Scaling-up Micro-Hydro, Lessons from Nepal and a few Notes on Solar Home Systems

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1. Introduction- Definitions

Small-scale hydropower in Nepal is divided into *micro-hydro* (<100 kW), *mini-hydro* (0.1-1 MW), and *small hydropower* plants (1-10 MW).

The *small hydropower plants* are usually connected to the national grid and are often privately financed and owned. Scaling-up small hydropower means to develop proper regulatory frameworks for independent power producers (IPPs) and to streamline the licensing and concessions systems for the use of water rights for power production and other competing purposes (irrigation, agricultural uses, potable water).

Mini-hydro plants are connected to the national or to an isolated grid. They can be developed and owned by the national power company, the community or by private investors. Scaling-up the use of mini-hydro for connection to the national grid is similar to the small hydropower, scaling up its use for isolated grid is similar to micro-hydro, which is discussed below.

Micro-hydro comprises not only "grid-connected plants for village electrification [2]", but also "mechanical-purposes only" plants and "mechanical cum electricity add-on [3]" systems.

2. Micro-Hydropower in Nepal

In Nepal, 85 percent of the population lives in rural areas. The *national electrification rate* is 13 percent, but above 80 percent in the cities. The low electrification rate provides a large market to se served by micro-and mini-hydros and by solar home systems (SHS). The power forecasts prepared by NEA (Nepal Electricity Authority) foresee that 30 percent of national households will be connected to the grid by the year 2020. Urbanisation is one causal factor. *Rural electrification* develops mainly via the extension of the national grid in the Southern Lowlands, the Terai, where

[1] The paper is based on insights gained by the author working as consultant to DANIDA for the preparation of the first five-year "Nepal Energy Sector Assistance Programme 1999-2003".

[2] The term "pico-hydro" has also been used for the very smallest of plants, which are currently being standardised and marketed under the term "peltric sets". These are produced in the range of 0.5 to 3 kW to cover the demand for electricity of a few households.

[3] The term "Add-on" is used for the case that a generator is connected to the turbine of an agro-processing unit, normally by a belt drive. The turbine is then used for agro-processing during the day, and for electric light generation during the evening/night.

40 percent of the national population will live around 2005. In the more inaccessible Hill and Mountain regions rural electrification takes place primarily via isolated grids.

Nepal has a feasible hydropower potential of around 80 GW. The political and expert opinion concerning the best strategy for the exploitation of this potential and the promotion of national electrification is divided into two camps. One side argues for the development of large-scale hydropower destined for exports to India with attached national grid electrification. Others argue that the primary focus of hydropower policy should be on the development of micro-hydro power. The latter technology is said to be relatively low cost, to rely on nationally manufactured technology and be well suited to provide power to the population in the isolated hills and mountain regions.

With regard to the preconditions for a successful promotion of micro-hydro, Nepal has potentially a lot going for it on the sides of supply and demand. 63 of Nepal's 75 districts have potential for hydropower. With the help of INGOs since the 1970s, Nepal has succeeded in building up an interesting manufacturing base capable of manufacturing or assembling all micro-hydropower components except the generators for micro-turbines up to 300 kW. The Government supported the development of micro-hydro on a stop-go basis through various technical and financial support programmes ever since the 1980s. At present, the Government budget provides a 75 percent subsidy to the electrical equipment parts of investments to micro-hydro projects in districts defined as being very remote, and 50% of electric equipment costs in other districts. This amounts to 20-30 percent of the total investment. Turbines, penstocks, waterways etc. are not subsidised under the budget line, but village electrification schemes have squeezed additional subsidies out of donors and development funds. The subsidy rates are now being reviewed by HMG, following a proposal to increase subsidies to 50% of total plant cost.

Originally, NEA was entrusted with the task of planning and implementing small isolated grid projects. The public sector has set up 35 of the *36 mini-hydro plants* mainly to supply district head quarters and market centres; five plants are connected to the national grid. Most of the mini-hydro plants connected to isolated grids are owned and managed by NEA. But NEA has realised that its cost structure and approach is too expensive for mini-hydro projects, and has withdrawn from mini-hydro. NEA has leased five of its isolated grids to private operators, and the development of new isolated grid projects is left to local private / municipal initiative. However, the ideal organisational model for local ownership and operation of isolated grid systems has not been identified yet. The installed capacity of micro-and mini hydropower can be seen below, which shows the modest use of micro-hydro for electricity generation.

