MICRO AND SMALL HYDROPOWER FOR AFRICA

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When talking about hydropower, one's thoughts automatically go towards large civil engineering works with huge dams and large reservoirs. Names like Kariba, Cahora Bassa and Aswan come to mind. However hydropower comes in various classes and sizes: Picohydro is defined as up to 10 kW, microhydro from 10 kW to 300 kW, small hydro from 300 kW up to 1,000 kW, and mini hydro above 1,000 kW.

The potential of micro and small hydro makes it an attractive option for meeting part of the future energy needs of the rural areas in Africa. The investments needed for small hydro constructions are generally lower than for conventional, centralised energy systems. Small hydropower offers a unique opportunity to meet the needs of the rural population in a cost-effective way, with an investment lower than that for individual solar home systems and providing high power systems.

The basic principle of hydropower is that if water can be piped from a certain level to a lower level, the resulting water pressure can be used to do work. If the water pressure is allowed to move a mechanical component then that movement involves the conversion of the potential energy of the water into mechanical energy. Hydro turbines convert water pressure into mechanical shaft power, which can be used to drive an electricity generator, a grinding mill or some other useful device.

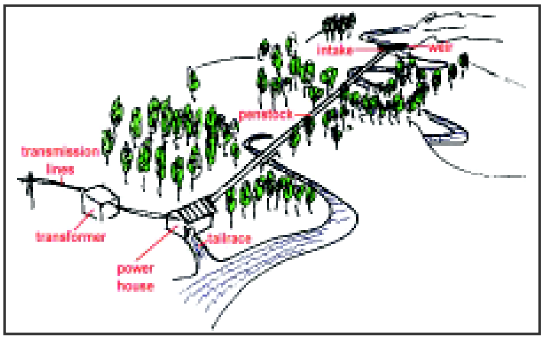
The use of falling water as a source of energy has been known for a long time. In the ancient times waterwheels were already in use, but only at the beginning of the nineteenth century, with the invention of the hydro turbine, was hydropower given a new impulse.

Small-scale hydropower was the most common means of generating electricity in the early 20th century. In 1924 for example in Switzerland nearly 7,000 small-scale hydropower stations were in use. However the improvement of electricity distribution possibilities by means of high voltage transmission lines limited interest in small-scale hydropower.

Renewed interest in the technology of small-scale hydropower started in China. Estimates are that between 1970 and 1985 nearly 76,000 small-scale hydro stations were built there.

Hydropower is a very clean source of energy. It does not consume, but only uses, water, and after use the water is available for other purposes (although on a lower horizontal level). The conversion of the potential energy of water into mechanical energy is a technology with a high efficiency (in most cases double that of conventional thermal power stations).

The use of hydropower can make a contribution to savings on exhaustible energy sources. Each 600 kWh of electricity



Typical layout of a microhydro plant.

generated with a hydro plant is equivalent to approximately 1 barrel of oil (assuming an efficiency of 38 % for the conversion of oil into electricity).

The main advantages of hydropower are:

- the power is usually continuously available on demand
- given a reasonable head, it is a concentrated energy source
- the energy available is predictable
- no fuel and limited maintenance are required, so running costs are low (compared with diesel power) and in many cases imports are displaced to the benefit of the local economy
- it is a long-lasting and robust technology; systems can last for 50 years or more without major new investments.

Against these, the main shortcomings are:

- it is a site-specific technology and sites that are well suited to the harnessing of water power and are also close to a location where the power can be economically exploited are not common
- there is always a maximum useful power output available from a given hydropower site, which limits the level of expansion of activities which make use of the power
- river flows often vary considerably with the seasons, especially where there are monsoon-type climates and this can limit the firm power output to a small fraction of the possible peak output
- lack of familiarity with the technology and how to apply it inhibits the exploitation of hydro resources in some areas.

