The interpretation of the low priority of electricity among the current development needs of the population in the project area is three-fold:

- Since electricity is already there (if not yet in the house it can at least be observed in neighbouring villages), the households do no longer regard it as something that needs much attention and lobbying.

- Households in the project area have a very realistic perception of what electricity can do. They realise that electricity is a convenient source of energy and can bring about new services (radio and TV) but is not as vital to them as a safe water supply or fertile land. The households in the project area seem to have gone past the stage where development miracles are expected from an electricity supply as are often observed in remote places such as Papua New Guinea or the Eastern parts of Indonesia.

- Even though perceptions are realistic, some of the respondents in the household survey were not fully aware of all the possibilities of using electricity. Food production and preparation, health and education services which were regarded as important development objectives may be improved through the use of electricity and modern appliances, a fact which some of the respondents were probably not aware of.

There is no doubt that an electricity supply responds to the needs of the population in the project area. But electricity is not (yet) considered a basic need among the majority of them.

Agreement with Development Priorities of Partner Government

The following paragraph looks at rural electrification and the Rangjung SHP project in view of it being in line with current development priorities as expressed in RGOB's development plans and policies.

The Eighth Five-Year Plan (1997 – 2002) specifies RGOB spending of about 14% of total on-going and new program budgets to be in the power sub-sector. This illustrates that electricity development is accorded high importance in Bhutan where still less than 30% of households have access to electricity.

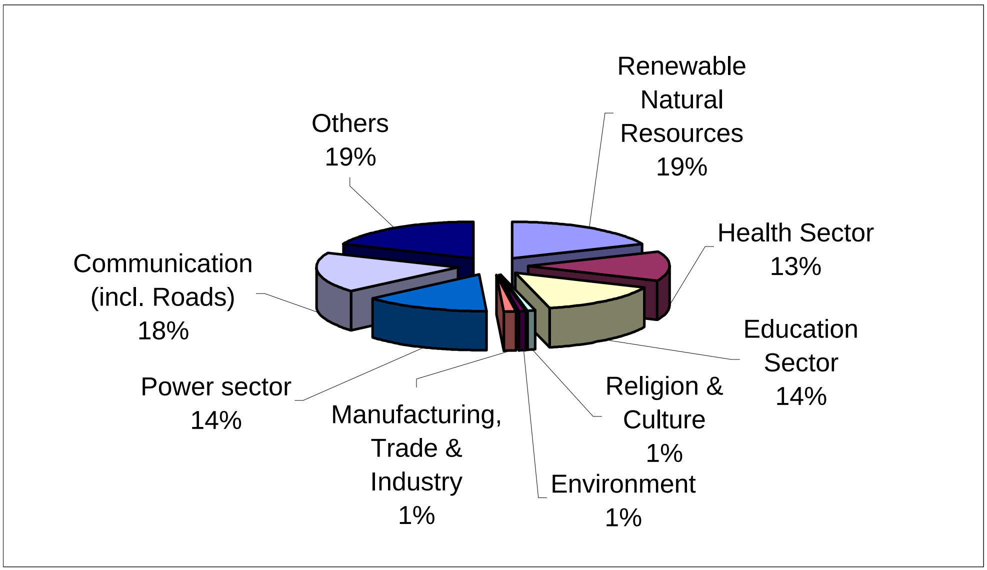

Figure 36: Sector-wise allocation of development spending in the Bhutanese Eighth Five-Year Plan (1997 – 2002)

A comparison with neighbouring Nepal on power sector resource allocation provides the following figure:

Country	***Period***	***% allocation of development budget to the power sector***	***(Rural) electrification targets***
Bhutan	Eighth Five-Year Plan 1997 – 2002	14%	7000 households
Nepal	Ninth Plan 1997 – 2002	18.5%	300,000 households

Figure 37: Budget allocations to the power sectors of various Asian countries

However, the relatively high spending in the Bhutanese power sector is misleading since major investments are allocated to large-scale hydropower development and associated transmission grids which are only marginally relevant for rural electrification since the exports to India dominate the capital requirements (only 20% of power generated is currently consumed in Bhutan).

A better measure of the relative importance of rural electrification in Bhutan is the targeted new household connections under the Eighth Plan. With 5990 rural households during the 7th Five-Year Plan and "only" 7000 new households to be electrified within the current five-year plan (1997 - 2002), the importance of rural electrification in development spending appears to be limited. In order to electrify the 60,000+ non-electrified households at the current rate, RGOB would need more than 25 years to bring electricity to a majority of Bhutan's population. For the Ninth Plan (2002 to 2007), the rural electrification target is expected to be set to about 15,000 new households[20] to be electrified within five years. This improved importance of Rural Electrification must be seen as the result of the RGOB's new concept of balanced power development. This concept takes into account that a rapid development of the country's vast hydropower potential for export purposes is not sustainable as long as the majority of the Bhutanese population is forced to over-exploit the forests for lack of alternative energy sources. Degraded and over-exploited forests in the catchment areas of the major river systems are feared to result in irregular stream flows (higher peak flows and poorer dry season flows) and generally reduced hydropower generation. Rural electrification is now considered to be one of the most effective measures to protect the watersheds from over-exploitation by the population. With new large-scale hydropower capacity coming on line in the next few years (Kuri Chhu, Baso Chhu, Tala with total capacities in excess of 1000MW), this new strategy is expected to provide even a larger momentum on expanding rural electrification as revenue from power exports and available funds for RE will substantially increase.

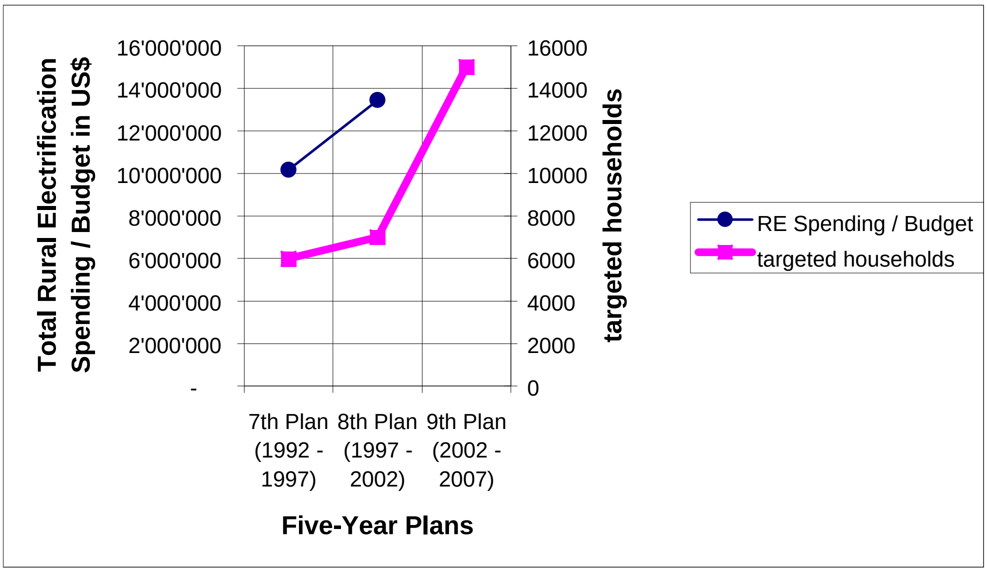

Figure 38: Rural Electrification Spending / Targets according to the Bhutanese Five-Year Plans

Sector Policy Development

The Rangjung SHP project supported a rural electrification strategy which was defined earlier by DOP. There is no evidence that the Austrian co-operation contributed in any way to defining this strategy[21]. According to this strategy, electricity services are expanded from mini grids at district headquarters to the surrounding rural areas using

[20] Personal communication of the Consultants with the DOP General Manager Mr. Sonam Tshering

[21] In fact, the RGOB had initially asked BmfaA to supply a turn-key mini hydro in Rangjung and had no intention for a close co-operation on strategic issues. Fortunately, this has changed over the years of Rangjung project preparation and implementation.

mini and micro hydropower plants. Such isolated mini grids when evacuating power from small hydro plants as in the case of Rangjung (2.2MW) spread over a relatively large area. The mini grid from Rangjung SHP spreads over at least 2 Dzongkhags (supply to the third Dzongkhag, Pemagatsel, has temporarily been discontinued due to insufficient capacity) with total line lengths of over 450km. This system of isolated mini grids powered by a small hydropower plant in the MW range was also applied in Central Bhutan (Bumthang, 1.5MW Chumey hydro) but is not considered as a long-term rural electrification strategy for Bhutan[22]. Demand in both the Central and Eastern Bhutan mini grids has rapidly outgrown supply and the need for bringing in a connection from a large hydro was regarded as the only way out of continued load shedding and supply restrictions. According to sources at DOP, the system of isolated mini grids is only used as an intermediate step followed by an interconnection with a large hydro as and when feasible and practical. The isolated mini grid option is the final solution in all those situations where grid extension from a large hydro is impossible (e.g., power lines through a national park) or not economic for many years to come.

For this reason, there are currently no small hydro power plants in the MW range under construction. Most rural electrification projects now use grid extension from existing large plants. For remote areas, micro hydro and associated micro grids or individual solar home systems are used as a pre-electrification strategy catering for small demands (lighting loads and entertainment) only. The 2.2MW Rangjung SHP has thus not served in all its aspects as a model and show-case for rural electrification in Bhutan. The conditions for the project were rather unique in the Eastern districts and similar situations are not present to repeat the project elsewhere in Bhutan. Hence, a multiplier effect has not been fully generated with this project as required by RGOB from all aid assisted projects (see 8th Five-Year Plan, p. 43). Even though the Rangjung SHP is not a model that can be replicated throughout Bhutan, it is nevertheless a project of significance. Firstly, it is the second largest hydropower plant in Bhutan serving a larger area than any other plant except Chukha HEP. Secondly, the Austrian input for Rangjung SHP has eased Bhutanese dependence on India in the power sector to some extent. This was achieved more by the mere existence of the co-operation between Austria and Bhutan and the resulting Rangjung SHP plant rather than by actively shaping the Bhutanese sector policies towards a higher degree of self-reliance. Given the geopolitic situation of Bhutan, an Austrian support towards a less dependent Bhutanese sector strategy was neither intended nor realistically feasible.

To conclude, the Rangjung SHP project responded to the needs of the targeted beneficiaries as is evident from the high connection ratios in the electrified villages. The project supported a development activity of the RGOB which was high up on the agenda but which will only gather momentum in terms of meeting overall electrification targets in the coming Five-Year Plan.

4.4.3 Participation and Donor Co-ordination

The next question looks at the co-operation mechanism and processes:

Question Q3: What decision-making processes and co-ordination mechanisms were developed with the partner government and other donors?

What was the degree of local participation and of other stakeholders? What role did NGO's and the private sector play?

[22] Personal communication of the Consultants with the DOP General Manager Mr. Sonam Tshering

Co-ordination Mechanism Developed

The Feasibility study of June 1989 outlined a classical engineering approach for the Rangjung SHP whereby the Austrian Consulting Engineer was to assume a leading role in all aspects of the project. Once the bilateral agreement between the two Governments was signed, the co-operation and co-ordination mechanism was virtually limited to the following pattern:

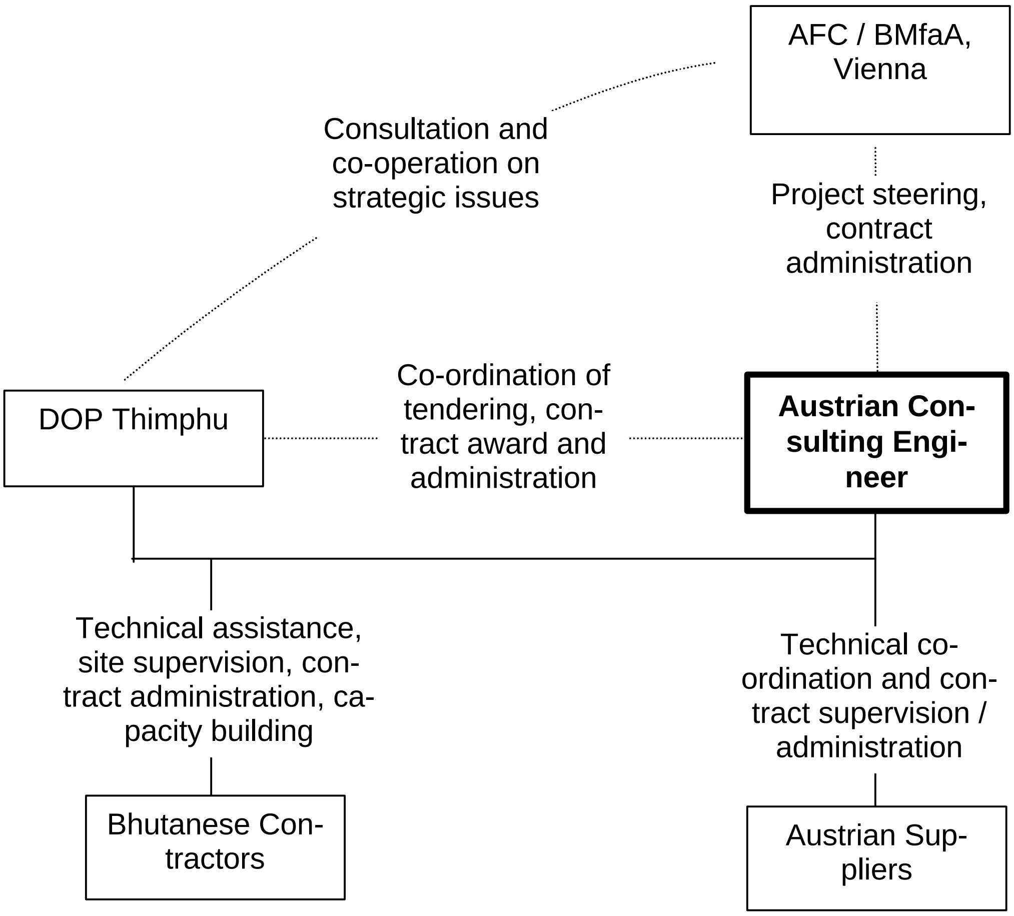

Figure 39: Co-ordination and communication pattern during Rangjung SHP implementation

The role of DOP was limited to approving and implementing the proposals by the Austrian engineers as far as designs and contracts with suppliers and contractors was concerned. There was practically no design role on the Bhutanese side with the exception of a limited responsibility for designing retaining walls and protection structures assigned to two DOP civil engineers attached to the Austrian consulting engineer at Rangjung.

Generally, project activities were confined to the engineering aspects of the small hydropower plant. The project was not concerned with the evacuation of power to the rural areas other than with the aspects related to the powerhouse sub-station, grid stability and electrical protection measures which were co-ordinated with the Austrian suppliers. The TOR of the Austrian Consulting Engineers did not include any advisory role on rural electrification and associated work such as grid expansion strategy, load development projections or the promotion of fuel wood substitution at household levels.

Donor co-ordination

RGOB provided for co-ordinating with the various donors contributing to the small hydro powered rural electrification efforts in the Eastern districts. After AFC had agreed to provide assistance for the Rangjung power plant, RGOB was able to allocate funds for the transmission and distribution line expansions in the eastern districts from national rural electrification projects:

- The Sustainable Development Project involving rural electrification with grid extension and solar home systems funded by the SNV (Dutch co-operation)
- Rural Electrification I and II projects with loan funding by ADB

The rehabilitation of Chenary small hydro by India can also be considered as a result of the excellent donor co-ordination efforts by RGOB. The integration of the Rangjung small hydro project into the rural electrification programmes operating on a national scale is adequate proof of the far-sighted approach of RGOB. The fact that up to four different donor / funding agencies contributed to the electrification of Eastern Bhutan shows that RGOB developed into a strong partner with clear objectives and was thus in the driver's seat of donor co-operation.

However, co-ordination *among* donors was limited. Rapid grid extension continues despite the fact that Rangjung is the only generating plant and demand has outgrown capacity since 1999. A concerted approach by the various donors in supporting a more balanced development of the Eastern grid would have been beneficial for the consumers and could have reduced the pressure on ESU Trashigang to meet the growing demand.

While RGOB timing with the rural electrification extension perfectly matched the completion of Rangjung SHP, it failed with the repair and rehabilitation of Khaling and especially Chenary mini hydropower plants which have not operated at their rated output since the early 1990s. As the Rangjung project had always been conceived as only one out of three generating plants in the eastern grid, the failure of bringing Khaling and Chenary to full capacity has inhibited overall project success. When DOP was unable to meet demand in the Eastern grid, it opted for alternative solutions (diesel back-up generators, Kuri Chhu interconnection) and did not attempt to rescue Khaling and Chenary plants or to introduce an improved load management concept with Austrian and ADB / SNV expertise under a co-ordinated donor approach.