Installed Micro-and Mini Hydropower in Nepal

Technology	Total number	Mechanical purposes	Add-on electricity	Electricity only	Installed capacity
Ghatta [1)]	25,000(350[5])	25,000	1	0	12 MW
Peltric sets [2)]	250			250	0.25 MW
Micro-turbine[3)]	950-1000	800	150	30	9-10 MW
Mini-turbine [4)]	36			36	8.5 MW

1) Traditional water mill. 2) 0.5 to 3 kW integrated turbine and generator sets, 3) >100 kW, 4) 100-1000 kW; the number of mini-turbines mentioned in the literature ranges from 20-36. 5) "Improved ghattas" that are installed.

Nepalese legal Provisions on hydro-power development provide a number of fiscal and administrative incentives for plants with a capacity less than 1000 kW:

- No licence is required for conducting surveys or for building and operating plants. For plants between 100 kW and 1000 kW, a notice shall be given to the concerned agency before commencing work on the project.
- No royalty shall be imposed on the electric power generated.
- Exemption of income tax is granted.
- The private producer may itself fix the selling price of electricity.
- In case a licensee is going to distribute electricity in an area where a plant smaller than 1000 kW is already generating and distributing electricity, the licensee is obliged to purchase the existing plant and distribution system, if the owner wishes.

Although NEA has withdrawn from providing support to micro-and mini-hydro development, there are still a number of important *institutions that support initiatives in the sector:*

Public institutions:

- *WECS,* the Water and Energy Commission Secretariat, under the Ministry of Water Resources, has provided an inventory of approximately 200 potential sites for MH, meant as assistance to developers [4]. The objective is to identify the 10-15 most viable micro-hydro power sites in each of the 63 districts having potential.
- The Alternative Energy Promotion Centre, *AEPC,* was formed late 1997 as an institution to promote development and monitor activities within the alternative energy sector, including Micro Hydropower [5].
- The Remote Area Development Committee, *RADC,* has been given the task of establishing MH plants at selected sites in certain districts at or near the border of Tibet, designated Very Remote Areas, under the “Integrated Rural Community Development through Village Electrification Program” [6].

[4] The practical usefulness of the inventory appears to be limited.

[5] AEPC is not yet fully operational. Danida provides institutional strengthening support to AEPC by special funding.

[6] Faced with feasibility studies that showed the projects to be neither economically nor financially viable, the reaction of the government has typically been “we do it anyhow in order to maintain a regional balance of service for reasons of equity”.

INGOs and NGOs

- United Mission of Nepal, *UMN*, has promoted the build-up of manufacturing capabilities in micro- and mini hydro-turbines by founding local manufacturing firms and by providing technical assistance to users and manufacturers through the company DCS-Development Consultant Services, founded by UMN.
- *ICIMOD* - International Centre for Integrated Mountain Development and ITDG, Intermediate Technology Development Group, (active in Nepal since 1979) provide conceptual and policy-making contributions.

International donors

- *Swiss* bilateral aid - through Swiss Association for Technical Assistance (SATA), Swiss Development Corporation (SDC) and the Swiss Foundation for Technical Cooperation (Swisscontact) - has been involved in developing village-based isolated grid schemes.
- *German* bilateral through GTZ (Gesellschaft fur Technische Zusammenarbeit) and German Development Service (DED) has identified options for private financed mini-hydro power projects for production to the national grid. DED supports the RADC programme. The result is published in the form of a "Master Plan".
- *Danish bilateral aid*, Danida has included support to micro-hydro development as one of five components in its 1999-2003 Nepal Energy Sector Assistance Program.
- *UNDP* is involved in mini- and micro hydro through the Rural Energy Development Programme (REDP). The REDP is active in ten rural districts. It encourages the individual District Development Committees (DDCs) to establish a district level authoritative office for promoting decentralised bottom-up rural energy planning and to create a District Energy Fund. At the village level, the REDP promotes the establishment of community organisations (COs) of male and female separately. The REDP has conducted technical feasibility surveys of more than 80 micro-hydro sites in the first five districts it was active in, and found 42 sites technically feasible.

