FACT SHEET 6:
HYDRO ELECTRICITY

'Hydro' comes from the Greek word hydra, meaning water. Hydro electricity is electricity produced from the energy contained in the downhill flow of water from rivers and lakes. Hydropower provides about 19% (2,650 TWh/yr) of the world's electricity supply.

History and Development

Using the energy provided by flowing water to drive machinery is not a new idea. The ancient Greeks were using wooden waterwheels as far back as 2000 years ago. In 1882 the United States built the first hydroelectric plant. It made use of a fast flowing river as its source of energy. Some years later, dams were constructed on the river to create artificial water storage areas. These dams also allowed the water flow rate to the power station turbines to be controlled.

Originally, hydroelectric power stations were small, built next to waterfalls and close to towns because it was not possible to send the electrical energy over great distances. There is now large scale use of hydro electricity because improvements in electricity transmission means it can now be sent over hundreds of kilometres to where it is required.

Hydropower is a proven and well advanced technology, with more than a century of experience. Modern power plants provide extremely efficient energy conversion.

How Hydro Electric Power Stations Operate

The amount of energy available from water depends on the amount of water flowing and the height of the surface of the water above the turbine. This height is called the 'head' and the greater the head the more energy each cubic metre of water has available to spin a turbine, which in turn drives a generator which produces electricity. The greater the quantity of water the greater the number and size of turbines that may be spun and the greater the power output of the generators.

Water is collected and stored in the dam above the power station for use when it is required. Some dams create a big lake behind the dam wall. Other dams simply block the river and divert the water through pipelines down to the power station.

While a water turbine is much more sophisticated than the old water wheel it is similar in operation. In both cases flowing water rotates a shaft when flowing past the shaft blades. After the water has given up some of its energy to the turbine, it is discharged through drainage pipes or channels called the "tailrace". This is usually into the river downstream of the power station. For more information on the different types of turbines visit the RE-Files.

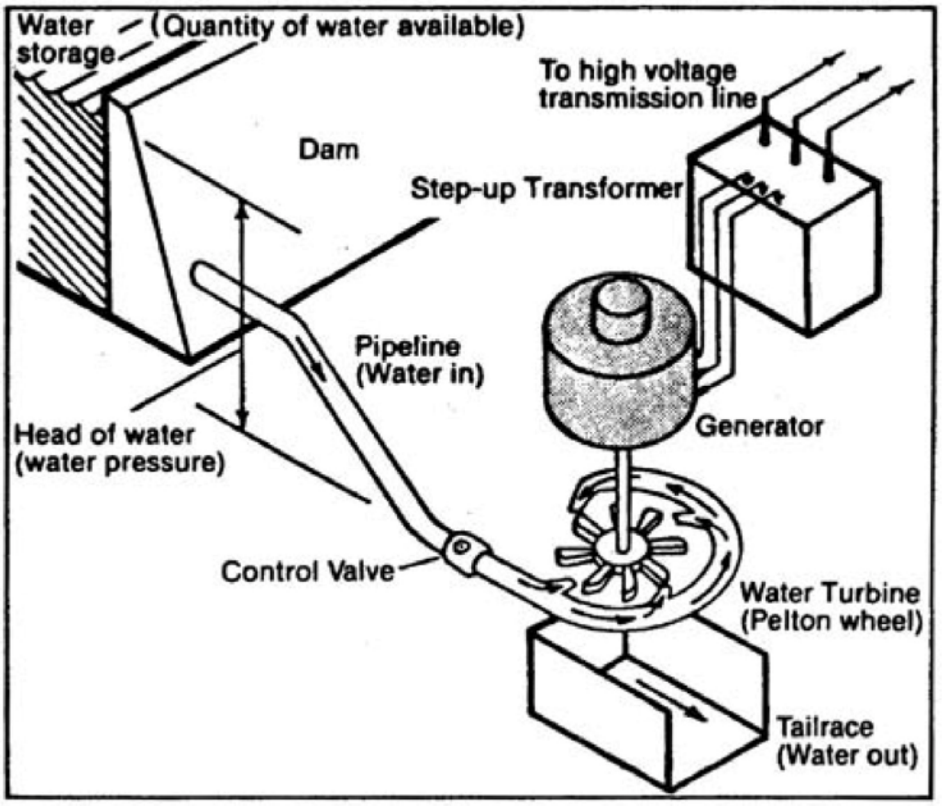

Figure 1.
Diagram of hydroelectric scheme
(Copyright Western Power Corporation [1])