The decision of DOP to seek alternative solutions instead of requesting foreign expertise to look into the problem can be interpreted as another proof of the Bhutanese commitment to the concept of self-reliance and national execution even though the current problems in the eastern mini grid have led to the impression among consumers in the project area as well as among observers that the Austrian built Rangjung plant was not performing as planned. In the light of the dedicated and highly professional performance of all personnel involved in the project, this negative publicity is totally unjustified and could have been avoided if DOP had invited the experts from all donor agencies involved to find solutions for the frequent interruptions of supply, the high peak loads exceeding Rangjung capacity or the problem of low output of Khaling power plant.

There is no evidence that project activities and lessons learned were co-ordinated and exchanged with other donors active in the power sector at a level of anything more than a brief visit to the Rangjung site (Japanese and UNDP delegations). The initial set-up of the project did not consider the fact that the construction of the Rangjung SHP would constitute a learning field which would be of interest to other donors. Therefore, the Austrian Consulting Engineer had no obligation to seek a dialogue with the

Japanese (engaged in micro hydro projects and large-scale hydropower studies), the Norwegian (training in O&M of hydro turbines) or the Dutch (rural electrification) development co-operation.

Decision-Making Process

As the construction of the Rangjung SHP was a genuine grant by the Austrian Government (no co-funding or mixed credit arrangements), the decision-making processes were somewhat biased towards the donor side. While in the early stages of the project, DOP representatives were invited for commenting on designs, technical specifications and contract awards and were even invited for discussions to Vienna, this joint approach was not rigorously continued during the rehabilitation process. Often, solutions for plant rehabilitation were discussed at the BmfaA in Vienna among Austrian officials, experts and consultants while DOP and the ACB were consulted only afterwards. Minutes of meetings seldom make reference to the opinion of the DOP and their personnel. For example, the decision about a turbine runner contract awarded to a new Austrian supplier with no previous relation to the project was not sufficiently communicated with ESU Trashigang and the Rangjung plant operators. Accepting the lowest bid in a procurement exercise may be totally adequate for the donor agency but it may not be the most efficient solution for the engineer in charge and the operators in Rangjung who will have to deal with the new supplier at the site.

Local Participation

The local beneficiaries (households) are not organised in distinct “user” groups and were thus unable to play a role in the shaping of the project. DOP maintains complaint handling offices at various Gewogs through which the consumers can voice their concerns.

During construction, official RGOB agencies handled land and other compensation negotiations and payments on an individual basis with each landholder concerned and according to national specification. There were no NGOs involved in the project. The private sector was only engaged as a contractual party and not as a stakeholder with an interest in shaping the project.

The Rangjung SHP was conceived as an engineering project with the objective to build a small hydro plant supplying the Eastern Bhutanese grid. In the project set-up involving the Austrian development co-operation, the participation of the local beneficiaries was not sought but was ensured by DOP in the context of the grid extension project with ADB and SNV funding.

The complaints about the unreliable supply from Rangjung as voiced by a number of institutional consumers in Trashiyangtse and Kanglung give rise to the question of whether the mini grid approach covering a number of districts under one system with currently over 450km of supply lines was the best electrification option. Beneficiaries of Trashiyangtse stated during interviews that if they had been consulted they would have opted for a separate project comprising a mini hydro for the Trashiyangtse district alone. They feel that their concerns are not always taken seriously down at ESU Trashigang and the Rangjung power station, both situated more than three hours’ drive away. The electrification strategy adopted by DOP for the Eastern Districts with small hydro power plants supplying an extended mini grid is not new (same in Central Bhutan, Bumthang) but might look differently (e.g., four to five smaller plants instead of the 2.2 MW plant) if local beneficiaries had had a say in its conception. From the point of view of the donor, a more decentralised electrification strategy as suggested by unsatisfied project beneficiaries would have been more expensive than the implemented one (considerable economies of scale with the 2.2MW Rangjung plant as compared with the development of a number of smaller mini hydro stations).

The more decentralised the supply option, the better can the requirements on local participation and local project ownership be granted but at the expense of higher project costs especially when (design) capacities at partners are limited. This conflict of many donors in rural electrification has never been an issue for the Austrian Development Co-operation as the underlying RE strategy of the Rangjung project was considered to be DOP's responsibility and part of their NEX (National Execution) approach.

4.4.4 Techno-economic Evaluation of Rangjung SHP

Question Q4a: Are processes, structures, plants and equipment technologically adapted to the frame conditions (technically, economically and ecologically) and designed in a sustainable way?

Several criteria and indicators have been used to evaluate these issues:

Relevance of electricity supply for the energy situation in the project area

	ENTEC Survey Oct.–Dec. 2000, (83 households)	[23]	[24]
Lighting	77% of hh use kerosene as main lighting fuel, average consumption 1.1 litre / capita /month	1.3 litre of kerosene per capita and month	1.22 litre of Kerosene per capita and month
Water boiling	Firewood as main source (>97%), 10.4 hours per capita and month of self-collection	114 kg of firewood per capita and month	29kg of firewood per capita/month
Cooking			94kg/ capita/ month
Space heating			12kg/ capita/month total 136kg/month/capita self-collection approx. 1 manday/ capita/month

Figure 40: Energy consumption pattern of non-electrified households in the project area from three different surveys

	ENTEC Survey Oct. – Dec. 2000 (244 hh in Trashigang and Trashiyangtse Districts)	***ADB funded survey Tata Consulting Engineers 1998 (33 hh in Radhi Gewog, Trashigang District)***	***Jadavpur University, Calcutta, 1995***
Lighting	87% of hh use electricity as main lighting source, approx. 3.7kWh/capita/m	Main lighting source is electricity, most households still use kerosene (0.9 litre of kerosene per month and capita)	No survey in electrified villages
Water boiling	Main sources: 77% firewood, 10% electricity 9% LPG, 4% kerosene	Main source: firewood 70kg/capita/month LPG use is 0,05 cylinders/capita/m which corresponds to 0.5 kg Electricity use for heating and lighting use is 12kWh/capita/m	
Cooking	Main sources: 70% firewood, 25% LPG, 3% electricity, 2% kerosene		
Space heating	Main sources: 87% firewood, 13% electricity Electricity use in heating is 18kWh/capita/m, firewood use is 88kg/capita/m		

Figure 41: Energy consumption pattern of electrified households in the project area

[23] *ADB funded survey Tata Consulting Engineers 1998 (44 hh in Phongme Gewog, Trashigang District)*

[24] *Jadavpur University, Calcutta, 1995 (1257 hh in Trashigang and Trashiyangtse Districts*

From the household survey, the following energy consumption pattern can be gathered (excluding transport and occupation-related activities):

The electricity supply from the Rangjung SHP has made major inroads into to the traditional household energy pattern only in the field of indoor and outdoor lighting. The heat requirements are still dominated by firewood. However, a growing substitution of firewood is taking place not only through electricity but also through LPG.

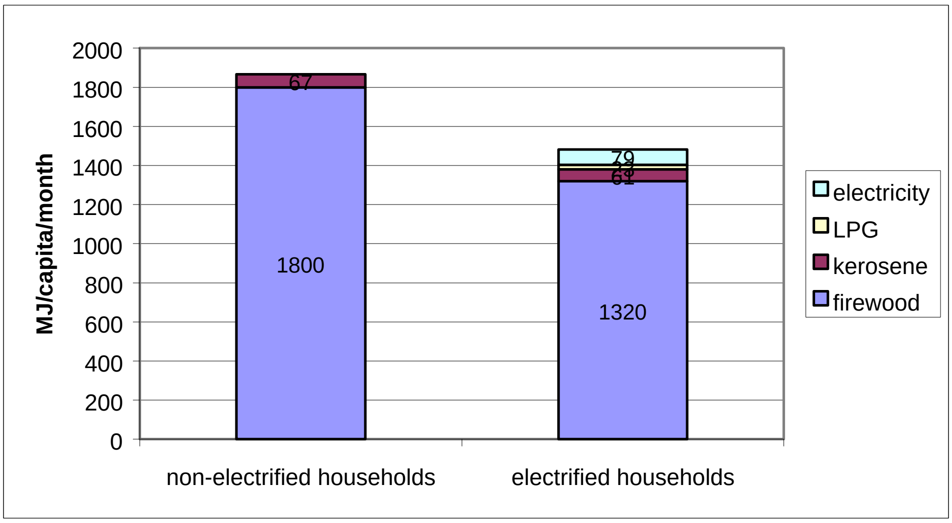

Figure 42: Sources of household energy in the project area (excluding transportation and agricultural activities)[25]

While the calorific input of the modern fuels used in electrified areas seems to be modest as compared with the dominating firewood input, it is surprising to see what reduction in total energy use these modern fuels can bring about: With an input of only about 100MJ/capita/month of electricity (and LPG), firewood consumption is reduced by over 25%. This is mainly due to the much higher efficiencies of the appliances used with the modern fuels. Rice cookers, water boilers and kettles are several times more efficient than the wood stoves, be they the traditional ones or the improved smokeless stoves. The reduction of firewood use in the order of 25% is thus a major achievement of the Rangjung hydropower plant and its associated mini grid.

The relevance of the Rangjung SHP project in the overall energy situation in Trashigang and Trashiyangtse districts remains limited because only a third of the households have so far been connected to the mini grid while demand has already outgrown the capacity of the plant during the relevant evening peak hours in winter (space heating). Thus, for the remaining two thirds of households in the two districts, the Rangjung SHP has no direct relevance in terms of energy services and firewood substitution.

The situation is different for non-household sectors:

- Agro-based industries have so far made little use of electricity. Of the more than 120 rice mills operating in the project area only 15 have so far switched from diesel to electricity powered prime movers. Conversion is slow because (i) the millers are not yet convinced of the reliability of the Rangjung power supply and (ii) an electric motor is only bought when the existing diesel generator is at the end of its service life.

[25] Calorific values used: firewood 15MJ/kg; kerosene 32MJ/litre; LPG 46MJ/kg; electricity 3.6MJ/kWh

- Commercial and small industrial consumers do not make much use of electricity yet. Their loads are limited to lighting and the odd compressor or refrigerator.
- Institutions, especially Government offices and health posts make up close to 20% of total electricity consumption in the Rangjung SHP supply area. Apart from lighting and communication facilities which were previously run by diesel generators or with Khaling MHP supply, space heaters have appeared now. Computers are widely used in offices but due to the frequent outages, officers still rely on hand-written notes and hard copies for fear of loosing data (and because there are more used to the conventional method). Basic health units have started to switch from kerosene operated vaccine fridges to electrical (or dual-fuel) ones but staff complain about frequent black-outs.
- Bulk consumers are the Kanglung College, the army and military training camps as well as the road construction and maintenance camps. The Kanglung college as the main bulk consumer is also often affected by poor reliability of supply requiring the back-up diesel generator to be used.

The energy situation of households and service institutions (Govt. offices, health posts, school/college) has improved since Rangjung power has been made available. Commercial and industrial consumers have yet to make full use of the benefits of the electricity supply.

Efficiency of Power Supply

Due to the fact that demand during peak hours has already outgrown supply (during winter), the efficiency of the plant and the associated mini grid is important. With each percent of plant efficiency improvement or loss reduction, at least 20 new households can be connected to the plant.

- Generation efficiency as initially measured during commissioning was very high and exceeded the guaranteed values of the supplier (close to 90%). However, due to the heavy wear on the turbine (sand abrasion damage), the efficiency is decreasing gradually.
- The water conveyance structures (piped headrace and penstock) are somewhat under-dimensioned: Total head loss is over 30m (at design flow after some 5 to 10 years of operation with incrustations in steel pipes) which corresponds to more than 15% of static head. The comparably small penstock and headrace pipe diameters are probably a result of the capacity increases which were ordered during construction when pipe diameters were already selected.
- Transmission and distribution losses in the Trashigang area were initially reported to be above 30% due to insufficient line capacities when Rangjung power became available. Over the past 4 years, these lines have gradually been upgraded and ESU Trashigang is now of the opinion that line losses are reduced to 15%. However, the available statistics do not reflect such improvements. Technical losses vary between 8% and 51% (see figure below). The increase of unaccounted grid supplies during the summer months were suggested to be the result of the non-metered connections such as the small rural customers which pay per light point and socket (about 250 hh) and all DOP staff (52 hh) whose actual consumption does not appear in statistics. It is not clear, why the non-metered consumers would have only very small consumption figures during the winter months (the opposite should be true due to the use of space heaters which are popular with DOP staff).

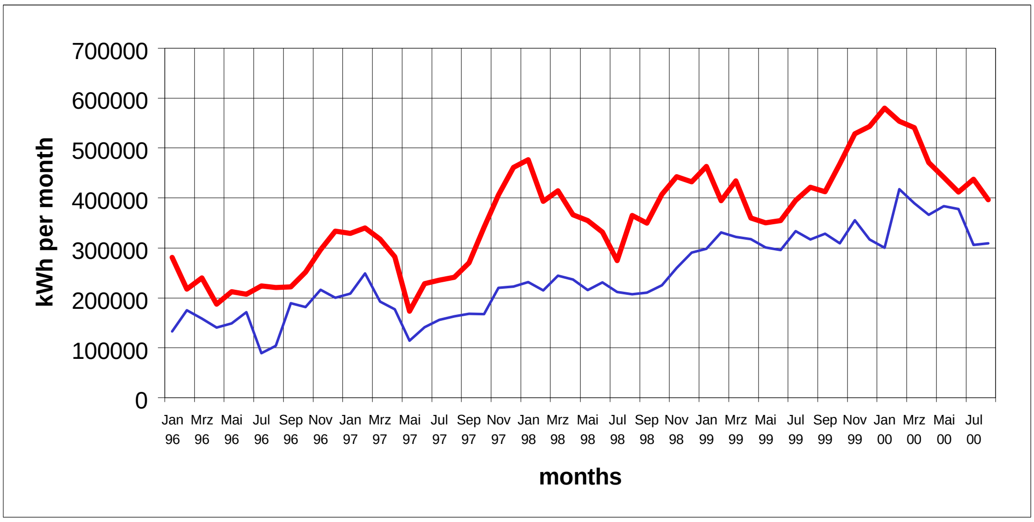

Figure 43: Generation and sales figures for Rangjung and Khaling power stations

Overall, from January 1996 to August 2000 the technical losses in the transmission and distribution system is 32.5% out of which station own-use is only 0.5%. The tremendously high loss of over 32%[26] in the project area is probably more related to a metering and reporting problem rather than to real technical losses in the system.

Adequacy of electricity supply

DOP provides a very generous supply level of electricity. The normal single-phase connection of a household features a 20Amp-rated meter. The fuse of similar rating must be provided by the consumer himself (through an electrician or a trained villager installing the house wiring). Thus, it is possible to connect lights and appliances of up to about 4kW with the standard connection and tariff rates. This policy of high-powered rural electricity connections is extremely favourable for encouraging the use of firewood substituting appliances such as rice cookers, hot plates, kettles and space heaters. In neighbouring countries such as Nepal, typical supply levels are below 250W in isolated mini grids. There are no constraints to be observed by consumers in regard to the time of day or season to be observed when making full use of the 4kW.

Safety of the plant and associated mini grid

There have been no accidents reported from the power house. The safety precautions and the protection schemes employed are in accordance with European standards. For the distribution systems and especially the house wiring, the situation is different. From the household survey (187 households), one fatal accident in Radhi Gewog was reported. 5% of households reported a major accident with injury while 6% reported an accident without injury. Extrapolating the survey result to all consumers, there must have been over 30 accidents (with injury) on average each year somewhere in the mini grid of currently over 3500 consumers and close to 23,000 people. Hence, the annual risk for an individual to have an accident with injury due to electricity in the project area is about 1 : 700 and an electrical accident with death 1 : 6100. In Europe, the risk of having a fatal electrical accident for non-professionals is about 1 : 30,000. Hence, the

[26] Typical rural electrification schemes in the developing world have up to 20% technical and non-technical losses, only occasionally above 25%, in Bhutan, official DOP figures for system losses are at 9%

supply in the project area is 4 to 5 times more dangerous. Two elements may contribute to this:

- People are not aware of the danger of electricity since this form of energy is relatively new to them, and
- The electrical wiring in the house is sometimes of substandard workmanship and people are exposed to unnecessary high risks.

Reliability of electricity supply

According to the operators' logbook at the Rangjung Powerhouse, the plant was available during 97% of time since commissioning in January 1996. This is a good result for Bhutanese conditions and is close to the values (98 to 99%) usually recorded for hydropower plants in developed countries. However, this favourable result covers the following two facts:

a) Since commissioning the plant encountered close to 1100 forced outages (one breakdown every 1.5 days!) with an average duration of slightly below one hour. The frequency of breakdowns has increased over the last two years. This may be associated with the fact that the plant is often run close to its supply capacity.

b) While the plant could mostly be brought back into operation within a few minutes after tripping, supply to the whole project area could not be restored in such short periods of time. No detailed records exist on downtimes of the various supply areas but it is estimated that downtimes due to line faults or load shedding usually last several hours to days.

It is not surprising that consumers – mostly at Government offices - often complain about the unreliability of supply. A failure every 1.5 days may be acceptable for a community-run micro hydro plant but not for a utility-operated small hydropower plant such as the Rangjung SHP. When analysing the cause of the frequent outages it seems that the plant often trips when it should not, probably due to tight tolerances and thresholds for voltage and frequency fluctuations. In an isolated small grid, voltage and frequency fluctuations due to load switching at the consumers are much larger than in large interconnected networks. Control and protection equipment must be adapted to these frame conditions.