To know the power potential of water in a river it is necessary to know the flow in the river and the available head. The flow is the amount of water (in m^3 or litres) which passes a cross section of the river in a specific time (normally given in cubic meters per second (m^3/s) or in litres per second (l/s).

Head is the vertical difference in level (in meters) the water falls down.

The theoretical power (P) available from a given head of water is in exact proportion to the head H and the flow Q.

Microhydro installation at a farm near Sabie in South Africa, operating on a head of 84 metres. The turbine is coupled to a 45 kW generator and supplied the whole farm and wood mill. Unfortunately floods in 1999 damaged the plant beyond repair.

$P = Q \times H \times c$ (*c = constant*)

The constant c is the product of the density of water and the acceleration due to gravity (g).

If P is in Watts, Q in m^3/s and H in metres, the gross power of the flow of water is:

$P = 1000 \times 9.8 \times Q \times H$

This available power will be converted by the hydro turbine in mechanical power. As a turbine has an efficiency lower than 1, the power generated will be a fraction of the available gross power.

Small-scale hydropower stations combine the advantages of hydropower with those of decentralised power generation, without the disadvantages of large-scale installations. Small-scale hydropower has few disadvantages: no costly distribution of energy, no huge environmental costs as with large hydro, independent of imported fuels and no need for expensive maintenance. Small-scale hydropower can be decentralised and be locally implemented and managed.

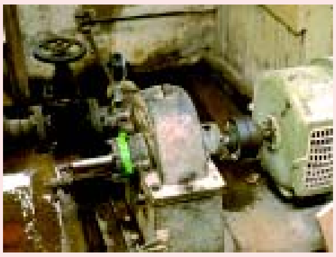
Power generated with small hydro stations can be used for agro-processing, local lighting, waterpumps and small businesses.

The context of small hydropower can be described as follows:

- decentralised, small demand for power (small industries, farms, households and rural communities)
- distribution network with low voltages (eventually sub-regional grid)
- owned by an individual, co-operative or community with semi-skilled workers
- short planning horizons and construction periods with the use of local available materials and skills
- depending on the generated power it can have a substantial impact on local standards of living (bigger than only the supplied power)
- as only limited information is available about the potential power often not more then 10 % of the potential is used.

Based on the advantages and the context as described above, micro and small hydropower could play an important role in the electrification of remote rural areas in Africa.

Example 1 – Svinurayi co-operative, Zimbabwe



The pelton turbine in the Svinurayi powerhouse.

Svinurayi co-operative is an agricultural co-operative near Cashel valley in the eastern Highlands of Zimbabwe. A hydro installation was established in the 1930s, consisting of a 10 kVA pelton generator by Gilkes coupled to a generator and maize hammer mill. Bad maintenance after independence led to the detoriation of the plant. In the mid 1990s the plant was rehabilitated with assistance of ITDG and new penstock installed.

Example 2 – Nelspruit

The Friedenheim hydro plant on the Olifants River in Nelspruit (South Africa) is an example of a hydro plant that feeds into the national electricity grid. Friedenheim hydro is privately owned and the bulk of the electricity generated is sold through a power purchase agreement (PPA) and the plant, which is owned by the members of Friedenheim Irrigation Board (FIB) and operated by MBB, is operated as a commercially profitable and sustainable business venture. The plant provides power for water pumping to FIB, but 93% of the power generated is sold to the Nelspruit local authority through the PPA that sets the tariff at 12% below the price at which Nelspruit buys power from Eskom (its bulk electricity provider).

The Friedenheim hydro scheme has proved a profitable and viable investment. Its successful track record has gone a long way towards dispelling the myths common in the electricity supply industry that it is not possible to compete with Eskom, especially the small and renewable energy producers selling energy wholesale.

The motivation for the PPA with the Nelspruit local authority was based on the cost savings involved in buying electricity at a rate below that of Eskom and to a lesser extent the increased security of supply offered through this diversification in suppliers

The powerhouse in Friedenheim.

The water inlet in Friedenheim.