Hydro electric systems are generally classified according to the size of their generating capacity. There is some variation in the definition of large, ranging from > 5 MW to > 50 MW, but it is most usual to classify anything over 10 MW as large. Small systems are further divided into mini, between 500 kW and 100 kW, and micro, < 100 kW:

The amount of electricity generated from a system depends not only on its capacity (size of turbine and generator) but also on the amount of water available. In times of drought water to hydro electricity systems is limited and they have a reduced electricity output.

Large Scale Hydro Electric Power Stations

WORLD WIDE

Large scale hydro electric power stations have been installed all over the world where there are large rivers flowing down steep courses.

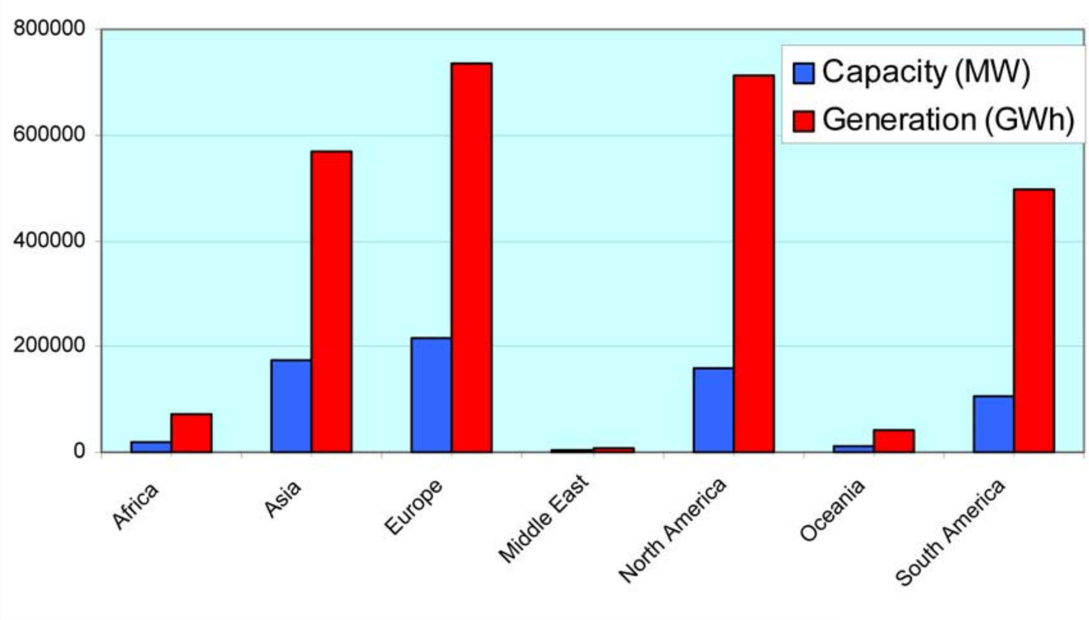

Figure 2.
World hydropower in 1999 (World Energy Council [2])

Canada and the USA have the most generating capacity and generate the most electricity from hydro. The world's largest system [3] is on the Paraná River between Brazil and Paraguay in South America. It has a capacity of 12 600 MW. When the Three Gorges Dam in China is completed it will be larger still at 18 200 MW and is expected to generate 85 TWh per year, or close to a tenth of current Chinese requirements.

Large scale systems require a very large dam, or series of dams, to store the enormous quantities of water they need. When full, the Kariba dam, between Zimbabwe and Zambia holds 160 billion m3 of water! Such dams are often used as a resource for irrigation and fishing as well as supplying the water for power generation.