With the new desanding facility currently being built, the Rangjung SHP plant need not be shut down for sediment flushing thanks to two parallel desanding basins which can be flushed individually. This will slightly reduce plant downtimes. However, during monsoon periods, flushing of the old desander which will serve as a gravel trap will still require the plant to be shut down.

For an extended grid of over 450km length as currently served by the Rangjung SHP, reliability of supply can only be improved through stand-by units which are large enough to carry peak loads. The installation of four diesel gensets at Chenary powerhouse and at Trashiyangtse is a logical step taken by DOP in improving reliability of supply.

O&M of Rangjung SHP and associated power evacuation facilities

The DOP records of operation and maintenance costs do not clearly distinguish between expenditure for the Rangjung supplied areas and expenditure for the other Eastern Bhutanese power plants such as Kalanzi SHP (Mongar District), Khaling SHP (partly serving Pemagatshel District) and Gangur SHP (Lhuentse District) where ESU Trashigang provides management and logistical services. In addition, some of the staff employed at ESU Trashigang are also engaged in line extension activities which are still on-going mostly in the Trashiyangste district. Nevertheless, the records can be used as a general indicator for the cost-effectiveness of the Rangjung SHP and its associated transmission and distribution grid.

Typical annual O&M costs for isolated rural electrification schemes energised by a small hydropower plants are in the order of US$20 per consumer (source: World Bank study on Power Sector Development Strategy Nepal, Rural Electrification Component, ENTEC 1999). The Rangjung project features annual O&M costs per consumer of more than twice this benchmark value. This poor performance of the Rangjung project is mainly due to the high personnel, transportation and equipment requirements to maintain the extended transmission and distribution grid of currently more than 450km length. In the above figures, the costs for major turbine spare parts such as runner, nozzle, deflector and spear valve or the 11kV breaker gear which have all been replaced recently have not been accounted for since they were supplied as essential spares with the equipment order under the Austrian grant. Including the costs of these spares in the O&M accounts would make the Rangjung operation look even worse in terms of financial viability.

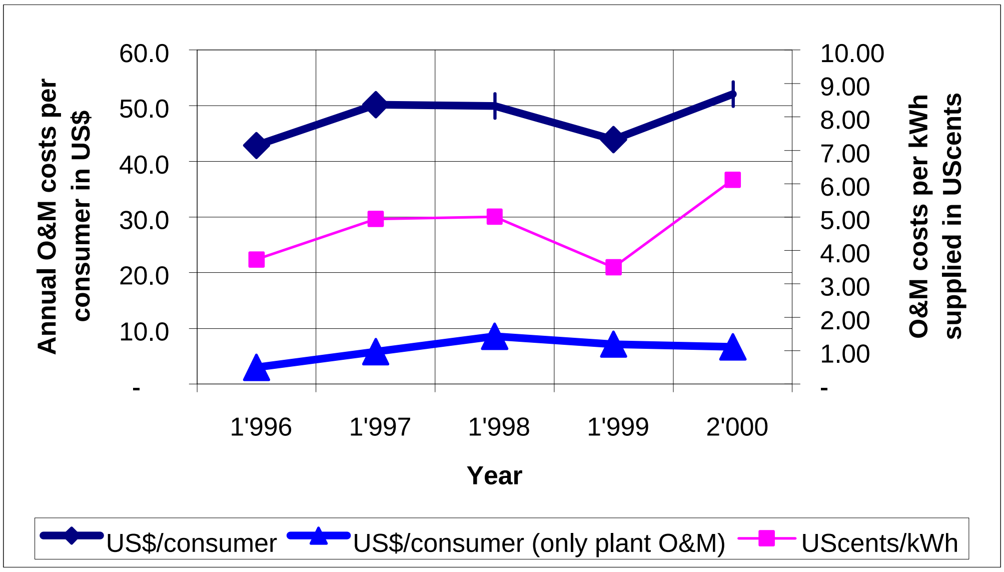

Figure 44: O&M costs as an indicator for the cost-effectiveness of the Rangjung SHP and its associated transmission and distribution grid

Another indicator for the efficiency of the electrification scheme is the amount of electricity sold per employee or the number of consumers served per employee. The supply area of the Rangjung SHP is served by the ESU Trashigang and the ESSU Kanglung which have a total of 52 staff employed including the 7 staff at the Rangjung powerhouse. This results in the following indicators:

The table inf Figure 45 shows that the staff performance of the Rangjung SHP and associated ESU is comparable to other utilities in the Himalayan region (NEA) despite the fact that personnel costs are the main reason for the high O&M costs. At the present frequency of outages (one breakdown every 1.5 days on average), it is not possible to reduce the number of staff at the Rangjung powerhouse to below 7. When the problem of frequent tripping is rectified, a reduction of permanent power house staff to about four or five should be possible. A reduction of the staff at the ESU Trashigang (currently 39) will be possible when line extension activities are no longer handled by DOP staff but by dedicated contractors under the RE II programme (with ADB loan financing).

	Rangjung SHP supplied area (2000)	***DOP (1997) excluding CHPC***	***Nepal Electricity Authority NEA (1998)***
Electricity sold per employee	75,000kWh / employee	554,000kWh / employee	130,500kWh / employee
Consumers served per employee	77 consumers / employee	42 consumers / employee	72 consumers / employee

Figure 45: Staff performance of Rangjung SHP supplied area in comparison with other supply areas and utilities.

Technical Sustainability of the Rangjung SHP Plant

The Rangjung SHP is a solid piece of engineering despite its flaws with the desanding facility which is currently being modified. Even when the new desanding facility is operational, the Rangjung SHP will still require important maintenance efforts year after year especially at the intake and the headrace pipe which are constantly being threatened by erosion and landslides respectively. This is a standard feature of any hydropower plant in the Himalayan region and is not in any way associated with an inadequate design or insufficient maintenance but is probably the price to be paid for using the abundant water resources of the region.

The technical sustainability of the Rangjung SHP plant may be in danger at the following three levels:

Flood damage at the intake structure: Erosion processes and scouring on and along the intake structure is a major cause of concern and could in the worst case wash away important elements or whole structures as has already been experienced in the 1999 monsoon season when the intake rack was washed away.

Figure 46: Pipe bridge crossing the potentially unstable slope on the Rangjung headrace

- Headrace failure: The headrace pipe is threatened by slope instability and landslides. Even though there are currently no active slides along the headrace, maintenance of the drainage facilities must be continued at all times in order to avoid fatal damage. Even a minor slide on the headrace can disrupt water supply to the powerhouse for several months and can also trigger costly reconstruction activities for pipe bridges and slope protection measures.

- Deteriorating maintenance: There is no official maintenance plan readily at hand at the powerhouse with detailed maintenance tasks according to plant running hours and time of day/week. The maintenance manual available contains all the details of each individual component of the hydro plant but is so voluminous that it becomes impractical for daily use. It serves only as a trouble-shooting and repair manual, (i.e., when components have failed), but not as a maintenance plan for preventing failures. There is no spare part inventory available and parts of the documentation and labelling is in German language. As long as the Austrian-trained operator - who speaks German fluently – is in charge, the language issue is not critical but as DOP staff is rotating frequently, the inadequate documentation may develop into a problem.
  There are already signs of deteriorating maintenance efforts developing: The spare parts available at the Rangjung powerhouse are not kept in a very orderly manner. Especially the electrical parts are stored on a shelf with too many other items. Some components which are currently damaged (intake rack, by-pass of

spherical valve at both units[27], seals at nozzle actuator) have not yet been replaced properly. DOP staff seem to rely on the supplier from Austria who was supposed to replace the turbine runners (after completion of the new desander). However, the runner supply contract went to a different supplier and communication with the first supplier has not continued as planned (to the detriment of the performance of the maintenance staff at Rangjung SHP).

With the commissioning of the Kuri Chhu HEP, the importance of the Rangjung SHP for the electricity supply situation in Eastern Bhutan will be reduced. In the case of a major failure at the intake, the headrace or the generation equipment, the DOP – in the absence of donor support in the future - might delay repair work on the Rangjung SHP until the following financial year. While waiting for the funds, the damage on the plant could develop further even to a point where repair is no longer economic. The current DOP management stated that it will remain committed to the plant and will continue to accord high priority to the Rangjung plant (after interconnection with Kuri Chhu) for reasons of supply security in the Eastern Bhutanese grid.

Viability of operation of the Rangjung SHP

Current tariffs paid by the consumers in the supply area of the Rangjung SHP are as follows:

Consumer class	***Tariff***	***Equivalent***
Rural households	0.50 Nu/kWh	1.1UScents/kWh
Urban households, commercial, Govt. offices, agro-industry, small industry, bulk and public consumers	0.70 Nu/kWh	1.5UScents/kWh

Figure 47: Current tariffs paid in the Rangjung SHP supply area (exchange rate: 46 Nu/US$)

[27] This goes back to a fault of the supplier who mixed stainless steel with a small portion of mild steel parts at a place where electrolytic corrosion can develop.

Figure 48: Electrical spare-part store at the Rangjung powerhouse

Rural households make up close to 50% of total consumption. Hence, the average tariff is 0.6Nu/kWh. With total annual consumption of close to 4 GWh and 4000 consumers, annual revenue per consumer is currently at Nu 600 (or Nu 660 if single-phase meter rent is added). This is equivalent to US$13/consumer and is only about a third of current annual O&M costs of US$40 to 50 / consumer. In other words, the tariff for full O&M cost recovery should be at around UScents 5 / kWh or Nu 2.3 / kWh (see also Figure above). This tariff level cannot possibly be charged to any of the consumers in the Rangjung supply area and the short-fall in revenue must be made up from subsidies. Hence, the current Rangjung operation is only operationally viable as long as subsidies (e.g., generated through electricity sales from large power plants to India) are made available. Upon interconnection of the Rangjung SHP with the Kuri Chhu hydro as scheduled for the second half of 2001, the viability of the Rangjung operation will dramatically be improved as excess power during off-peak periods can be put to an economic use in other parts of Bhutan (or in India). With total energy output of about 17 GWh / a the Rangjung plant can generate a revenue of over Nu 10 million (at the average tariff of Nu 0.6/kWh) and the total O&M costs of slightly below Nu 10 million can be covered. Reserve funds for major repairs can be accumulated so that no further subsidies will be required. Thus the viability of operation will be given when excess power can be sold through the new transmission lines from Kuri Chhu HEP.

Environmental compatibility of the Rangjung SHP design

Negative environmental impacts of hydropower plants mostly stem from altered flow regimes in the by-passed river section and from interruption of fish migration. For the Rangjung SHP, the situation looks as follows:

- In the winter season during reduced stream flows, the by-passed river section falls dry during the evening peak period because all the water is used for power generation. There is no allowance at the intake structure for maintaining a residual flow in the river. This period of the year coincides with fish migration (mostly carp species) from the large rivers up the smaller tributaries such as the Karthiri river, the source of the Rangjung SHP. Since the flow in the river is only reduced to zero during a few hours in the evening and the change of flow is gradual (not instant), the fish are said to have time to come down to the powerhouse / tailrace where water is released and move up again when flow in the river is back (during late night and day time when power demand is reduced again). However, this favourable situation is likely to be changed when Rangjung SHP is able to supply all its excess capacity to the Kuri Chhu transmission line. During about 40 to 50% of time, the by-passed river section will be dry if no residual flow is allowed for. The residual flow should be in the order of 350 l/s.

- The longitudinal connectivity of the river ecology is partly interrupted due to the weir structure. Migrating fish and other aquatic life is unable to reach the river sections upstream of the weir since a fish ladder has not been provided.
- During sand trap flushing, the sediment concentration in the by-passed river section currently reaches about 30grams / litre of flushing flow. This is more than the recommended concentration limits of 10 to 15 grams / litre as usually applied in Alpine regions. Since the sediment is relatively coarse, sandy material (0.06 to 2mm in diameter) it will not stay in suspension and thus not be carried very far and the impact on the aquatic life (silting up cavities in the river bed where water species live) is reduced to the immediate vicinity of the sand trap. The same applies for the new desander currently being built.

The design of the Rangjung SHP lacks some environmental mitigation measures such as provision for a residual flow and a fish ladder. While this was not critical with the current usage of the plant, provision for a residual flow in the by-passed river section is essential once the plant can make use of its excess power and operate at optimum capacity throughout. Dry river beds will then occur more frequently.

The Rangjung SHP project has brought about a significant shift in energy consumption patterns away from the traditional firewood and kerosene fuels to electricity with the result that the power demand has already outgrown the Rangjung plant capacity during the winter peak demand periods. Without the (somewhat rushed) decision to upgrade the plant capacity from 1.1 to the current 2.2MW, the supply situation in Eastern Bhutan would be much worse.
However, frequent breakdowns of supply have been the cause of major complaints by consumers, mostly institutions. While the Rangjung SHP is a solid piece of engineering (despite the flaw of the desanding facility) the supply seems to suffer from a host of minor deficiencies not only on the generation side but also on the transmission and distribution side. This large grid of currently over 450km length is inadequately served by one single power plant (without a stand-by unit); the repair of Khaling and Chenary power plants and / or the interconnection with the Kuri Chhu HEP is therefore overdue.
The technical sustainability of the plant is constantly threatened by floods and landslides, a fact which no design or protection measure will ever be able to fully remove.
The economic viability of the plant will only be ensured when the Rangjung SHP is interconnected with the Kuri Chhu plant and excess power can be put to an economic use . Until such time, the Rangjung operation must be subsidised as annual O&M costs (including transmission and distribution) exceed current revenue by a factor of 3.

4.4.5 Project Effectiveness and Efficiency

Question Q5: What is the result of the analysis as far as effectiveness of interventions and efficiency of allocated funds are concerned?

All four project objectives (outputs) have been reached and the Rangjung SHP has been operational since more than 5 years. Thus, the intervention has been effective. When looking at the efficiency of the intervention, it must be stated that the initial budget request (after capacity optimisation) stood at ATS 72.25 million. The Austrian consulting engineer managed to remain within this budget up to commissioning in January 1996 (excluding repair and rehabilitation in the subsequent years). This is an outstanding achievement as most hydro plant construction activities suffer from budget overruns.

However, when looking at the supply efficiency of the plant, the situation is less favourable since the economic viability of operation is currently not given as indicated above. The poor economic performance of the Rangjung SHP is not much improving as long as day-time loads are low resulting in an average plant capacity of about 15 to 20% only. This situation is likely to improve when excess power during off-peak hours can be put to economic use via the transmission line from Kuri Chhu. This should be possible towards the end of the year 2001. With this possibility, the full energy potential of the Rangjung SHP of estimated 17 GWh annually can be sold. A cash-flow analysis with a total investment of ATS 72 million (1992 to 94, excluding early planning costs and rehabilitation and repairs since 1996) provides the following picture:

Plant capacity	2200	KW
Investment (excluding transmission grid)	72 million	ATS
	6.3 million	US$
Investment cycle	1992 – 1995	
Foreign Inflation	2.4	%
Commissioning	Jan. 1996	
Specific investment cost	2865	US$/kW
Annual O&M costs (for year 2000)	174,300	US$/a
Initial energy sales (1996)	1.91	GWh
Potential energy sales (2002 onwards)	17	GWh
Domestic sales tariff (1996 – 2001)	1.4	UScents / kWh
Sales tariff of excess power	1.5	Nu / kWh = USc/kWh 3.3
Economic Internal Rate of Return (EIRR)	1.4	% nominal

(all revenues and expenses discounted/compounded to the end of 1995, the beginning of generation)

Figure 49: Cash flow Analysis Rangjung SHP

Note that the above cash-flow analysis excludes all transmission and distribution investment so that it becomes comparable with the original computations of the 1994 proposal by the Austrian Consulting Engineer. While the specific investment is with US$ 2865 / kW relatively low and beats other small hydropower plants in rural electrification schemes by far (e.g., ADB funded Tatopani SHP in Nepal, 1000kW, US$ 4970/kW, Swiss funded Salleri Chialsa SHP in Nepal 600kW, US$ 9375/kW), the EIRR of projected 5.2%[28] has not been achieved. In order to reach this higher level of economic viability, the sales tariff for excess power would have to be about UScents

[28] Source: Request to BMfaA for additional funding, 1994

5/kWh a level which would not be competitive neither in Bhutan nor in the Indian market where the cost of supply is around UScents 4.5/kWh (generation and distribution).

The difference between the projected EIRR and the actual economic performance of the Rangjung SHP must be attributed to the long delays incurred during construction (major investments in 1993/94, commissioning as late as 1996) and probably to the very optimistic assumptions on load development in the project area (daytime use of power).