Yet despite all support, progress is not satisfactory. Investments in new micro-hydro plants are stagnating or falling and existing plants experience operational and institutional problems. A study on the functional status of MH demonstrated that:

- 75%-80% of the plants had loans overdue
- Some 30% were not operating for a variety of reasons
- Poor site selection, inadequate/inaccurate surveys, wrong size, poor installation, faulty equipment.
- Plants affected by floods and slides.
- Poor estimation of hydrology. Surveys conducted in the rainy season is one reason.
- Uneconomic canal length, bad canal design
- Civil works usually neglected.
- After breakdown of generator, many owners had not been able to replace it.
- Wrong estimation of raw materials, of demand, of end use possibilities, oversized plants, over-estimation of tariff collection, inappropriate rates, ignorance of competition with diesel

- The plant factor of micro- and mini plants is 0.2 on average. Lighting for 4-5 hours can theoretically give maximum plant factors in the order of 0.15 to 0.20. The use of one mill for some hours per day can theoretically double the plant factor, but in practice most micro-plants have plant factors lower than 0.25.

Some 11 manufacturers produce turbines, which is an impressive achievement. Anecdotal evidence, however, suggests that the quality of the equipment has declined during the last 10 years. And the cost of the equipment seems to have increased faster than the rate of inflation, a fact, which has reduced the impact of the subsidies.

During the 8th Five Year Plan (1993-98), the Government hoped that 5 MW of hydropower would be developed. The result was far below. It is obvious, that the present strategy of the Government does not lead to "scaling-up". In order to find out what can be done, it is necessary first to look at the technological characteristics of micro-hydro and next at the socio-economic characteristics of the village community.

3. Technical Characteristics of Micro-hydro

Compared to the level of development in the isolated communities, where it is introduced, hydropower represents a very advanced technology in terms of hardware and in terms of operational requirements. The three available technologies are the peltric units for single ownership, the micros for smaller communities and the minis for larger communities (or group of smaller communities). As one moves from one to other, the technical sophistication of the technology, including the demand for highly skilled manpower increases.

The civil technology of micro-hydropower plants is simpler and cheaper in terms of initial investment than in the case of mini-hydro. Dams and intakes are made of concrete in the case of mini-hydro plants, and of earth/stones in the case of micro-hydro. The civil technology allows making intensive use of "free" labour by the local community for construction and annual maintenance. This reduces the cost of initial investment, ranging from US$1200 to 2500 per installed kW in micro-hydro projects [7]. But it adds to annual O&M costs, which can vary from 3 to 50 percent of original investment - and leads to the shutdown of the plant and loss of electricity production during15-40 days per year, when intakes and canals have to be rebuild following destruction by monsoons and landslides. And although the cost of investment per kW compares favourably with large plants, the low plant factor implies that energy costs will be comparatively high for micro hydro [8].

The <u>organisational requirements</u> are substantial during all phases of project identification, preparation, investment and operation, and not sufficiently satisfied:

- *Site surveys and feasibility studies*. It is normal practice in Nepal that micro-turbine manufacturers perform the survey and project assessment in which the turbine and generator

[7] More often than not there are no roads to the site - several days by foot may be the only way to reach the nearest road. Transport cost will be a be a significant part of total plant cost, up to 30% - 40% are reported.
[8] Reported costs for Nepalese mini-hydropower plants are in the range of USD 2,800 - 7,600 per kW.

capacities are decided. The manufacturer receives a nominal fee for his survey, and has to recover the actual costs in the turbine price. A manufacturer should ideally produce equipment from specifications given by others - he cannot be expected to be technically capable of performing total project assessment, nor can he be expected to be totally unbiased in his selection of turbine size. Stream flow assessment is particularly unreliable. There is a lack of data on water resources for micro-hydropower resources. Measurement technique is a problem by itself, and if made outside the dry season leads to overestimation of flow. Socio-economic aspects are not covered in detail. A too optimistic demand forecast is a frequent cause of financial problems. In village electrification projects, the assumption is often made that even the poorest of the population will at least afford one light bulb as a minimum, since they are expected to make savings on kerosene. In agro-processing projects, competition for services is underestimated.

- *Project survey*. The Agricultural Development Bank, ADB/N, in charge of financing arrangements on behalf of the government, does not possess sufficient expertise or resources to assess the projects technically.

- *Investment*. The civil works during construction (in particular intake and canal construction, but also poles and distribution lines) require to organise local labour on a “volunteer non-paid” basis in order save on the monetary cost of construction.