Large dams bring considerable environment and social change. People living in the area to be flooded are displaced, as are local fauna and flora. Flooding downstream may be reduced and while this may have a positive effect in the short term, in the long term it may mean loss of agricultural productivity. Proposed hydro electric power projects often face pressure from environmental and human rights groups concerned about the social and environmental impacts. Examples are the 18.2 GW Three Gorges dam project in China, the 2.4 GW Bakun project in Malaysia, and the 400 MW Maheshwar project in India [4].

Proponents of large hydro consider that the amount of electricity presently generated by hydro could be more than doubled with projects that are economically viable. Most untapped hydro potential is in developing countries in Asia, South America and Africa.

AUSTRALIA

Australia has few large rivers and there are limited sites available for hydropower. Nevertheless close to 10% of the nation's electricity comes from this source. The Snowy Mountains [5] hydroelectric power scheme is the largest hydro electric system in Australia, with a generating capacity of nearly 3,800 MW. It includes seven power stations, 145 km of tunnels and

16 dams. The largest dam, Lake Eucumbene, can hold nine times the water volume of Sydney Harbour.

Tasmania's Hydro-Electric Corporation [6] generates the second largest amount of hydro electricity in Australia. Other hydro stations include: Barron Gorge power station near Cairns(60 MW), Kareeya power station at Tully Falls in Cairns region (72 MW), Somerset Dam power station on the Brisbane River (40 MW), Wivenhoe Dam power station on the Brisbane River (500 MW) and Ord River Hydro in the north of Western Australia (36 MW).

Small Scale Hydro Electric Power Stations

Small scale hydropower systems can use dams (either existing for another purpose or new) or can be 'run of river' systems where part of the river flow is diverted for power generation. A well designed small hydropower system can have minimal negative environmental impacts.

The cost per unit of electricity will depend on the site, rather than the size of the dam and the power station, but less initial investment is required for small systems. There is considerable scope for development and optimisation of technology to reduce the unit cost of electricity from small systems.

Small scale hydro power has huge, as yet untapped potential in most areas of the world and can make a significant contribution to future energy needs. In developed countries there are limited sites that could be used for new large hydroelectric schemes. However, there are many potential sites for small and mini hydroelectric power stations which could provide electricity to the local distribution network.

SMALL AND MINI HYDROPOWER SYSTEMS (10 MW – 100 KW)

Europe and North America have been using small hydro systems in streams and rivers from the early days of electricity usage. They were installed in dams and sluices of old windmills. The growth of the national transmission networks (the grid) in the 1920s caused them to be abandoned because the electricity from large power stations on the grid was more reliable and stable. Recently there has been renewed interest in these small scale systems for a number of reasons:

- concerns about blackouts and brownouts on the grid;
- there are only a few unused large scale reserves left; and
- the cost of controlling the output of the small scale generators has decreased due to advances in electronics.

The Chinese are world leaders in the use of small hydro systems and have installed over 100,000 plants in the last 25 years as part of a rural electrification program. By the end of 1995, the installed capacity of small hydropower in China amounted to over 19 GW and the annual electric output to 64 TWh [7].

These smaller hydroelectric systems are an attractive alternative to large fossil fuel systems in developing countries with suitable sites and limited capital. The small units are independent and any problems with an individual unit will only affect the local population. Transmission lines only have to cover short distances requiring less maintenance and again improving security of supply. Smaller systems are simple and easily understood and can therefore be maintained by local personnel.

There is significant scope for small scale hydro in Australia (AGO) (SEDA)

MICRO HYDRO SYSTEMS (LESS THAN 100 KW)

Micro hydro systems are generally stand alone systems not connected to the main electricity grid. They operate by diverting part of the river flow through a pipe (penstock) to a turbine, which drives a generator producing electricity (Figure 3). The water then flows back into the river. Micro hydro systems are mostly "run of the river" systems, allowing the river flow to continue which is preferable from an environmental point of view. Using this type of system seasonal river flow patterns downstream are not affected and there is no flooding of valleys upstream. The electricity output is not determined by controlling the flow of the river, but instead the turbine operates when there is water flow and at a rate governed by the flow. This means that a complex mechanical governor system is not required, reducing costs and maintenance requirements. The systems can be built locally at low cost and the simplicity gives rise to better long term reliability. The main disadvantages are that water is not carried over from rainy to dry season and that the excess power generated is wasted unless an electrical storage system is installed.