The question is whether the Rangjung SHP with its relatively poor economic performance is in hindsight still the best option to supply electricity to the Eastern Bhutanese region. The following alternatives of supply can be considered:

- Waiting for Kuri Chhu: A large power plant such as Kuri Chhu (60MW) has lower generation costs (Nu 2.3/kWh long-run marginal costs[29]) than small hydro plants but their gestation periods are also longer. For the Eastern Bhutanese region, the large hydro option would have meant a delay in electrification of at least 6 years during which the development of the region would have suffered from the costs of un-served demand and continued use of alternative fuels such as kerosene and firewood. To what extent the region would have suffered is probably irrelevant because waiting for the large hydro would have been politically unacceptable and RGOB would certainly have opted for other options (in the absence of the Austrian intervention in Rangjung) in the meantime.

- Installation of diesel generators: This is the easiest and most convenient option to supply electricity to a newly electrified area as new units can be added as demand grows. With a current diesel fuel price of Nu 17.04/litre (US$ 0.37/litre) at Trashigang, generation costs of a diesel power station of around 2MW capacity supplying an isolated grid (plant factor 0.20) is in the order of Nu15/kWh (US$ 0.33/kWh) and hence, more expensive than the Rangjung SHP supply. In addition, diesel fuel supply is often erratic and would result in a poor reliability of the electricity supply.

- Installation of three to four mini / micro hydropower plants: The installation of three to four mini / micro hydropower plants of around 600kW capacity each close to the main load centres would have been a slightly costlier solution as micro hydro plants have slightly higher generation costs than small hydro plants. In addition, the transmission and distribution grid from these micro plants would still resemble a pre-electrification approach and would not be as generous as with the current approach where the transmission grid has been designed for a fully interconnected system.

- New renewables such as solar PV or wind converters are not considered as viable alternatives as these systems are, firstly, more expensive than hydro and, secondly, do not provide the level of service needed (> 1kW/household) to substitute cooking and heating fuels.

From the above it is clear that there was no better alternative for supplying electricity to the Eastern Bhutanese region than with the construction of the Rangjung SHP despite the fact the function and importance of the plant will be slightly reduced once Kuri Chhu power is connected to the Rangjung supply area.

[29] Indication by Mr. Sonam Tshering, General Manager DOP, Thimpu

Economic impact of repairs and re-design of the Rangjung SHP

The decision to increase the plant capacity from initially 1.1MW to 2.2MW when construction was already under way was – in hindsight – a very wise decision. Not only would DOP have had to introduce load shedding as early as 1997 (two years earlier than with the present plant capacity), but also the economics of the plant would look worse. With a total investment of ATS 59.75 million (US$ 5.2 million) and only 1.1MW capacity (7.9GWh of potential annual energy output), the specific investment would have been US$ 4727/kW and the EIRR would have been –3.4%.

The repair and modification work that were necessary after commissioning in 1996 do not have a major impact on the economics of the Rangjung SHP. Even though the modification work on the desanding facility are still ongoing in the field, the following preliminary costs can be given:

Year	***Item***	***Amount in ATS***	***Amount in US$***
1996	Slope stabilisation (civil works)	3,328,000	310,500
1996	Slope stabilisation (Engineering and site supervision)	2,224,767	207,500
1999	Replacement runner	830,000	62,700
1999	Two spare runners	1,699,397	128,450
2000	New desander basin (civil works)	3,977,795	276,800
2000	New desander (steel structures and site supervision)	2,770,940	192,800
	Total repair work	ATS 14,830,899	US$ 1,178,750
	Project cost before 1996	ATS 72,080,720	US$ 6,299,127
	Total project cost	**ATS 86,911,619**	**US$ 7,478,877**

Figure 50: Final project costs after modification and repair work

The modification and repair work implemented between 1996 and 2000 represent an increase in total project cost of 21%. Because this additional investment is distributed over several years, the impact on the economics of the project remain modest and the EIRR is reduced from 1.4 to 0.5%.

In order to become an economically viable project model (EIRR >8%), SHP projects of the Rangjung type would have to achieve an overall sales tariff for supplies to the project area as well as for its excess power of about Nu 3.7/kWh or UScents 8/kWh. The present tariffs in Bhutan are about five times lower than the above value which can be considered as the tariff required by a commercially operating utility or an Independent Power Producer (IPP) wanting to repeat the successful example of Rangjung SHP on a commercial basis.

Rural electrification policies in Bhutan are not conceived along these commercial lines. Bringing electricity to all Bhutanese households is seen as a national target which is to be achieved as rapidly as possible and through projects cross-subsidised from power exports to India. Not only is electricity considered to be a basic need that has the potential to contribute to economic and social development thus improving both the gross national product as well as the “gross national happiness”, it is also considered a means to reduce the environmental pressure of excessive fire wood use in Bhutan. Given this policy, the Rangjung SHP project has still effectively contributed to expanding rural electrification and to the development of the Eastern districts despite its failure to meet projected economic efficiency targets.

4.4.6 Impacts on population and resource base

Question Q6: What are the economic, social and cultural impacts for the population of the project area? Which direct effects have occurred in terms of economic and industrial development; in particular what are the income and employment effects?

What impacts on the resources (water, land, pasture and forest) have resulted from the interventions e.g., on their exploitation and access and on the housing situation, health conditions and the social structure of the population? What impacts have resulted on welfare and education, mobility and migration, lifestyle and cultural activities. What is the current status of corresponding indicators and processes of the impact monitoring?

Socio-economic impacts of the Rangjung small-hydro have been more limited in nature and scope than those experienced in the Namche Bazaar project area, because the beneficiary population does not share the economic driver that tourism supplies, and because the power has been very much more thinly distributed and less reliable, due to some transitory technical problems. Moreover, the country has been much less exposed to western influence, media and technology, and to date shows little of the economic diversification into commerce and services that is beginning to emerge in Namche Bazaar.

Economic Impacts

The subsistence economy is largely intact in Trashigang and Trashiyangtze. Agriculture still occupies 57% of the surveyed population, while 25% are in government service, 9% in small commerce and 1% in industry.

Though baseline socio-economic data were not gathered in the project area at the time of commissioning the Rangjung plant, informants state that the major economic change has been in an efflorescence of shops and dwellings in the small town of Rangjung itself. In other areas where power has been distributed, the most visible changes are in the improvements to public facilities such as schools, hospitals and Basic Health Units. Limited economic impact is predictable where consumers are using electricity only for domestic purposes, and little productive use has emerged.

Income and Employment Impacts

The new productive uses of electricity emerging in Namche Bazaar, are not yet apparent in Trashigang and Trashiyangtze. This is attributable largely to the relative unreliability of electricity supply. Ten per cent of the 33 institutions surveyed maintain back up generators. Secure electricity supply is their top priority, along with education, and ahead of transportation, water supply and other social and physical infrastructure.

There has been no recent population census, and the 1998 Statistical Yearbook does not give per capita GNP. The ADB estimate (1996 figures) is US$ 390. The Rangjung project area is still cash income poor by this comparison. In the households surveyed, of 201 responses the stated average household income is US$ 330, or US$ 49 per capita. In electrified households, the average is US$ 55, and in non-electrified households, US$ 23 per capita.

There is thus a striking correlation between higher income and electrification, though in general electrified households are closer to roads and hence access to markets than those where the absence of roads is one on the factors inhibiting grid extension. No pre-electrification comparative data is available, but it is fair to surmise that increases in incomes have been small but not been spectacular since electrification.

Reported evening activities in electrified households give a small insight into stimulation of economic activity provided by electricity supply: 94% of respondents said that they use time in the evening to produce handicrafts and articles for sale. Many of these are women, who weave at home on the back strap looms the cotton and silk *kira* (women's traditional garment) and other woven articles that are marketed through a weaving co-operative in Thimphu. These attract good prices, at between Nu 1,500 and 15,000 per piece, depending on the yarn and the elaboration of the design. It takes two weeks to a month or longer (depending on the design), working in the evenings, to produce a *kira.*

Increases in production are a direct impact on employment and incomes of electrification.

Figure 51: Back strap weavers at the Weaving Centre in Khaling

Household Economy

The Government of Bhutan has a conscious policy of affordable electricity provision to rural dwellers, and the costs reported through the surveys suggest this is succeeding. While non-electrified surveyed households spend on average Nu 88 per month on lighting, electrified households spend only Nu 73 on electricity, and receive far better quality light than those dependent upon firewood or kerosene. However, they still spend money on other lighting fuels, in total around Nu 125 per month. Kerosene is cheap at Nu 8-10 per litre delivered to remote areas, but supply is often short. Candles cost Nu 1.20 each, and are regarded as very expensive.

Household fuel use reported through the survey is shown in th table Figure 52.

Notable is the still extensive use of alternative lighting fuels in electrified houses. This is a further illustration of the untrustworthiness of supply at the time of the survey. Electricity has failed to make the inroads into the cooking, water boiling and heating that was observed in Namche Bazaar. Indeed, 69% still say they prefer to cook with wood. This is at least in part because many families (87% of the whole sample) still gather their own wood, despite its scarcity, and regard it as a free good. Men gather more than women and children, around 85%. This is a further indication of lack of employment options and opportunity value of time. Gas is preferred over electricity for cooking and boiling water. It is expensive at Nu 330-360 per 17.6kg refill delivered, but is more reliable than electricity, and can be used with a quite cheap burner.

Number of Users and Percentage Main Use of Household Fuels								
	Lighting		Cooking		Boiling Water		Space Heating	
	E	N/E	E	N/E	E	N/E	E	N/E
Candles	76	5						
Main Use %								
Gas			91	1	53	1	4	
Main Use %			*26*		*10*		*0.4*	
Kerosene	150	77	35	11	24	5	4	2
Main Use %	*3*	*77*	*1*	*4*	*4*		*0.4*	*1*
Fuel wood	117	35	194	96	204	82	225	82
Main Use %	*9*	*23*	*70*	*96*	*76*	*98*	*86*	*99*
Electricity	243		20		46		69	
Main Use %	*88*		*3*		*10*		*13*	
Other		4			4		2	
Main Use %								

Data Source: household surveys October- November 2000
Legend: E = Electrified households
N/E = Non-electrified households

Figure 52: Household fuels used in the Rangjung area

At this point in time it would appear that the principal impact of electrification on the household budget is to provide a better quality product at a competitive price compared with alternatives.

Ownership of household appliances

Ownership and use of appliances is low compared with Namche Bazaar. This reflects both the lower incomes and mistrust of supply in Trashigang and Trashiyangtze. In addition, over 50% of both men and women stated that the cost of appliances was a problem, and over 40% find the tariff high, where nobody in Namche mentioned the cost of appliances as a problem, and only two found the tariff high.

The much lower ownership rates of luxury item such as TV (11 versus 37%) is also an indicator of lower levels of income, though in both areas reception is not always available, and this acts as an additional inhibitor.

Ownership of Appliances		
Item	**Number of owners**	**Percentage of sample**
Light bulbs	206	81
Tube lights	145	57
Radio cassette deck	106	42
TV	27	11
Fan	17	7
Refrigerator	18	7
Space heater	31	12
Water heater	41	16
Hot plate, cooker	42	17
Iron	15	6
Mixer, grinder, blender	12	5
Power tools	2	1
Other	0	0

Data Source: Household Surveys, October-November 2000.
Sample size: 253

Figure 53: Ownership of electric appliances in the Rangjung area

Health Impacts

Hospitals are present at Dzonhkag level, and most Gewogs have a Basic Health Unit (BHU). In addition, distant hamlets are sometime served by an Outreach Clinic. Public health facilities are given priority electrification. Six out of 18 in Trashigang are covered so far, and the only non-electrified BHU within the area of the distribution system has suffered soil subsidence, and has not been connected out of safety concerns. It will be connected as soon as soon as the situation is remedied.

Hospitals and health units are very well serviced and equipped relative to the levels of development of the areas they serve. All but one are in solid permanent buildings, kept clean and tidy by professional staff.

Typically, the electrified BHUs have lights, water and space heaters, a refrigerator for vaccines with kerosene dual fuel capability as a back up, and an autoclave. Non-electrified BHUs use kerosene for lighting, and can accordingly offer only limited services.

Case History

The new hospital at Trashiyangtze received its first patients in March 2000. It was planned for electricity. It has two stand-by generators, but can run only one at a time because of diesel shortages.

Medical equipment that runs on electricity includes suction equipment, plaster cutting equipment, operating lamps, dental equipment about to arrive, and autoclaves, also run on gas. X-ray equipment has been ordered, and will arrive soon. The hospital cooks with gas and firewood. A 17.6 kg cylinder of gas costs Nu 360 and lasts 10 days on average. A truckload of wood is used per month at a cost of Nu 4,500.

There is a geyser to heat water for washing. Water for showers and toilet comes from the kitchen, and is mainly heated with wood. Laundry arrangements are not yet made, but it is planned to get an electric boiler and hire a dhobi. The hospital has no incinerator.

Electricity "makes the difference between day and night" in the delivery of health services according to the Medical Officer of Health, though there is still a prevalent cultural tendency to resort first to ayurvedic and traditional medications and to shamans before coming as a last resort to hospital.

Comparative statistics of incidence of morbidity and mortality are not available; in some case they were not collected, and in others the administrative areas covered by the BHUs have changed, so that figures are not comparable.

The principle health problems reported to the hospital are diahorrea, skin ailments, worms, conjunctivitis and other eye infections, peptic ulcers, otitis media, oral disease and scabies. In Trashigang, the Health Section Head listed diarrhoea, respiratory tract infection, a small amount of malnutrition, iron and other dietary deficiency disease, some urinary tract infection and sexually transmitted disease in the top ten causes of morbidity.

Though it is too early for statistical trends to show differences in heath status of people in electrified versus non-electrified areas, the doctor is adamant that electrified homes house healthier people. He still sees patients from electrified homes with upper respiratory infections, but they are from dust and smoking, and less from stoves as people begin to learn to cook with electricity. Eye infections, too, are more from dust and agricultural residues such as husk, or from bacterial infection than from soot. He also draws attention to better levels of personal hygiene he observes in patients from electrified homes.

…End of story…

Educational Impacts

Like hospitals, schools receive priority for connection once electricity is available. Fifty percent are now electrified, and at least have electric light. This is reported to be making a great difference in that many are now able to offer Non-Formal Education after normal working hours in numeracy and basic literacy in Dzongka for the many older residents who had no access to school as children

Education is a major focus of government effort. Parents share this concern. In ranking development objectives, both men and women placed education and health high on the list, after the most pressing need, water supply; education was ranked second by men and fourth by women, while health was ranked second by women and third by men.

As populations are scattered, most post-primary schools also cater for boarders. Energy use is therefore critical to education institutions in terms of living conditions for students and staff, as well as for pedagogic purposes.

Case History

Sherubtse College is the only tertiary institution in the country, founded in 1962-3 by Father McKee, a Jesuit priest, on condition that he did not preach, and progressively taken over by the Government of Bhutan.

The College has 609 students, 436 male and 173 female, of whom 531 (87%) are boarders. Most (95%) of the 59 teachers, 48 male and 11 female, also live on campus.

It offers three-year undergraduate programmes in Information Technology, Science and Engineering and Commerce. Electricity is therefore a crucial input. The College has its own Ashok Leyland 60 kW diesel generator; it is 30 years old but can support whole campus, though fuel is scarce, and delivery difficult. Power outages cause extreme inconvenience; one occurred in the middle of a computer science examination with devastating consequences for the students, who were unable to complete their paper.

Electricity consumption has increased sevenfold over the past 10-15 years. It is used for teaching computer science, audiovisual teaching aids (videos, OHP, slides, cassettes), in the science laboratory for refrigeration of chemicals, and teaching physics. Electric light enables teachers as well as students to perform better; they too can do their homework, and prepare and mark lessons.

Residential uses include lighting throughout premises, administration areas, staff and student quarters, cooking for the students in a baking oven (12900 W) 10 years old, in staff quarters for space heating, TV, computers, ovens, rice cookers, curry cookers, water boilers, immersion heaters, geysers, and a washing machine.

Electricity supply is also now critical for administration, and is used for fax, computers, email, and internet access. It is also used in the carpenters' workshop for power tools and welding.

Both staff and students use electrical appliances for recreation and leisure. The students have their own photo club where they can develop films. They also show videos. The home science club bakes cakes and pastries, which are sold for fund-raising ventures. Bulk laundry is mostly hand washed and dried, but the college would like an electrified laundry.

The college community uses a variety of other commercial fuels.

Fuel wood is still the main source of cooking fuel for students' mess; a truckload containing 8-9 m^2 costs Nu 2,700[30]; in winter the school uses 4-5 truckloads. Some teachers have fuel wood stoves for space heating. Wood is also used for water heating.

Some teachers use kerosene for cooking. It costs 10 Nu per litre delivered, but availability is limited. LPG is used in the science laboratory, which consumes 50 cylinders per month at Nu 330 per17.6 kg refill.

The Principal states that electricity is very good value for money at an average Nu 12,000 per month in summer, and 21,000 per month in winter.

Some students choose to remain at college during the holidays because there is no electricity at home and they cannot study effectively.