- *O&*M. Routine maintenance requires a dedicated and reliable daily operator:
  - Intakes for micro-hydro are nearly always of the “temporary” type, meaning that continuous (daily) maintenance and yearly (or more often) cleaning out of sand and stones in the intake pond will be necessary.
  - Sediment will enter the intake and may cause rapid erosion of the turbine runner. Chambers for sedimentation of pebbles and sand (sediment traps) are necessary. The correct design of these requires knowledge, and for successful operation they need to be inspected and cleaned regularly.
  - The design, slope and alignment of the headrace, be it a canal or a closed conduit, requires some skill in hydraulic design and an eye for topographical or geological conditions that may cause maintenance problems.
  - The forebay and/or the peaking reservoir must be be cleared periodically for sedimentation.

- *Repairs*
  - The distance from the villages to repair facilities and competent experts, who can offer inspection services, repair, advice and training is a problem.
  - The major annual repairs following landslides and monsoons demand village mobilisation.

Thus, although micro-hydro technology may be relatively simple in terms of hardware, its soft-organisational requirements are anything but simple.

4. Characteristics of the potential target group for micro-hydro

Micro-mini-hydro projects are located in rural areas at considerable distance from electric transmission lines and distribution network. Access from nearest road will be by foot or mule, with a duration of a few hours to several days. The economic conditions in the settlements vary from very poor at subsistence level to relatively well off communities at or close to popular tourist routes or trade centres. The communities can differ considerably with regard to the degree of caste homogeneity and ethnic diversity of the population.

The *household demand for electricity* in the isolated communities and *the ability and willingness-to-pay* for electricity is low. Household metering equipment is not installed in micro-hydro projects. Households pay according to the number of light bulbs they use or according to their demand for capacity - a fuse / cut-off device will typically limit the maximum demand of a household to 100 W. Monthly household charges are NRS 0.5-2 per W capacity, or NRS50-200 per month (US$0.74-2.94, or roughly US$0.05-0.20 per kWh of consumption) [9]. This is far from enough to cover the cost of supply; and although projects receive substantial investment subsidies, the revenue is often insufficient to cover the cost of O&M and repairs and to repay loans received from ADB/N. In several projects, households refused to pay agreed monthly charges, once the investment had been made. The project promoters then felt forced to accept lower and loss-making monthly rates rather than no revenues.

Lack of knowledge in *book-keeping and accounting* is a problem, which is encountered in almost all micro-hydro projects, whether the plant is for agro-processing only or is used for household electrification. Revenue above the cost of O&M is regarded as profit and treated so.

Four types of *ownership-developer models* for micro-hydro electricification were tested in Nepal:

1. Promotion, development, ownership and management by national power company NEA
2. Promotion and development by outside (I)NGO (sometimes assisted by the local district development committee), ownership and management by local community
3. Local entrepreneur builds, owns and manages the micro-hydro plant primarily for agro-processing purposes and sells electricity to community households
4. Outside (I)NGO promotes and develops the micro/mini-hydro power plant, a jointly INGO / local Government / local community owned limited liability company owns and manages the plant

No ownership model has come out as a clear winner. A clear lesson is that *power companies such as NEA* are not geared to handle micro-hydro projects. They think to big and too quality standard conscious during the design stage and their staff is too costly during the operation phase. *Individual entrepreneur* ownership has the advantage of providing a productive demand for

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[9] The 400 kW Salleri Chialsa power plant, supported by Swiss bilateral aid has a more sophisticated billing system, consisting of three components. (i) The initial connection fee increases with the amount of power allowed from NRS250 for a 100W. connection to NRS1500 for loads higher than 4 kW. This Connection fee is automatically transformed into company shares. (ii) The fixed rates for admissible power are subdivided into eight levels, from NRS50/month for the first 100W connection to NRS500 / month for the highest power level. (iii) The energy charge per kWh ranges from NRS0.9 to NRS3.0.

power with household electricity demand being an add-on. But it experiences more problems about water use rights and makes it more difficult to organise "free labour" for civil construction and for major repairs. Furnishing lighting to a larger group of customers must involve the engagement of the community in some manner, and a strong agent must be present to enforce rules. *Community ownership* calls for a long, intensive period of community awareness building (one to two years) before any infrastructure investment is made. The case system of Hindu society, as also NRECA found out during the 1970s in India, is not conducive to the establishment of electricity co-operatives. If, in addition, the community is ethnically heterogeneous, the task becomes "impossible". Only one experience with the *corporate* model exists - a mini-hydro project, which received massive Swiss bilateral support to succeed.