The Principal notices no particular difference in achievement between students who come from electrified versus non-electrified homes at time of entry, but those from non-electrified homes perform spectacularly after arrival because a new frontier has opened to them. The College has extensive development plans for both buildings and educational services that will be critically dependent upon reliable electricity supply

[30] There are enormous differences in price for a truck load of fuel wood in the project area. The reason for these differences must be attributed to varying quantities bought, different transportation distances and varying profit margins of suppliers.

…End of story…

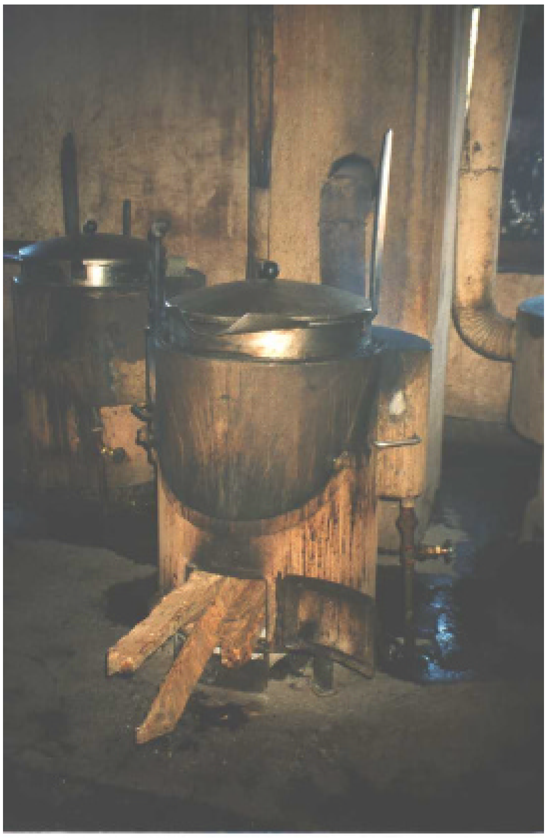

Figure 54: Cooking at Sherubtse College, Kanglung

Sherubtse is one of a number of outstandingly well appointed and run educational institutions in Trashigang and Trashiyangtze that try set an example of environmentally responsible fuel use which their students take home and apply in their private lives. As electricity supply improves, students who have attended these institutions and are becoming the consumers of the future will make choices that will dramatically increase the beneficial impacts of electrification in the area.

Figure 55: Computer room at Sherubtse College, Kanglung, in the dark as another black-out occurred at the time of visiting the establishment.

Cultural Impact

In a country that jealously guards its cultural and religious heritage, some nervousness over the exposure to outside influence created by electricity is to be anticipated. Instead, religious and cultural leaders express confidence and optimism about their ability to manage change, of which electrification is only part, and to use electricity for their own purposes.

As in Namche Bazaar, the Monastery in Rangjung is an enthusiastic proponent of electrification, for the general public good as well as for its own usage. The monastery was established seven years ago. At the time there was no electricity, and it had a small generator, not adequate for all the needs of the 95 monks and 25 additional staff who live there. The monastery is planning extensions that will double the number of monks on the premises.

Four years ago the monastery was connected. It now has four meters, and uses fans, lights in the monks' cells. In the kitchen is a rice cooker, refrigerator and water heater, and there are seven power points in the common areas, used for radio and VCR and other appliances. Though a signal is not yet available, the monks regard TV as necessary; they cannot help people to understand modern life and adapt to it if they do not know what is going on in the rest of the world. The abbot at the sister nunnery in Radhi takes the same view, though he censors videos before the nuns see them.

There have been vast changes in spiritual and cultural life, irrespective of the arrival of electricity. Electricity helps the monastery to manage their largest ceremony, attended by 22,000 people. Without electricity this cannot be performed, and alternative energy sources are inadequate for the lighting and sound system required.

The Monastery has also observed positive impacts on public life with the arrival of street lighting; petty dishonesty is less prevalent, people socialise more and feel safer. Both the monastery and the nunnery try to behave in an environmentally responsible manner, and therefore encourage electricity use.

Figure 56: Typical Bhutanese farm house with electricity supply and satellite dish

Another cultural institution in the project area is the Rigney Traditional Arts and Crafts Institute, established in 1997 and electrified two years later. The Institute was a conscious response to a decline in traditional craft skill, and a complementary need to create employment for youth. It offers instruction in seven of the thirteen traditional Bhutanese crafts. Most of these are, and will continue to be manual activities, but certain functions such as wood turning and lacquer drying can be electrified with great benefit to quality, and no detriment to craftsmanship in the view of the ex headmaster Principal.

The Institute, like many educational institutions is residential. It has electrified as many of its living and administrative functions as possible in the interests of economy, efficiency and environmental protection, a concept firmly embedded in its philosophy. The management see electricity as a powerful partner in supporting culture.

No one in the Rangjung household survey found anything culturally offensive to note in the media they can access, and in general, as in Namche Bazaar, people express optimism rather than fear about change, and confidence in their ability to adapt without danger.

Generally, the population in the project area is much more enthusiastic and grateful about the project and its impacts than the economic and social indicators would suggest. The beneficiaries consider their living conditions improved, the perceived gap between the rural and the semi-urban (district centres) areas narrowed and security problems reduced. Even though this positive outlook by the beneficiaries cannot yet be fully backed by statistical evidence, it is certainly having an effect in terms of the population becoming more open to experimenting with new cash crops (potatos), investing into small projects and businesses[31] and becoming active in the community for issues of general concern (education, irrigation).

4.4.7 Gender aspects

Question Q7: How do the impacts compare in terms of gender balance? How has the work load of women and children changed? In what way have gender aspects been considered in design and implementation of the projects? What gender specific support mechanisms have been developed?

Electrification has benefited both sexes in the area. It has extended working hours for women; over 90% say they perform housework and income generating activities in the evening, but everyone likes the entertainment value and the reduction in the sense of isolation achieved through radio. Because its applications have been mostly domestic, women have especially stood to gain from better light, and from the applications that save labour and increase amenity in their daily lives. Penetration of uses that save labour and the environment, and assist with income generation are still quite limited.

Case History

An exception is in cottage industry weaving, mostly done by women and girls in the evenings. A Weaving Centre in Khaling established in 1983 received an electricity connection in 1988, prior to commissioning of the Rangjung plant, which now supplies that area because supply from the local micro-hydro is inadequate. The Centre has gradually grown in to a training institution; a dormitory was completed in April 200 for 40 trainees, young women 15 to 20 years of age specially selected as school dropouts from poor families. These young women also receive non-formal education at nights at the centre, to give them literacy and numeracy skills.

They now receive training for one year in all aspects of the craft; harvesting dye materials, dying, weaving, embroidering. While dying will continue to be done by traditional methods, boiling over a wood fire, electricity is used for lighting, space heating, food preparation, cooking, and refrigeration. The electricity bill is Nu 200-250 per month, but they changed from using the traditional Bukhari wood heater to electricity because it saved so much time collecting fuel wood. They regard electricity as offering very good

[31] The BDFC's Group Guarantee Lending and Saving Scheme in Eastern Bhutan has seen a considerable boost since 1999 which has been attributed in part to the improved outlook by the rural people generated through the newly-gained access to electricity (from personal communication with regional BDFC officer)

value for money; it is less expensive than kerosene. If the electricity fails, they use two packets of ten candles per night at Nu 1.20 each; this is very expensive.

The women work mainly during hours of daylight, but after their training they return to their villages and their normal lives, and work mainly in the evenings. They regard weaving as a pleasant and creative way of earning some extra income. Two gewogs supply the Centre with weavings for the Thimphu Handicrafts Emporium, one electrified, the other not. The Principal states that the women from the electrified village produce much faster. Their work is better quality, cleaner and freer from faults such as mistakes in the patterns or flawed yarn, and they are making much better money. They use rice cookers, which saves them time, and they enjoy listening to music or radio while they work.

…End of story…

Development objectives of residents in Trashigang differ quite markedly in priority from those in Namche Bazaar, but as in Namche, the objectives of men and women are not far apart.

4.4.8 Environmental impacts

Question Q8: How were the sensitive ecological conditions and consequences taken into account and what measures for resource protection have been taken? What are the direct and indirect impacts of the energy supply through hydropower on the conservation of the natural resources (in the project area and downstream) and in the energy balance of the households, esp. fuel wood harvesting?

Direct environmental impacts on the water resources have been evaluated in Chapter 7.1, when commenting on the Rangjung SHP design and construction. Here, the impact of the project on the forest resources in the Rangjung supply area is evaluated.

Total forest cover, excluding scrub forest, in the Trashigang district is 150,000 ha (66% of total area,) or about 18ha per household. For the Trashiyangtse district, the true forest cover is about 97,000ha[32] or about 30ha/household. Sustainable annual yield of these forests is difficult to estimate but the management plans for the Korila, Khalung-Kharungla and Lingmethang Forest Management Units (FMUs) in the Mongar and Trashigang Districts suggest an average annual yield of $4m^3$/ha. If these figures are used, every household in the Trashigang District could sustainably use up to $72m^3$ per year of wood resources as construction timber and fuel wood. However, this global approach is totally misleading as neither the households themselves nor the official contractor harvesting wood has access to all the remote forest areas in the district. Given the currently limited extent of (forest) roads, only a fraction of the $72m^3$ are actually available to the households. According to current regulations each household is only allowed 2 to 3 standing trees which corresponds to about 6 m^3 per household and annum. This is probably a more realistic figure of what a sustainable annual yield in Eastern Bhutan could be. In this figure, deadwood which can freely be gathered, is not accounted for. From the household survey conducted in October / November 2000, non-electrified households consume on average about 120kg of firewood per capita and month which corresponds to about $12m^3$ per household and year. This fact suggests that the forests around the settlements are probably over-exploited and either firewood reduction/substitution programmes or firewood harvesting in remote forests of the district (requiring construction of forest roads, etc.) must be introduced.

[32] Source: Land cover maps, Ministry of Agriculture / DANIDA

The supply of electricity and the use of modern fuels such as LPG contribute to firewood substitution. From the household surveys in electrified villages of the Rangjung supply area, a reduction of firewood use of about 25% or 3m^3 per household and year has been observed. Thus, the households in electrified areas use about 9m^3 of firewood per annum, which still seems to be above the sustainable annual yield of the forests of around 6m^3. While this is by all means an extraordinary achievement (to which the Rangjung projects contributed over 75%, rest by LPG), its impact on forest conservation is limited as this substitution effect takes place only at those 33% of households which have been electrified so far. The Rangjung SHP project is unable to contribute further to firewood substitution as demand has outgrown its capacity during the peak demand period. Only with load management methods could the positive impact be further improved but this is unlikely to happen in view of the upcoming interconnection with the Kuri Chhu hydropower plant and its “unlimited” capacity.

4.4.9 Sustainability of Project Institutional Structures

Question Q9: Which measures to achieve viability and sustainability of interventions have been taken? How far have relevant institutions and capacities been developed?

Capacity Building

The sustainability of the Rangjung plant operation has been an important objective of the Austrian intervention and capacity-building measures were implemented to its end:

- A thorough training course in Austria of four year’s duration has been staged for four Bhutanese mechanics/electricians from DOP. Upon return in late 1997, one of them has become the In-charge of the Rangjung powerhouse while the other three have been posted to other power plants.
- Two DOP engineers were assigned to the Austrian consulting engineer during project implementation so as to acquire hands-on know-how on small hydro design and construction.
- The local civil contractors have been given substantial support by the Austrian consulting engineer. The larger of the two has gained expertise in small hydro construction which is unparalleled in Bhutan. This enabled him to become the main civil works contractor for the Baso Chhu project.

Despite the fact that training measures were high up on the Austrian agenda, the in-country capacity building measures were limited to the on-site training of DOP field office staff and the local civil contractor’s staff. Although the terms of reference of the Austrian Consulting Engineer explicitly contains the task of “ensuring the sustainability of the intervention”, notably the electricity sales and technology transfer issues, activities in this regard were limited to on-the-job training for construction staff. The project progress reports by the Consulting Engineer do not mention specific activities and achievements related to these issues.

The costly training courses (4 manyears in Austria!) for power station staff are not complemented by similarly thorough capacity building on the management level of DOP where important decisions concerning small hydropower and rural electrification are taken. For example, the problem of poor reliability of the Rangjung plant (frequent tripping) has neither been addressed in detail by DOP staff nor has it been submitted to the suppliers (or the donor) for immediate action.

Project Ownership

DOP has resumed project ownership at a very early stage of project conception. It was DOP who made the Rangjung SHP the corner stone of their rural electrification strategy for the Eastern districts. RGOB and DOP inputs have always been timely and adequate in quantity and quality. While project ownership on the national level has been achieved, a similar sense of commitment to the plant at the local level is in the process of being developed. Power station operators are committed to their job and do not mind working overtime when the situation requires it. Gewog development committees are actively involved in establishing new electricity connections (request to DOP via Dzongkhag level) and provide house wiring and other services. This partly voluntary work is proof of their commitment to the project. A lack of sense of ownership has been observed at institutions where officers complained about the poor reliability of supply. They often switch back to their back-up generators rather than assisting DOP in finding the flaws of the system. These are sometimes found to be at their own premises (poor workmanship of house wiring, lack of proper earthing).

The sense of project ownership at the national level is not tied to individuals but to policies, strategic priorities and budgets. As these can change, the sense of project ownership can get lost rapidly. DOP at national level seems to have lost the sense of project ownership for the Khaling hydropower plant. Efforts to rectify the technical problems there and to properly maintain the plant have been limited for many years so that its current performance is poor. DOP has shifted its attention to Rangjung SHP and the interconnection with Kuri Chhu. The same tendency could develop at Rangjung SHP in a few years time unless a group of (local) DOP officers make it their task to become the advocates of the Rangjung plant for the rest of its service life and channel sufficient repair and maintenance funds to Rangjung.

The Rangjung SHP project would have presented excellent opportunities to enter into a close co-operation with DOP on rural electrification strategies, management models and load promotion. What appears to be a missed opportunity in hindsight was in fact an achievement with considerable bearing. At the time of project initiation, the Bhutanese Government expected a turn-key small hydro project from the Austrian Development Co-operation in much the same way as the Indian hydro projects of that era. The idea of a joint development effort was not yet recognised by the Bhutanese partners in the late 1980s. The early years of the project were thus mainly used by the Austrian side to convince DOP that the turn-key project approach was to be replaced by a partnership approach with project ownership already during planning and construction stages clearly on the Bhutanese side.

Today, Bhutan has adopted ownership of their development projects and the partnership approach as initiated by the Austrian Development Co-operation has now gathered widespread acceptance. This change of attitude in Bhutanese Government circles must be attributed to a large part to the Austrian intervention under the Rangjung Small hydro project. It is one of the most significant but not fully recognised achievements of the Rangjung project.

Unfortunately, the Rangjung project itself could not make much use of the partnership approach as it went into implementation before the change of attitude became widely accepted within RGOB. A closer co-operation with DOP on policy and management issues right from the start of the project could have been beneficial for the Bhutanese power sector as a whole.

4.4.10 Project Steering

Question Q10: How effective have been the steering measures and the backstopping of the HQ and the co-ordinating offices? Which conclusions can be drawn from this for the steering of similar interventions in future?

The steering of the Rangjung SHP project was mainly carried out from the HQ at the BMfaA which issued the contracts to the Consulting Engineer and the suppliers of electro-mechanical equipment. When difficulties occurred such as the capacity increase, the slope instability problem and the turbine damage requiring repair work, the concerned Austrian parties met in Vienna to resolve the issues. This proved to be cost- and time-effective as decision makers and Consultants were all based in Austria and no international travels were necessary. However, this approach of steering the project has the disadvantage that both the Bhutanese project partners and to some extent the Austrian Co-ordinating Bureau (ACB) in Thimphu had no say in the project steering process. Bhutanese project officials (DOP staff) voiced their concern about the change of consultants and suppliers in the course of project planning and implementation. A total of four different consulting engineers were involved[33] from the pre-feasibility study to project hand-over. For the turbine runner replacement, a new supplier was selected and the good working relation between operators, ESU Trashigang and the initial Austrian equipment supplier who provided free advice by fax and phone whenever a problem came up was not given the opportunity to develop further. Hence, for the Bhutanese field levels, project steering and management from the Austrian HQ were not always regarded as very transparent.

In order to avoid such difficulties, project steering tasks and project responsibilities should in future be decentralised to the ACB as much as possible. Similar decentralisation efforts have successfully been introduced by the German and Swiss development co-operation much to the benefit of the partner countries. However, for purely engineering oriented, small projects this approach might prove inadequate as competent stakeholders might not be resident in the country (chief design engineer often back in Austria) and the technical competency of the ACB might be insufficient to make far-reaching decisions.

The need for rehabilitation and repair (desanding facility and turbine runners) shortly after commissioning of the plant throws a negative light onto the design concepts of the Austrian consulting engineer. What seemed to be a small omission (adjustment of desander size to increased plant capacity) in an otherwise impeccable performance of the consulting engineer turned out to become a major rehabilitation exercise. The consulting engineer for the Rangjung SHP was shouldering responsibilities for project planning, design, implementation as well as for project sustainability and its integration into the Bhutanese power sector. In private-sector approaches to such a comprehensive undertaking, there is usually a competent specialist engaged on the client's side to advise project managers on technical issues and to provide quality assurance. In development co-operation, this expertise on the client's side is often omitted for cost reasons.

At the Rangjung SHP the external expertise was only engaged when it was too late for corrective action and the errors identified by the expert could only be rectified through costly rehabilitation and repair works. The need for regular independent reviews of projects by specialists in the technical, social and the developmental fields is apparent.

[33] Posch&Partners, TBW, Bernard&Partner, Dr. König

4.4.11 Lessons Learned for Sector Policy Development

Question Q11: What role do such interventions play in the development of a sector policy (of the Austrian development co-operation)? Which conclusions and recommendations can be drawn?

Lessons may be learned at various levels, but not all are naturally of the same relevance.

Impact level

The evaluation of the Rangjung SHP project has shown that:

- Electricity supply to rural areas can assist development activities and can substantially improve living conditions, a fact that is perceived by the beneficiaries at large. It boosts their positive outlook on life but these perceived benefits cannot yet be fully substantiated by statistical evidence from comparisons between electrified and non-electrified areas. The lesson learned is that if given sufficient time, electrification projects do have a positive impact on social development since electricity is linked to modern life and it has thus the potential to change the attitudes of the rural population towards modern production processes, the importance of education and skills development, the need for improved communication. There are few sectors with such comprehensive impacts towards development and the close to ATS 90 Million investment in the Rangjung SHP for the development of the eastern districts seem to be well spent.
- A positive environmental impact of the Rangjung SHP in terms of fuel wood substitution at household levels has taken place (quite to the surprise of the evaluators) thanks to the DOP strategy of providing high-powered connections (>4kW / hh) at low tariffs (below generation costs) which are suitable to operate rice-cookers, kettles and boilers which have become popular in the project area within a short period of time. There is room for further improving fuel wood substitution through power saving campaigns and load management activities.
- Sustainable levels of fuel wood use in the project area cannot be brought about through electrification alone but these require energy saving measures in cooking and space heating and general economic development so that people naturally switch to modern fuels when their opportunity costs for the long hours of firewood gathering exceed the costs of the modern, commercial fuels.
- Economic development takes off on a slow pace following electrification of the project area. In the case of Rangjung there is only a limited number of niches available in the agricultural, small industry and services sectors that can thrive on the use of electricity.

Policy level

A development project is successful in a wider context if it has an impact beyond the individual project and if its effects and models are disseminated and replicated elsewhere in the sector. The Rangjung SHP has shown sustainability in so far as its service to the people in the project area will continue beyond the Austrian intervention. But its significance and impact on Bhutan's energy sector beyond Rangjung is not so evident and subsequently lessons for the energy policy formulation of the Austrian development co-operation are only gradually emerging:

- Human resources development (HRD) has been the most effective intervention that generated effects beyond the Rangjung project proper. While the four Austrian-trained technicians and the on-the-job training of site personnel of contractors and DOP are fine examples of HRD relevant for the whole sector, it is not comprehensive enough to gradually reduce the Bhutanese dependence on foreign expertise in small hydro development. A comprehensive HRD package would include – in addition to what has been implemented - on-the-job training for design engineers and project managers including short-term hydro training courses overseas. This would require that planning and design is carried out in Bhutan and not at the home offices of Austrian consultants.

- The Rangjung project has successfully brought about a shift in Bhutanese project implementation concepts. Back in 1986, the Bhutanese side had initially requested the AFC to fund a turn-key small hydro plant at the Rangjung site in much the same way as the Indians contributed to the Bhutanese power sector. The Austrian development co-operation rejected this concept and managed to gradually introduce a partnership approach featuring transparent decision-making processes and consultation throughout project planning and implementation. The lesson learned is that development co-operation is allowed to interfere with partner concepts and believes and must contribute to change as long as such interference is conducted in a mutual spirit of co-operation and trust.
- Another Rangjung lesson is that the introduction of new models and concepts to partners must be limited to what seems to be realistic and feasible at the time of project implementation. The Austrian development co-operation introduced the high-head small hydro technology into Bhutan but refrained from introducing other new concepts at the same time such as new electrification strategies, new tariff models or load management concepts even though a need for these had been identified. When difficulties with the high head concept occurred (turbine runner abrasion) the Rangjung project was fully occupied with resolving this problem and convincing Bhutanese partners of the viability of this concept in the Himalayas. The lesson learned is that projects are well advised not to overload the co-operation effort and to tackle too many problems with new concepts at the same time. The Rangjung project has successfully observed this lesson and is likely to prove the viability of the high-head concept in the Himalayas shortly (final evaluation pending due to late completion of the additional desanding facility).
- Successful completion of a hardware and engineering-oriented project as in the case of Rangjung SHP paves the way for entering into co-operation with partners in more sensitive areas such as rural electrification policy modifications, gender, poverty alleviation or civil society improvements. The lesson to be learned is that the sensitive, process-oriented issues can only become components of co-operation when credibility has been achieved through successful (hardware and input-oriented) projects such as the Rangjung SHP. It is likely that supply-oriented projects must continue in order to remain accepted by partners to co-operate on policies and process-oriented activities.

Project steering

- Even though the co-operation set-up of Rangjung SHP was very lean and comprised only a limited number of actors, the decision making process was rather lengthy. This was mainly due to the fact that the project was – at least in the beginning - centrally steered and managed from the AFC desk in Vi-

enna with long-distance consultation with Bhutan. Following consultations among the (Austrian) actors, consultants prepared proposals and offers which had to be accepted by both Austrian and Bhutanese partners. Upon agreement, works and supplies were tendered, tenders evaluated and contracts awarded to suppliers and contractors by the BMfaA.
This procedure - though time-consuming - proved to have the right pace for a development co-operation project. Although Austrian suppliers commented rather critically on the slow progress, it allowed the BMfaA to thoroughly consider development co-operation principles and objectives in all its decisions. These aspects would have been lost if the Rangjung SHP had been implemented under an EPC[34] contract with an Austrian-Bhutanese consortium as is currently en vogue in international hydropower development. The lesson learned is that BMfaA's in-house project steering and management was an adequate approach as it provided for a considerate and flexible[35] co-operation. In addition, the BMfaA was able to build up an institutional memory on hydropower development and on the details of the Austrian-Bhutanese co-operation which has proven useful for the more recent, joint projects .

- The quality of the planning and design work of the Austrian consulting engineer was outstanding given the difficult conditions in the Eastern districts of Bhutan. Nevertheless, an omission by the consulting engineer or his inadequate assessment of the sediment concentration in Himalayan rivers and its consequences on high-head power development resulted in extensive rehabilitation and repair work which is still on-going. From this, the following lesson can be learned: When introducing a technology (small high-head hydro) into a new environment (the Himalayas) where well-documented experience is missing, the quality of the design work can only be assured through independent reviews by another consulting engineer. Such “second- opinion” consultation should be an integral part of the project set-up as it provides the Austrian project steering staff with the confidence they need to defend the adequacy of the technical “innovation” vis-à-vis the project partners.

[34] EPC = engineering, procurement and construct

[35] A doubling of plant capacity at a time when construction was well under way shows how flexible the project was managed.

5. OVERALL COMPARISON OF BOTH PROJECTS

5.1 Project Cost, Technical and Institutional features

5.1.1 Project Features

Project feature	Rangjung	Namche Bazaar
Intended power supply	To mini grid	Stand alone
Plant capacity	2.2 MW	0.63 MW
Plant type	High head, run-of-river	High head, run-of-river
Power transmission & distribution line length	450 km	13 km
People served (capita)	23'000	3'000
Installed capacity per capita served	0.1 kW	0.21 kW
Transmission distance per capita served	19.6 m	4.3 m
Total cost to Austria (ATS)	86.9 Mio	83.2 Mio
ATS per kW installed (power plant)	39'500	54'600
ATS per kW installed, incl. Transmission + Distribution	n.a.	132'000
ATS per capita	3'780	27'730

Figure 57: Technical and cost data for Rangjung and Namche Bazaar SHP

Technically speaking the two schemes are of the same type and both belong to the small hydro size range. Capacity-wise, Rangjung is about 3.5 times larger than Namche.

The purpose and the use of power is rural electrification for both projects. Both feed into an isolated grid. However, the actual intention for Rangjung was to complement two existing mini hydropower plants while Namche was designed for stand-alone mode.

Rangjung supplies power into an extended transmission and distribution grid, from which power is distributed to a very dispersed population.

Namche supplies power to relatively dense settlements in the vicinity of the plant, at a service level (kW/capita) of more than twice the level of Rangjung.

5.1.2 Comparison of Impact Potential and Visible Impact

Data	**Rangjung**	**Namche Bazaar**
Year of project start	1986	1976
Year of commissioning	1996	1994
Current annual generation	4 GWh	2 GWh
Current plant factor (annual generation / potential annual generation)	23%	41%
Cumulated power production	17.5 GWh	8.4 GWh
Fire wood substitution		
Cumulated total	6'600 tons	2'700 tons
Current level of firewood substitution at electrified premises	25% or 2600 to/a	Max. 30% or 900 to/a
Number of jobs created		
Direct	7	15
Indirect (estimate)	n.a.	24
Number of business establishments electrified	260	95
Number of govt./educational/social/ cultural institutions supplied	196	20

Figure 58: Main impact figures for Rangjung and Namche Bazaar SHP

The Namche Bazaar scheme is in a situation with a higher potential for economic opportunities, mainly due to the growing tourism industry. This is reflected in the relatively large number of business activities (more than 15% of all connections) that benefit from electricity. This benefit is reciprocal: While businesses such as lodges, restaurants and specialised tourist services can grow and offer yet more services to tourists, the power plant benefits from higher load demand and consumption, thus improving the plant factor (percentage of the plant output that is used by consumers). In Rangjung, the potential for economic growth due to electrification is limited as only few niches for economic activities using power have been identified and exploited so far. This is reflected in the poor plant factor of Rangjung which is a result of low day-time use of power.

The population in the Rangjung project area uses about 33'000 tons of firewood annually. The current level of firewood substitution of about 2600 tons at electrified premises has a limited impact on forest preservation.

5.1.3 Institutional Set Up and Ownership

Again, the two projects are situated very differently. While the Rangjung project is a component in the national strategy of rural electrification, and ownership and identification are national, the Namche Bazaar scheme represents a more isolated approach that addresses itself to an ethnic minority. Ownership and identification are communal and local rather than national.

Parameter	**Rangjung**	**Namche Bazaar**
Type of organisation	Sub-division of (national) DOP	Private Limited Company, largely owned by community
Austrian Input	Complementary to Bhutanese and other donor inputs	Comprehensive and long-term
Significance of Austrian input to the sector	High, as Rangjung is second largest hydro in Bhutan	Low in physical terms but high in terms of institutional model development
Role of Austria	Financial and technical support with shared responsibility	Overall implementer and donor with almost sole responsibility
Partnership	With a national organisation	with local levels
Approach	Co-operation on small hydro plant engineering	Developed from an engineering approach into a comprehensive development project
Ownership	National (local ownership in the process of development)	Local user groups with marginal participation of central government

Figure 59: Institutional and Co-operation issues

5.1.4 Achievement of Austrian Development Assistance Objectives

The terms of reference for the evaluation emphasise, in addition to the common objectives of evaluation, an assessment of the achievement of objectives of Austrian Development Co-operation, on a comparative basis. Comparative in two ways: The situation before and after the intervention, and between the two projects. The question is which one of the projects have better served Austrian development co-operation objectives. Although a lot of time and effort have been spent to answer this question, objective evidence has been difficult to come by. Difficulties have been a lack of base line data, partial non-availability of current data and considerable differences in the institutional and political setting of the two projects.

While Rangjung significantly contributed to reaching Bhutanese rural electrification targets (physical infrastructure development), the Namche project stands out in terms of institutional model development in rural electrification but does little to physically improve rural electrification ratios in Nepal. This difference in achievement is a result of the different paths that the projects have taken through their long histories. Both projects assumed a pioneering role in establishing the Austrian development co-operation in the partner countries. The Austrian entry into the power sectors of the partner countries was achieved in different ways which partly explains the different project outcomes: While Namche was initially accepted by partners thanks to its model character, Rangjung was welcomed by the Bhutanese partners due to its physical significance and its geo-political importance for reducing Bhutanese dependence on India in the power sector.

Despite the different routes, both approaches proved to be relatively successful in terms of achieving development co-operation objectives:

- project ownership has been achieved in both projects but at different levels;
- sustainability is assured in both projects if certain conditions are fulfilled in the future
- Intended beneficiaries as well as the environment have profited in both projects but at different scales and depths
- Models that can be replicated elsewhere in the sector have been developed in both projects but on more comprehensive issues in the case of Namche.

A final answer to the question of whether the ATS 80 to 90 million spent the “Namche-way” have provided a higher development impact for Nepal than the same amount spent the “Rangjung-way” for Bhutan cannot be given in absolute terms. The evaluators are of the opinion that both projects and their development impacts are needed in both countries: While institutional models for small private power development are still pending in Bhutan, a significant expansion of rural electrification would also be urgently needed in Nepal. All indications are, that this would best be approached following the “Namche model”.

A comparative table is included in Figure 60 on the following page.

Objective	Rangjung	Namche Bazaar
Poverty Alleviation	Relatively successful due to large area coverage and affordable tariffs	Relatively limited due to concentration on a small area with limited incidence of poverty
Development of Democracy; Ownership	National ownership with geopolitical dimension; the intervention fosters the independence of national institutions	Successful institution building process which resulted in local and communal ownership
Addressing Local Needs	To a high degree: the projects contribute to improved living conditions, better health, improved education, and are elements for economic development	
Positive Ecological Impact	yes, through fire wood substitution in the domestic sector	yes, through reforestation and fire wood substitution in commercial and domestic sectors
Gender Equality	Yes, women benefit explicitly from improved indoor air, energy services and employment opportunities	
Scheme Economic Viability	Possible in future through economic use of excess power thanks to interconnection	Good chances for the future
Induces Economic Growth	Virtually absent as only limited economic niches available	Yes, on a large scale due to tourism
Scheme Sustainability	Assured as long as national strategy favourable	Possible with good management and a favourable economy
Fits into national strategy	Yes, important contribution to achieve rural electrification targets	Yes, is a good example of private sector power development
Capacity building	Thorough technical skills development but limited impact on building up design, project management and policy formulation capacities at partners	Successful on various levels: public awareness, technical training of staff, management and board of directors
Model character of project	Pioneering roles in: • Austrian-Bhutanese co-operation • application of small high-head hydro technology	Pioneering roles in: • Austrian-Nepalese co-operation • small high-head hydro technology application in remote rural electrification • local ownership development in private sector undertaking • technical equipment for load management

Figure 60: Achievement of ÖEZA Objectives and related Concerns

5.2 Socio Economic Analysis and Comparison

5.2.1 Consumer Profiles

The Thame generating facility in Solukhumbu District in Nepal serves the populations of two Village Development Committee (VDC) areas, Namche Bazaar and Khumjung. Namche VDC comprises the user groups of Namche Bazaar itself, and the user group Thame, while Khumjung VDC covers the user group Khunde-Khumjung, and the large consumer Hotel Everest View (HEV).

The Rangjung installation serves the main populations in 10 out of 15 Gewogs of Trashigang Dzongkag. Small areas of northern neighbour Trashiyangtse have been connected more recently. Coverage of neither area is complete, owing to logistical constraints.

The most recent official population data are given below.

	Total Popula-tion	Male	Female	Number of house-holds	Average House-hold size
Trashigang Dzongkhag	Approx. 53,600			Approx. 8,000	6.7
Trashiyangtze Dzongkhag	17,969	8,804	9,165	3,275	5.5
Namche Bazaar VDC	1,647	880	767	397	4.1
Khumjung VDC	1,809	895	914	433	4.1

Data Sources:
Nepal Population Census 1991
Ministry of Agriculture, 2000
Trashiyangtze Dzongkhag Annual Health Statistics for the Year 1999

Figure 61: Population data of the project areas

The populations in both areas are fairly homogeneous, comprising in the main peoples of Tibetan stock, speaking Sherpa and other Tibeto-Burman languages in Namche Bazaar, and Dzongka, Sharchop and various dialects in the Rangjung project area. The local populations ebb and flow with trading, labour and seasonal migration, which is a feature in both survey areas. Refugees from Tibet are present in both communities. This fluidity has thus far confounded attempts to define and count residents and households consistently, and renders statistical analysis difficult, as different government agencies use different criteria as to who is counted as a resident, whether a dwelling counts as a household, and how many households are contained within a dwelling.

In addition, in Rangjung more than one household may share a connection, which may or may not be metered, and in Namche Bazaar, households may have more than one connection, metered or un-metered, for different functions within the dwelling. Numerous consumers are not connected at the appropriate level; for example households may have expanded to offer some trekker accommodation, but still have an un-metered low user connection associated with household use.