The agricultural development bank ADB/N provides 5 to 7 years loans at a 16 percent rate of interest to until 80 percent of the cost of micro-hydro projects. Even when revenues are sufficient to cover the cost of amortisation ADB/N experiences *problems with overdue loans* in its loan portfolio to micro-hydro projects. The relatively richer and politically best connected farmers have the worst repayment records. ADB/N has a bad image among the rural population. The dual role of ADB/N as rural technology promotion and rural credit agency blurs its role as a professional financial intermediary. The rural population's willingness-to-pay normal credit rates is negatively affected by the Government's use of ADB/N to channel direct investment subsidies and interest rate subsidies to specific materials and technologies. Corruption in the public sector is endemic in Nepal and ADB/N is affected also, helped by its near monopoly position in rural credits. ADB/N has about 670 rural offices, the two most important competing banks have 20-30 each.

It can be concluded that a number of factors on the demand side block a wider penetration of micro-hydro projects.

5. Towards scaling-up

Micro-hydro has two major built-in obstacles for scaling up:

- The technology is rather *demanding in its requirements for organisational back-up and support*. Even the simplest case of a micro-hydro, the small peltric unit, involves technology for which the owner/user may be totally unprepared. Yet, the technology is for use in isolated areas, where supporting infrastructure is expensive to build up and difficult to sustain.

- Micro-hydro is investment intensive, but low in operating energy costs compared to diesel power. Yet, the potential cost savings from low operating costs are not sufficiently compensated in the isolated regions, where lack of a productive demand for power leads to low plant factors. *The cost of production per kWh is expensive*, which, coupled with the low purchasing power of the target population, makes it difficult to identify financially viable micro-hydro projects.

It is easy to say at a general level, what the requirements are for scaling-up:

- *The quality of the* feasibility studies *needs to be improved*
- *Local energy planning* and comm*unity awareness building* must be supported
- The system of *subsidies* must be made more effective
- Official regulations must define guidelines for *tariff setting* in isolated grids
- The mono*poly of ADB/N in rural energy credits* must be broken and guidelines be developed for project appraisal and approval
- The *locally produced equipment* must be subject to standards and to quality control
- *Service centres* for technical backstopping and basic repairs must be established
- *Training* in O&M, fault identification, simple repairs, and book-keeping must be provided to entrepreneurs investing in hydro-power plants and to key staff in community owned plants
- *Productive use enhancement* must be an integrated activity in projects receiving financial support
- The *manager of AEPC*, the Alternative Energy Promotion Centre, should be offered training in the principles of modern management, participatory planning and innovative schemes for financing.

The devil is - as always - in the details and in the large scope of supporting initiatives that is required.

Feasibility studies

There is general agreement among Nepalese experts that the quality of feasibility studies needs to be substantially improved, and that this requires more qualified manpower and more subsidies. Neutral experts, not manufacturers should prepare the feasibility studies, not by manufacturers. If however, a subsidy of 75% is provided to this activity, then procedures must be defined (i) for the selection of consultants (qualification requirements or certification, training), (ii) for setting a maximum amount for the cost of the study (relating it to the number of consumers, or to plant capacity), and (iii) for splitting the remaining 25% of the cost between the local entrepreneurs / communities and the financing institution.

Support to local Energy Planning and Community Awareness Building

It is well known that a top-down approach is unlikely to result in local identification with the project. All so-called experts pay lip service to the mantra that rural projects must be based on bottom-up perceived needs and local financial commitment. The promotional efforts have, so far, been top-down, nevertheless: institutions such as WECS make inventories of potential hydro-sites after which attempts are made to persuade the local community that a micro-hydro electrification project is what it needs. The ongoing UNDP/ REDP project is a valuable exception. That project planning and development must start with resource assessment is obvious. The mistake is that the information is not fed into a local planning process, but into the project identification process of higher placed outsiders – either national institutions, (I)NGOs or donors.