It is therefore difficult to state exactly what is the population or the number of households that could be served from the installations, against the number that receive service. However, in both locations, the utilities and local officials asserted that with one exception due to a local quarrel, every single household within range of the distribution systems has connected in both localities. This has been facilitated by easy conditions of connection, requiring no more cash outlay than the cost of internal wiring and a connection charge of Nu 267.50 (US$ 5.80) for a single-phase 20Amp connection in the Rangjung supplied area. Effectively, the acceptance rate has been 100%, though the distribution systems unfortunately cannot reach all households within the administrative areas largely covered, due to very difficult terrain and high costs of distribution system extension.

Both installations serve remote communities in fragile environments, where environmental protection is intertwined with the capacity of people to improve their socio-economic status.

In the Khumbu region in Nepal, the household survey shows that almost 40% of economic activity is in trade, industry and commerce. Much of this depends upon eco-tourism for its vitality, while tourism in its turn depends upon a pristine environment.

The growth of tourism has been astounding: In the early seventies, between 1000 – 3000 tourists were recorded in the area. By the mid eighties, is was still less than 5000 tourists per year, while the number of 10’000 was crossed in the early nineties. However, in 1998 and 1999, 22’000 and 26’000 tourists were recorded. In 2000, a new record may be achieved. In the peak season, tourists almost double the population in the more popular places like Namche and Khumjung.

Conservation in the Rangjung area is driven by the imperative to maintain the vegetative cover that protects Bhutan’s watersheds, and sustains the country’s ability to produce and export the electricity upon which its self-reliance strategy rests.

The Namche SHP serves a more mature market, showing emerging characteristics of use of electricity to diversify occupational and leisure time pursuits, while population served by the Rangjung plant has been more constrained by limited power supply to early electrification patterns of use. In the sections that follow, consumer characteristics will be discussed by broad consumer category. The categories recognised are listed in the table below. Not all are applicable in the project areas.

Household Consumers

Level 1, 2 and 3 consumers, intended to be households, account for 94% of connections in Namche Bazaar. Households currently represent over 85% of connections in Rangjung. Household surveys were conducted in September-October 2000. Secondary school and college students were trained as enumerators, and administered survey questionnaires appropriate to their training. In Namche Bazaar, a 9% sample consumers was achieved, and in Rangjung, 249 consumers out of close to 4000 consumers (6% sample) and 85 non-electrified establishments out of a potential of over 7000 establishments in the two Dzongkhags (Districts) have been surveyed.

In addition, experts administered some household questionnaires. Not all questions were asked of all informants. In the analysis that follows, the sample size will be indicated where necessary. The spreadsheets showing raw survey results are in Annex 4.

All but three Namche Bazaar households surveyed are electrified. Responses from the non-electrified households are not separately analysed as they are statistically insignificant, though contrasts are noted in commentary. In Rangjung, 25% of the households surveyed are not electrified. Separate analyses have been conducted to illustrate contrasts.

Households in both project areas comprise a mixture of nuclear and two-generational families. Matrilocality is common in both areas. Average surveyed household sizes are as shown in the table below. The Rangjung sample gives exactly the same average household size as the statistics for the whole of Trashigang. Official data for Namche Bazaar given in section 6.1 above show smaller household sizes than the sample, but the information is rather dated.

Average Surveyed Household Sizes	
Namche Bazaar	5.3
Rangjung;	
• Total sample	6.7
• Electrified households	7.0
• Non-electrified households	6.3

Data source: Household Surveys, October-November 2000

Figure 62: Size of surveyed households

Namche Bazaar, in the Sagarmatha National Park Area, is tightly clustered, constrained by National Park regulation, scarcity of relatively level land, and a cultural preference to agglomerate. Households served by the Rangjung installation are scattered in small dispersed hamlet clusters, adding to the difficulties and costs of electricity distribution.

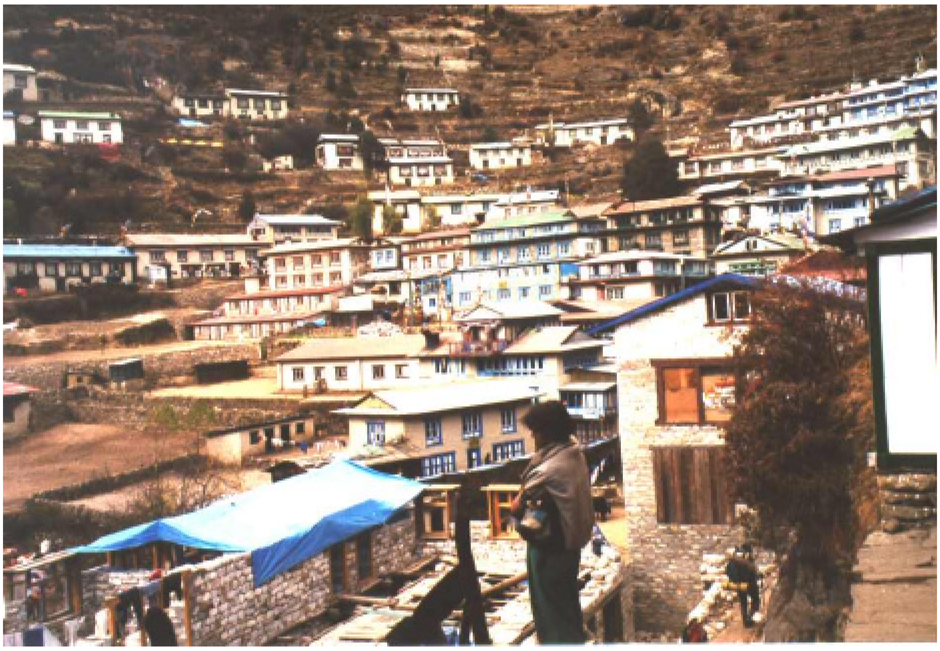

Figure 63: Namche Bazaar, Solu Khumbu's most important trading and tourist town

Occupational Profile

Traditionally, herders, subsistence agriculturalists and traders through their respective routes to Tibet occupied both survey sites. Economic activity varies with the season, raising and selling surplus crops and animals, trading, portering and guiding or labouring. Most households have more than one earner and economic activity, making cash incomes difficult to predict and count. Many respondents either did not know or would not tell their cash income.

Figure 64: Typical hamlets of relatively disbursed households in the Rangjung SHP supply area, Eastern Bhutan.

The table below shows the occupations of the householders surveyed. In neither Nepal nor Bhutan has a full occupational census been undertaken, and as no baseline survey data exists from the time of commissioning of the systems, comparison with the pre-electrification situation is not possible. However, figures from the most recent available official data are given as comparators.

Though the comparative data is dated, the relative diversification of employment patterns in the project areas is clear. When the electrified and non-electrified households in the Rangjung area are examined separately, still greater diversity of occupations in electrified households is evident.

Occupations in Households Surveyed and Comparators, per cent				
Category	Namche SHP project area	Solu-Khumbu District	Rangjung	Bhutan
Agriculture	54	89.3	57	57.2
Trade and Industry	29	n.a.	1	n.a.
Commerce	7	1.3	9	0.6
Service	3	4.1	25	2.0
Other	3	n.a.	8	1.4
Total	100		100	
Earners per household (average)	3.7		1.4	n.a.

Data Sources: Household Surveys Namche SHP, October-November 2000, Statistical Yearbook of Nepal, 1997 for Solu Khumbu (1991 data), Statistical Yearbook of Bhutan, 1998 (1984 Sample Census data)

Figure 65: Occupational data of project areas

Occupations in Electrified versus Non-electrified Households Surveyed, Rangjung, Bhutan		
	Electrified	Non-electrified
Agriculture	53	68
Trade and Industry	1	2
Commerce	9	8
Service	28	16
Other	9	6
Total	100	100
Average household size	7.0	6.3
Earners per household (average)	1.4	1.3

Data Source: Household Surveys, October-November 2000

Figure 66: Occupations in electrified and non-electrified households

While the samples are not large enough to generalise, a correlation exists in these survey areas between electrification and diversity of economic activity.

Poverty Status

In neither country is there an official poverty line, and nor are mechanisms to identify the poor well developed. In Bhutan, the issue arises in the context of taxation; residents are taxed at one of two levels. Those assessed at the lower level have smaller landholdings and poorer quality houses. Officials state that taxpayers are divided about 50/50 in the project area.

In Namche Bazaar, the smaller, poorer households tend to be those that are not in any way associated with tourism, and lie away from the beaten tracks.

In neither project area is there abject poverty. Most residents are adequately nourished, and housed in dwellings of permanent building materials, though migrant workers are often in informal dwellings around Trashigang. Especially in Trashigang, rural people tend to be dressed in rather ragged and dirty clothing, and to suffer from obvious minor health complaints such as common cold and conjunctivitis that are often associated with relative poverty.

Relative poverty in both areas is associated with lack of access to both physical and social infrastructure; the effects on health and physical appearance are largely a function of distance from roads, water, energy resources, and health facilities, as well as with low cash incomes. In both areas, the education facilities are relatively very advanced. Use of electricity, and impacts of the project upon these phenomena is discussed in sections 3.4.6 and 4.4.6 respectively.

5.2.2 Other Electricity Use

Commercial Consumers

Commerce in both survey areas is small scale and almost always family-based, with supplementary labour hired if necessary. The most prevalent commercial activity is the small shop, displaying little specialisation, aiming to supply daily necessities principally to local people. In Namche Bazaar, the tourist industry gives these small shops an external focus and an additional source of income during the short but intensive tourist season, two months in spring, and two in autumn. Many still stock an identical range of general goods, but there are signs of specialisation, some of which are totally electricity dependent, and have arisen as a direct impact of the project.

Figure 67: Electric Bakery in Namche Bazaar; a profitable commercial use of electricity

Examples are e-mail and fax services, laundry services, hot showers, sauna, and bakeries. Another family runs a small cinema, showing only Nepali films, and aimed specifically at local people on market days.

The next most prevalent form of commercial activity is lodge and restaurant management, in its infancy in Trashigang, but well developed in Namche Bazaar. Most are still family businesses, with five to ten guest rooms as a typical size. Specialisation and niche marketing in this area are also beginning to emerge in Namche Bazaar with two luxury lodges featuring amongst the most significant consumers of electricity.

Figure 68: Cyber Café in Namche Bazaar; the highest in the World?

In both centres there are banks offering basic credit and savings services.

Businesses served in the Rangjung project area are less constrained by difficulties of road and market access, but do not enjoy the stimulus of tourism present at Namche Bazaar. Though LPG and gasoline suppliers number amongst the commercial electricity consumers, constraints to energy supply, both electricity and diesel, limit the ability of many businesses to develop and grow.

Significant for its absence in both project areas is any form of specialised electrical goods supply or repair outlet. The practical impossibility of having electrical appliances serviced further constrains development of the electricity consumer market.

Government Offices

In Namche Bazaar, most government offices are unmetered Level 3 consumers. Present are the VDC offices, the Police *chauki* , a Post Office, the National Park Headquarters and a number of non-governmental offices such as the Sagarmatha Pollution

Control Committee. None of these are a significant consumer, and they enjoy no particular privileges. The hospital at Khunde that serves both Namche Bazaar and Khumjung VDCs is a private foundation, and receives no government funding. It is a Level 7 consumer with an 8 kW 3-phase connection, and it maintains the generators used before the arrival of the mini-grid as back-up capacity.

Figure 69: Doctor's practise at the Khunde Hospital in the Namche SHP area

By contrast, government offices in the Rangjung project area are given priority connection, and some (Department of Power personnel) receive electricity under a flat-rate tariff set according to the staff grade without metering. This distorts the consumption patterns, but has the beneficial effect of ensuring electrified services, especially in schools and health posts.

Agricultural Consumers

Agricultural workers in both project areas are essentially subsistence farmers and herders, and their consumption profile does not differ in substance from household consumers.

Namche Bazaar is at too high an altitude, and too dry to be well suited to agriculture; only one annual crop is raised on the small amount of terraced and cultivated land, and the high pasture is used for open grazing. As the area is several days' walk from the nearest road head, agro-processing is unrealistic, since there is no ready market. There is a little small scale processing of locally produced food for local consumption, for example grinding of local grain. This is done at household level; there are no commercial operators of agricultural processing machinery.

In the Rangjung project area there is small scale agro-processing, but electricity consumption for this purpose is constrained by limitations on supply, and discouraged by the favourable price of diesel that has been negotiated with neighbouring India. Officials say that consumers would like to switch to electricity for husking and grinding when the supply is improved, and their existing diesel machinery wears out or breaks down. Moreover, diesel supplies are unreliable, and the grade supplied has a pour point of 7 ^{0} C, which gives rise to ignition problems with motors in the winter, Initially agro-based industry is likely to continue to be small scale and localised, because of the dispersed nature of the population, and the limitations of road and market infrastructure.

At present there are only 16 agricultural consumers in Rangjung, 0.5% of the total consumer base.

Figure 70: A porter on the steep approach to Namche carrying empty water bottles for the local factory.

Industry

Only one industry operates in Namche Bazaar outside of small-scale cottage industry; a water bottling plant that supplies the local trekker market with ultra-violet treated water. Its power demand is quite modest and seasonal. It is unfortunate that the technology selected incurs the environmental penalty of portering thousands of plastic bottles in to the National Park area. Those found discarded are burned, creating toxic fumes and a residue of non-biodegradable waste. Carrying bottles is the porters' most hated task, since though light, the bales of bottles are unwieldy, and impose a real danger on narrow steep trails in the high winds that funnel around the valleys.

It would appear that this is an impact of electrification that could have been better planned, since alternative technologies and management systems are available that avoid these negative impacts.

There is a small amount of cottage industry; many of the consumer goods seen in the bazaar are traded in from Tibet and India.

The Rangjung project area features numerous small industries, characterised by rather low levels of mechanisation and automation. Industrial consumers include a sawmill, a metal workshop and an agricultural equipment machine shop. In addition, there is quite vibrant cottage industry encouraged by the local presence of craft co-operatives and a craft college, both with well organised marketing links to Thimphu. However, once trained, most practitioners work at home and are domestic consumers.

Industrial consumers comprise 0.1% of consumer connections in Rangjung.

6. Conclusions and Recommendations

6.1 Conclusions

6.1.1 Success of Implementation

While Rangjung significantly contributed to reaching Bhutanese rural electrification targets (physical infrastructure development), the Namche project stands out in terms of institutional model development in rural electrification but does little to physically improve rural electrification ratios in Nepal.

From an engineering point of view, both projects have been implemented successfully, despite remaining design and implementation flaws. In the case of the Namche Bazaar SHP costs have been exorbitant. Specific costs (ATS/kW) for the power plant are 38% higher than for the Rangjung SHP. Reasons for this are the extreme remoteness of the site in Nepal, and the extreme climate and altitude. However, these factors cannot entirely explain the much higher cost. Numerous delays in implementation was certainly another factor. Rangjung also benefited from a degree of economies of scale. Overall, the efficiency of spending money appears to be better in the Rangjung project. This may well be due to the superior quality of co-operation with Bhutanese partners at the national level and more efficient project steering which was possible with permanent local representation with the ACB.

6.1.2 Project Sustainability

KBC, the Khumbu Bijuli Company owns and operates the Namche SHP. It is a private sector, community-owned set up. Sustainability is assured, if KBC can survive and develop. Sustainability is directly in the hands of the beneficiaries, to a large extent. In financial terms, KBC has not achieved sustainability so far, but it is on a good course. In its most recent financial year, gross surplus has increased by more than 300% over the previous year. It will take yet other similar income increases over time, to attain a cash flow level that permits full depreciation of assets. The chances to achieve this are intact.

The Rangjung SHP is under national ownership. Its sustainability does not depend on local initiatives but is determined by the commitment of the national government. As the revenue that can be generated by Rangjung SHP with current tariff levels is insufficient to achieve sustainability of operation, a dependence on national strategies and budgets is inevitable. As long as the Rangjung SHP fulfils a vital role in electrifying Eastern Bhutan it will be given the resources it requires. If this situation is superseded by the events (large HEP supplying the area at lower cost), the sustainability of the Rangjung SHP is threatened.

6.1.3 Project Approach and Steering Mechanisms

Both projects assumed a pioneering role in establishing the Austrian development cooperation in the partner countries. The Austrian entry into the power sectors of the partner countries was achieved in different ways: while Namche was initially accepted by partners thanks to its model character, Rangjung was welcomed by the Bhutanese partners due to its physical significance and its geo-political importance for reducing Bhutanese dependence on India in the power sector. Despite the different routes, both approaches proved to be successful in terms of achieving development co-operation objectives.

BMfaA's in-house project steering and management - though time-consuming - proved to have the right pace for co-operation projects in Nepal and Bhutan. It allowed the BMfaA to thoroughly consider development co-operation principles and objectives in all its decisions. In addition, the BMfaA was able to build up an institutional memory on hydropower development and on the details of the Austrian co-operation with Nepal and Bhutan.

6.1.4 Achievement of ÖEZA objectives

The conception of both projects dates back to a time when the present Austrian development co-operation objectives did not explicitly exist. Allowance needs to be made for this fact when judging results achieved.

Environmental concerns are successfully addressed by both projects, mainly due to successful (but only partial) fire wood substitution. In both projects, environmental damage caused during construction has been successfully removed through slope stabilisation and reforestation.

In the Namche SHP, where tourism tends to pose an increasing environmental hazard, electricity contributes significantly to fire wood substitution. On the basis of commercial tariffs in this consumer sector, this also creates a good part of the income for KBC. Fire wood substitution in the domestic sector, on the other hand, was achieved with a relatively generous connection capacity (1.26 kW), and a social lump-sum tariff, which is subsidised.

In the Rangjung SHP, firewood substitution is taking place thanks to low tariffs which makes cooking and water boiling affordable to consumers. This shows the complexity of the issues at stake: While tariffs below generation costs jeopardise sustainability of projects, the same feature enables the achievement of environmental objectives.

Social issues of gender equality and poverty reduction were not explicitly addressed in the implementation of the projects. However, it has become apparent that women, who are generally in the role of housekeeper, benefit more from electricity than men in the domestic domain, while economic opportunities are slightly more favourable for men, due to the prevailing social structure.

Poverty reduction has been achieved to some extent in both projects, but it is difficult to quantify this. Due to a better cost per capita ratio in the Rangjung SHP, the project is more efficient in terms of equitable development than the Namche SHP.

Democratisation and Ownership Development in the Namche SHP is one of the first examples in Nepal of private sector and community ownership in rural electrification. It is a successful pioneering project in this respect. The model developed in Namche Bazaar has implicitly been adopted for remote rural electrification in the 9th Development Plan of HMG.

Project ownership of the Rangjung SHP has been assumed at national levels and as such has a different quality: The Rangjung SHP was used by the Bhutanese partners to reduce the massive Indian dependence in the power sector. Due to these geopolitical issues, application of local ownership concepts or alternative institutional models had to give way to national considerations such as generation planning (which the doubling of the Rangjung plant capacity is a result of) and rural electrification coverage.

Local and national needs and priorities have been met to a considerable extent in both projects.

In Namche, on a local level, the acceptance rate of electricity has been 100%, and numerous economic opportunities are exploited with electricity. On the national level, the Austrian intervention has contributed with 23% to overall new small hydro capacity in the 8th Plan of HMG.

The Rangjung project contributed effectively to meeting rural electrification targets as set in the Bhutanese Five-Year Development Plan. On a local level, connection ratios are 100% in all areas within reach of the grid powered by Rangjung SHP. Nevertheless, water supply, education, health and food production / preparation are given priority over electricity by households when asked for their most pressing development needs.

6.1.5 Impact

On the project level, specific impacts have been shown. In the overall context, there are a few more issues of broader interest.

Human resources development (HRD) and concept development have been the most effective interventions that generated effects beyond the projects. Training measures implemented under the Rangjung and Namche SHP were mostly on the level of operational staff.

In Namche, the concept of private community-owned power development has been accepted at the national level. Its application is restricted by a lack of local capacity for its dissemination.

Development co-operation must be willing to interfere in partner concepts and believes, in order to contribute to development and change to the general benefit of the population and the environment. Such interference is only acceptable as long as it is conducted in a spirit of co-operation and mutual trust which is time-consuming to develop. Austrian development co-operation successfully converted the initial Bhutanese turnkey hydro assistance concept into a partnership approach. In Nepal, the initial attempt at partnership on the central level failed, not in the least due to political turmoil and policy changes. Interference at the policy level has paid off in both cases.

Sensitive, process-oriented issues and policy development can only become components of co-operation when credibility has been achieved through successful (hardware and input-oriented) projects.

6.2 Recommendations

6.2.1 Background

Looking at international trends in development co-operation it becomes apparent, that a gradual change of strategy is occurring. Interventions become more complex: Not the single project anymore stands in the centre, but a number of related interventions , as well as the interaction of projects with the respective environment. Concentrating on focal areas (Schwerpunktsetzung), bundling and complementarity of activities aim explicitly at delivering impulses to achieve large scale and/or long-term impacts of development. The progress that a developing country can make is not so much a function of the success of all the individual projects, but rather of how all projects, institutions and government interact and complement each other in achieving the objectives of local and national development.

On this basis, German development co-operation and the World Bank in its Comprehensive Development Framework, formulated the following new emphasis in development co-operation.

- Emphasis on a few countries and few strategies (Schwerpunktländer und Schwerpunktstrategien): fewer countries and fewer sectors, to be able to bundle interventions with the aim to contribute to structural reform.
- From project to program: Instead of scattered unrelated projects, the new policy concentrates on inter-linked and related intervention packages on different levels
- Global structural reform: Complementary activities on the national and the supranational level, and its integration in networks (Vernetzung).
- Intermeshing (Verzahnung) of bilateral development co-operation with other activities on the donor side and with the partner country, to achieve broad impact and to assure coherence of policies.

In essence, related and interacting interventions move to the centre of attention.

It is argued in this connection, that the most important criteria for evaluation is not sustainability any more, but large scale, or overall impact beyond individual projects (Breitenwirksamkeit). The latter is often referred to as external sustainability when looking from the project level. However, there is a strong argument for looking at the overall impact separately, which would lead to more clarity in the analysis.[36]

The authors of the evaluation are of the opinion that, with a view to contribute to the development of future strategies, it may be very useful to also consider these new elements in the Austrian sector policy.

6.2.2 Policy recommendations (BMfaA)

The objective is to contribute to policies that are suited to achieve Austrian Development Cooperation Objectives and to integrate new elements as lined out in the background given above.

The two SHP projects in Namche and Rangjung have shown that development can effectively be supported in many different ways as long as the partners, be they local or national, work towards common objectives and strategies. Perseverance and professional inputs are likely to produce successful interventions. Development impacts that continue to be effective beyond the project proper, and contribute to improving frame conditions and sectoral structures are more difficult to achieve.

The evaluation has shown that if given sufficient time to get fully operational, electrification projects do have a positive impact on rural development since electricity is linked in many aspects to modern life and it has thus the potential to change the attitudes of the rural population. There are few interventions with such comprehensive impacts towards development. As development co-operation is constrained by increasingly scarce budgets, such positive impacts must be achieved with leaner budgets and in shorter periods of time than experienced with the Namche and Rangjung SHP projects. The recommendations in this connection are:

- Small-scale hydropower development should remain the general theme of Austrian assistance to the energy sector not only because of Austria's comparative

[36] Reference: Dr. Dirk Messmer: Zum Verhältnis von Nachhaltigkeit und Breitenwirkung; Anmerkungen zur BMZ-Querschnittsevaluierung über langfristige Wirkungen, in E+Z, Jg.42, 2001:1

advantage and the experience in the BMfaA with this technology, but more so because of the inherent potential of small-scale hydro electric development to induce change at the target population and its many inter-linkages with the environment (water catchment area, firewood substitution), the economy (job creation) and the service sectors (health, education) as well as its positive impact on gender balanced development.

- In order to fulfil these promises, interventions must be comprehensive. Physical infrastructure deployment implemented by Austrian suppliers and consulting engineers is not sufficient or may even be counter-productive. Comprehensive packages may comprise a selection of the following:

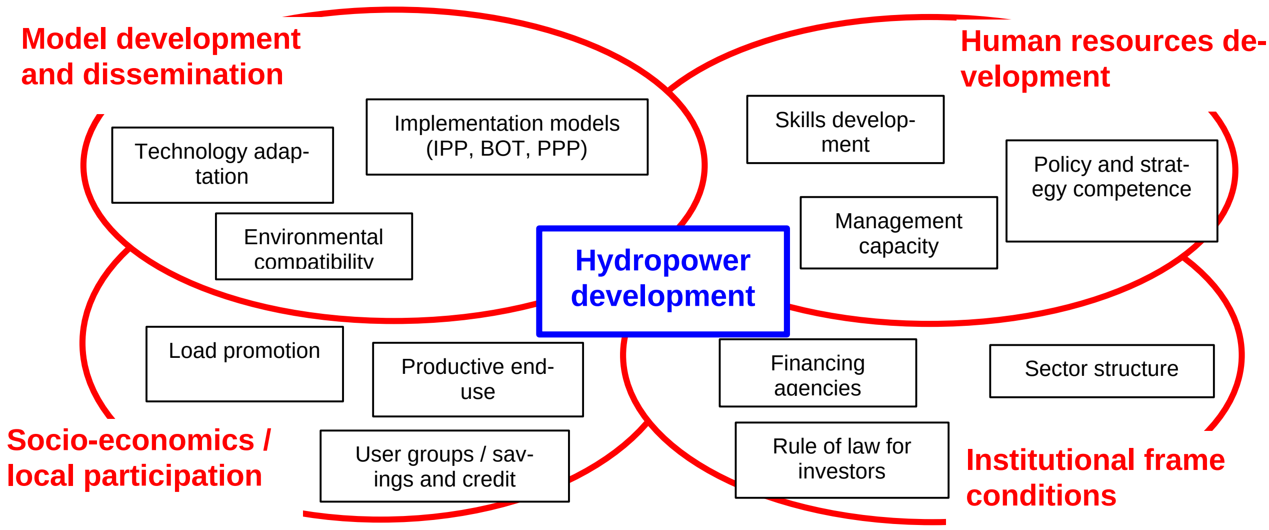

Figure 71: Spheres of intervention in hydropower development

For achieving broad-based development impacts it is not necessary to carry out interventions in all the above spheres. Depending on the state of development in a country or region, a judicious mix of areas for intervention must be selected in such a way that the primary constraints of the sector are addressed and the intended development effects are likely to be achieved. The selection must be based on a thorough development concept which considers the forward and backward linkages of the various elements and their interdependence (systems approach). Adequate timing of the various components of the intervention is also essential. It is recommended that the following principles be observed for formulating a sector policy with a focus on integrated hydropower development:

- Flexibility: Development does not follow a linear cause-effect relationship but includes dead-ends, iterative loops and sudden turns. This requires projects to flexibly adapt to new conditions without losing track of objectives. The concept of action research is often useful when experimenting with new institutional, financial or organisational models.

- Donor co-ordination and co-operation should become the rule. Activities of other donors in the power sector must be leveraged to create synergies. No single donor can possibly address all the constraints on its own.

- The instruments to be used can be process-oriented (HRD, capacity building, institutional development) or output-oriented (hydropower construction and hardware supply). But a concentration on either of the two is only warranted if it can be assured that the other component is handled by national agencies or other donors in a complementary way. Neither component alone is likely to be effective.
- A multi-level and multi-partner approach is also to be observed. For example, private-sector hydro-development must include both an intervention at the investor/developer level as well as at the institutional (meso) level in order to improve enabling conditions (permits, incentives, guarantees) for the individual actors (developer and the financing agencies).
- Inter-linkages of micro levels (rural electrification projects) with issues at macro-level, such as global environmental protection / climate convention or power trade with neighbouring countries, are to be shaped as win-win opportunities whereby both sides can benefit.

The vast hydropower potentials of both the Nepalese and Bhutanese mountainous areas is in the course of being developed in large-scale, internationally financed schemes. These developments are aimed at supplying urban centres and the export market. How these developments will foster equitable development in rural areas remains questionable. Austrian development co-operation, given its objectives and experience, is well suited to make an impact in equitable rural development, since:

- The majority of the people of both countries still live in these relatively underdeveloped areas with no (or poor) access to electricity
- Objectives of Austrian development co-operation can comprehensively be addressed in the energy sectors of the rural areas;
- Off-grid power development involves solutions to institutional and social issues. The large-scale sector and private investment are unlikely to address these sufficiently.

The Austrian sector policies should focus on the various themes of rural electrification and related interventions as shown in the figure above but should refrain from entering into sectors that are not related. This would only dilute the effectiveness of the Austrian intervention as a whole and it would not sufficiently capitalise the invaluable experiences of the Namche and Rangjung SHP projects. In concrete terms, the Austrian energy sector policy for Nepal, could manifest itself in the following:

- Co-ordination with HMG and other donors in the energy sector on balanced subsidy policies;
- Capacity building at meso and macro levels to further develop and disseminate the concept of community-owned hydropower and democratic rural electrification development;
- Development of technical concepts that enable a gradual adaptation of power supply to the growing power demand of communities and avoid establishing large capacity reserves during the early project stages;
- Capacity building in the field of project finance in collaboration with administrators of power development funds (to be provided by the World Bank and KfW, Germany), private investors and banks as well as GEF funding where applicable.

In Bhutan, the Austrian sector policy could be substantiated through the following:

- Development of decentralised organisational and management concepts for small-scale hydropower and rural electrification schemes in remote areas of Bhutan, suitable to reduce costs for DOP. Make maximum use of the Namche experience;
- Assistance to the development of the legal and administrative framework for the above decentralisation concept at national level;
- Capacity building for rural electrification and rural energy development planning at national level;
- Skills development at local private consultants in the field of plant design and construction;
- Capacity building in the field of project finance including the bundling of plants and funding agencies to increase financial volume and to reduce transaction costs.

In both countries, co-operation on conceptual issues and capacity building will only be accepted by partners if funding support for physical infrastructure deployment is provided through Austrian facilitation. This need not and should not be pure grant financing for demonstration projects but should include loan funding, GEF contributions and private investment with guarantees by the donor. It is further recommended that the following aspects be observed when implementing the above policies:

- Comprehensive interventions will require a commitment for a long-term engagement where results cannot be expected within a two to three-year period but rather after five to ten years of co-operation.
- Administrative procedures of the Austrian development co-operation should be streamlined and given sufficient specialist resources such as for example through regular independent reviews of project designs and interventions.
- Regular collaboration and networking between Austrian partners in the two countries as well as with national and regional institutions and associations working in the same fields is imperative. Appropriate forums must be supported to this effect.

6.2.3 Recommendations for KBC regarding the Namche Bazaar SHP

- Improve the documentation status of the scheme: Incomplete documentation has been reported on several occasions during project history. Apparently, there are still some gaps. It is recommended that KBC checks out in detail what is missing and is ordering these documents from the respective suppliers.
- Improve the leadership situation: Comparison of the effective personnel functions and the organisation chart make it clear, that some board decisions are pending. It is suggested that the organisational situation is clarified as soon as possible.
- The most recent financial year has shown a dramatic increase in revenue. KBC is to be commended on this. It is recommended that a further substantial revenue

increase be made a priority, without jeopardising social and environmental concerns. The suggested means to do this are:

- Maximising the load factor by all means available, using load switching as a new, promising technology
- Diligent and persistent profit-oriented tariff increases and connection policy changes over time
- Fully metered consumption only: this measure is relevant to be able to monitor technical and non-technical power loss in the mid term. Where small consumers are concerned, full metering could be done for a cluster of consumers with one common meter.
- Instrumentalise the ongoing Thame Valley Development Project to achieve KBC objectives to the maximum feasible extent: The tourist season dependence of electricity sales and a good load factor is a problem. Potential improvement lies in the off-season productive power use development. Hopefully, this is an area that is also of eminent interest to the Thame Valley Development Project.

- Apply the appropriate accounting mechanisms: The practise to show increasing profits in the profit and loss account on one hand, and to not depreciate assets on the other hand, gives a wrong impression about the financial situation of the company. Moreover, it will become relevant in terms of income tax in a few years. It is recommended that depreciation of assets is introduced in accounting immediately, and to a degree compatible with income for the time being.

As soon as surplus exceeds the amount needed for full depreciation, it is suggested that reserves should be built up, before showing profit.

- Accumulated profits and surplus reserves should be used for business expansion. This could be grid extension (perhaps not Lukla), capacity expansion or additional services to consumers. In connection with any plans of grid extension, capacity expansion will have to be planned for at an early date, since implementation takes several years.
- A vision exists among small hydro experts about the total electrification of the Solu Khumbu and perhaps adjoining districts. According to this vision, the Namche SHP, the Salleri Chialsa SHP and various new schemes would all be interconnected into a regional grid. All participating isolated schemes would become interconnected schemes, which has a number of advantages. It is recommended that KBC participate in developing this idea further to ascertain its own role, should implementation become feasible.

6.2.4 Recommendations to DOP regarding Rangjung SHP

- Provide engineering support in rectifying the poor reliability and safety of supply from the Rangjung SHP and associated transmission and distribution grid;
- Maintain a residual flow in the by-passed section of the Karthiri River in order to reduce the negative impacts on the aquatic life, especially when making use of excess power during off-peak periods;

- Make sure that a well-elaborated and easy-to-use maintenance plan (e.g., computer-based) is adhered to by Rangjung powerhouse staff and that a spare-part inventory is established.
- Improve recording and accounting of electricity generation and sales so that system losses can be evaluated and ultimately be reduced.
- Keep track of expenditure at ESU Trashigang by introducing a detailed accounting system which distinguishes at least between power plant O&M, line extension work, line O&M, administrative and consumer related expenditure.

ANNEX

1. Terms of Reference for the Evaluation, derived criteria and indicators
2. Effective time schedule for the evaluation
3. List of persons met, institutions visited
4. Economic Analysis of the Rangjung SHP
5. Questionnaires used for household surveys
6. Survey Data Namche Bazaar, Nepal
7. Survey Data Rangjung, Bhutan