The way forward is to get project proposals identified through local energy planning making use of participatory planning techniques and receiving part-financing from locally available development funds. At present, a structure for local energy planning does not exist. The Government has started on a policy for increased decentralised decision taking and financing. The District Development Committees and Village Development Committees now receive some modest funds for local development financing. But this democratization process must be further intensified, and technical assistance must be provided to the District and Village Development Committees in energy planning and in participatory planning techniques. The latter is a powerful method for awareness raising.

Direct and indirect Subsidies to Investments

Without subsidies, investments in micro-hydro will stagnate. Some micro-hydro turbines for mechanical uses will be installed every year (they are not subsidised now). But use of hydro for electrification purposes will be an exception and be almost exclusively in the form of add-on electricity and peltric units. Progress in rural electrification based on micro-hydro power requires *direct subsidies* for investments and feasibility studies and *indirect subsidies* for supporting the build-up of professional advisory and training services. The direct and indirect subsidies are mutually interdependent. Unless there is a sufficient level of investment in micro-hydro (need for subsidy), there is no economic justification for setting up elaborate supporting services.

The tricky question for subsidy design is to find adequate comprises between (i) efficient allocation of scarce resources, (ii) ease of administration, and (iii) local and regional equity.

The 50%/75% subsidy provided by the state budget to purchases of electric equipment amounts to around 25% of project cost. Communities have been able to draw on other sources of grants to increase subsidy levels to 50-80% of the cost of investment. Such high levels of subsidies are a strong indication of misallocation of resources. If the 25% self-financing share expresses the willingness-to-pay for electricity, then it is likely that villages have other investment priorities than electricity. If they reflect skilful bargaining, they represent wasteful use of scarce subsidies. The Government's subsidy support programs should prevent subsidy shopping by insisting on minimum levels of self-finance (including non-subsidised loan finance), of at least 50%.

The question has been raised whether the target of the subsidy should be extended to include the total cost of investment, that is, also the cost of *civil construction*, of *mechanical* equipment and of the *turbines*. So far these items have been excluded, as there is no commercial need to subsidise micro-hydro plants that are used for agro-processing only (distortion of competition). Due to the existence of multi-purpose plants, it was believed, that such subsidies could not be restricted to electricity generating plants, but would automatically call for including "agro-processing only plants". In fact, it has been proposed already to include these. This is not necessary. One can introduce a scheme, which pro-rates subsidies to the non-electrical parts according to the expected use between agro-processing and household electricity demand.

A much discussed issue is whether the subsidy should be given as a *percentage of total cost* or in terms of a *fixed sum per installed kW capacity* or *per connected household*. A lump sum subsidy has the advantage, in principle, that the lowest cost projects are implemented first (which presumably have the highest rate of return) and offers good transparency. The danger is that it may lead to oversizing of the plant and/or cheating with the stated capacity.

A further equity issue is whether the *extra transport cost associated with remoteness* should be subsidised. The same regions are already disadvantaged in terms of income (ability to pay for electricity). The Government operates with two subsidy rates (50% and 75%) depending on the region. That system can and should be refined, providing lump-sum subsidies to communities on the more objective basis of days of walk from the nearest road to the project site.

In many donor-supported programs, *interest rate subsidies* are provided by revolving funds. That policy should be discontinued or reconsidered. First, because interest rate subsidies introduce distorting signals into the rural credit systems. Second, because it is known from subsidy programs in general, that the incentive impact of an interest rate subsidy is lower dollar for dollar than a direct investment subsidy.

Regulations for Tariff Setting

The Government / AEPC should issue *regulations providing guidelines for tariff setting* for two reasons. To ensure the financial viability of community owned projects (adequate allocations for major repairs and for loan repayments) and to reduce tensions in tariff negotiations between entrepreneur-owners and the customers. It is easy to see from the table on page 2, that “electricity only” plants are seldom, the majority of plants used for electrification are “add-on electricity” and the peltric sets. Typically, electrification thus involves negotiations between a private plant owner-entrepreneur and the community on the tariffs. In principle, this can and should be left to market forces. However, there have been several damaging disputes about tariffs. The guidelines cannot eliminate these, but they may ease their intensity.

New Financial Intermediaries

With its 670 branches in rural areas, the ADB/N has been and is a logical collaborator in rural development programs. The ADB/N, unfortunately, is not only part of the solution it is also part of the problem. Donor programs in rural energy must look beyond the short term and make an intensive effort to develop new rural financial intermediaries. The monopoly of ADB/N must be broken, even though it costs lost time in the short to medium term.

Norms, standards and quality control

Whereas the opinion of manufacturers is divided, other Nepalese experts seem to be convinced of the need for setting up a laboratory for turbine testing and quality control. The tricky question is how such an institute can be made financially sustainable at the end of donor support. It is not likely that the institute can price its services to manufacturers on the basis of full-cost coverage without excessive consequences for the price of turbines.

Service Centres

At present, there are three service centres in Nepal for providing technical backstopping and minor repairs to turbine owners (major repairs require that the turbine is brought back to the manufacturer). Two other attempts have failed for financial reasons. The situation might have been different, if the market for micro-hydro had expanded during the 1990s, instead of contracting. But as it is, the commercial demand is insufficient to justify the creation of more centres. A proposal has been made to finance the creation of 10 more centres under Danida's Nepal ESAP. A more viable approach may be to train existing workshops in rural areas to perform such repairs and technical backstopping.

Training of entrepreneurs and of community operators

Experience has shown that entrepreneurs and operators of community owned plants need to get more training in O&M, identification of technical problems and solutions, and in book-keeping.

Promotion of Productive Uses of Electricity

The active promotion of productive uses of electricity in rural electrification projects is becoming a normal feature in developing countries. The practical results do not quite correspond to the attention, which is given to the theme. But in view of the "free ride" of increasing the plant factor in micro-hydro projects, promotion of productive uses must be an integrated part of micro-hydro projects. The potential for this can be maximised if AEPC succeeds in establishing close collaboration with agricultural irrigation and other extension projects.

Training to AEPC

The Alternative Energy Promotion Centre, AEPC was created late 1996, and became operational in the beginning of 1998. AEPC was originally conceived and supported by (I)NGOs working with rural energy issues in Nepal. The AEPC is set-up under the Ministry of Science and reports to a Board of representatives from several ministries. The original intention of including private sector and NGO representatives on the board was dropped, and the AEPC is already showing characteristics of a traditional red-tape bureaucracy. Staff stability will be a problem, as public sector salaries are very low. Yet, the AEPC was created in response to a perceived need for coordination and should be strengthened as much as possible. Staff training courses will be developed and implemented. Special care will be given to provide AEPC's manager with training in the principles of modern management, in participatory planning techniques and in innovative financing schemes. Far too often, donor provide training in energy related issues – energy economics, planning, technologies. The difficult role of AEPC, however, is to introduce proper management and coordination!

Scope of activities and the time factor

The tasks, as shown above, are very comprehensive and the resulting investment level in terms of MW will be modest. Yet, since the typical demand of the target rural households amounts to 100W at present, each cumulative MW of new capacity represents 10,000 households that have received electricity.

The message is that the promotion of micro-hydro takes time. A donor wishing to provide support to the sector should go in with a minimum perspective of 15 to 20 years, and preferably 30 years. The donor should be aware not to expect early results. The level of investment will not increase substantially until several years after the start of the program.

6. A few Notes on the Promotion of SHS in Nepal

Three local manufacturers produce 35 Watt SHS of reasonable quality, and a 50 percent Government subsidy has attracted around 6,000 applications for SHS, of which only a fraction could be satisfied due to lack of subsidy funds. The rural situation in Nepal in many ways favours the penetration of SHS:

- An important part of the population will for decades remain outside the reach of grid connected electricity.
- The productive demand for energy of this group will be low for many years to come; the low power output of SHS thus has no consequences.
- The technology is financially sustainable, as it permits consumer discrimination – only those who can afford to purchase a system will do so.
- Sustainability depends only on a satisfactory level of after-sales service from the manufacturers.

The establishment of the latter, however, calls for a minimum level of consumer demand to make investments in SHS promotion and maintenance services feasible. At present levels of income, it is believed that demand – at unsubsidised levels will be insufficient to permit an adequate development of such an infrastructure.

Assistance to the promotion of solar home systems (SHS) is another component of Danida's "Nepal 1999-2003 Energy Sector Assistance Program". The specific details of the promotion strategy are still being defined. But at present it looks, as if the component is going to have the following features (subject to change):

- Danida will finance an open-ended subsidy to purchases of SHS during a five year period with annually declining levels of support. *Market based interest rates will be combined with a lump-sum subsidy, irrespective of the size of the system*. 20W, 35W and 55W systems will be marketed. The subsidy sum is pre-fixed for each of the five years and declines every year. During the first year, the level of subsidy for a 35 W system is around 30 percent, declining to 10 percent during the last year.
- Only products of *manufacturers that provide adequate after-sales service* and that fulfil quality norms will benefit of the subsidy. Hit-and-run suppliers are unwanted.

- Technical assistance is provided for the establishment of a *solar test station* that offers technical advisory services to manufacturers of solar heaters and SHS, fixes standards for supported equipment and monitors the quality of local products.
- For equity reasons, community and social institutions will be offered SHS at particularly favourable rates. The build up of promotion and afters-sales in very remote regions may be supported financially.

The programme expects to market 5-6000 SHS per year. At the end of the five year period it is expected that market demand at that level can be maintained without further subsidies. The cost of SHS at that time will be lower, a nation-wide structure for promotion and maintenance will be in pace, and the demonstration effect of SHS in nearby homes will have a powerful motivating demand.

Since Danida's development assistance has a clear poverty focus, and the SHS benefit the relatively richer community, the question was, whether subsidies to solar home PV-systems could be justified? Proponents base the justification of the subsidy on two arguments:

- The first *is cost reduction through "pump-priming"*. The production, marketing and servicing of PV-systems are subject to economies of scale. By expanding the market in an initial phase, a minimum scale of efficiency is reached. This provides cost reductions that stimulate demand and allow the subsidy to be reduced. Pump priming helps establishing the minimum service infrastructure that allows PV-systems to provide a reasonable level of reliability.

- The second justification is *equity*. Rural consumers living in areas, where a grid is constructed, get a higher quality form for electricity and get their electricity subsidised. To give subsidies to PV-consumers puts "isolated consumers" on an equal level. That the subsidy benefits relatively richer consumers is defended with reference to the market build-up argument. Market development has to start somewhere. It must obviously start with the "richer consumers" (who are poor by industrialised world standards). The establishment of a national infrastructure in the form of local manufacturing and region-wide maintenance services leads to cost reductions. The poorer inhabitants benefit from this in the long run as it enables them to get access to the PV-systems at a lower cost and to an established structure for servicing and maintenance.

Both arguments have merits. But the equity argument is relatively weak:

- In grid based electrification, the *poor get access immediately* due to better affordability; in villages, where PV-systems enter, they get a "pie in the sky".
- Subsidies to rural electrification are not given only for social equity reasons, they also serve the purpose of enabling the establishment of a *basic infrastructure*. Going from one village electrification to the next through a gradual extension of the grid, enables the nation-wide penetration of the grid to take place. The build up of a demand for electricity in an isolated grid, generates in the long term sufficient demand to permit connection to the national grid. PV-systems are individual consumer goods. The promotion of the systems does not provide the country with a basic infrastructure apart from the service network.

- A 30% subsidy to a 35 W SHS costing NRS32,000 (US$450) reduces the annual amortisation burden of a seven year ADB/N loan (deducting a NRS5000 down-payment) from NRS6700 to NRS2700. In a grid based rural electrification scheme, a consumer with the same level of demand pays NRS2500 for the connection fee and NRS720 per year for his baseline consumption of 20 kWh/month. Assuming that the monthly bill covers roughly one third of the true cost of production [10], *the grid connected consumer receives an annual subsidy of NRS1500 which is considerably less than the annual NRS4000 given to the beneficiary of a PV-subsidy*.

- Grid based electrification takes place based on *the national least cost power expansion plan*. The reason why the target group of PV-consumers is not connected to a grid is that the cost of connecting other consumers is cheaper. The non-availability of electricity, thus, is the result of *a rational allocation of scarce public financial resources*. To jump-start the electrification process by asking for subsidies to PV-consumers on grounds of social equity can lead to a misallocation of scarce public finance.

The above did not lead Danida to a total rejection of subsidies to PV systems during a short pre-defined period. But it asked for caution with regard to the level of the subsidy and with regard to fixing the length of the period during which the subsidy scheme remains. The objective is to provide consumers with the opportunity to get access to well-serviced SHS made of good quality components and benefiting from cost reductions due to economies of scale. Whether they make use of the opportunity, or have other preferences is up to the consumer.

[10] The cost of production of a small isolated grid supplied by a micro/mini plant is guess-estimated at US$0.15/kWh = NRS8.2/kWh.