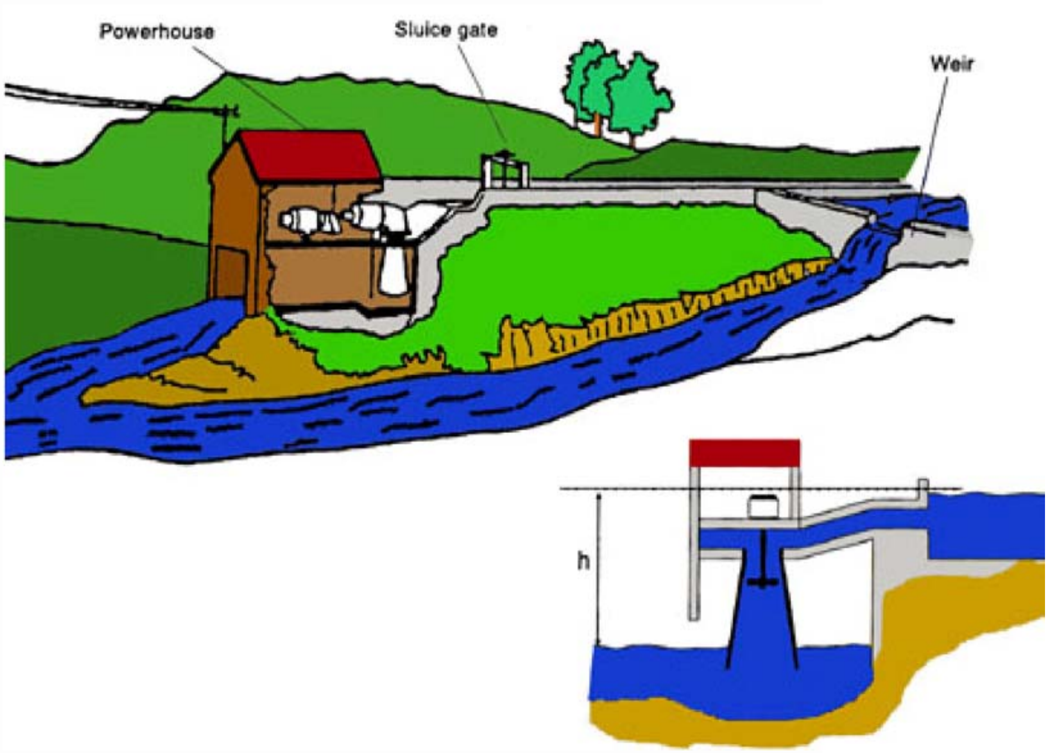

Figure 3.
A low head micro hydro installation
(Image adapted from Stockholm Environment Institute [8].)

Micro hydro systems are suitable as remote area power supplies for rural and isolated communities. They are an economic alternative to extending the electricity grid. The systems provide a source of cheap, independent and continuous power, without degrading the environment. However, unless they are built on a river with a continuous steady flow they will not supply year round power.

Costs and Benefits

ADVANTAGES OF SMALL HYDROPOWER

Hydro-electricity has many positive aspects:

- Hydroelectric energy is a renewable energy source.
- No carbon dioxide is emitted as a result of hydropower.
- Hydroelectric energy is non polluting. It does not cause chemical pollution of ground or water or the release of heat or noxious gases.
- Hydroelectric energy has no fuel cost and has relatively low operating and maintenance costs, so it is a good investment in times of inflation and can provide very low cost electricity.
- Hydroelectric stations have a long life. Many existing stations have been in operation for more than half a century and are still operating efficiently.
- Hydropower station efficiencies of over 90% are achieved, making it the most efficient of energy conversion technologies.
- Hydroelectric energy technology is a proven technology that offers reliable and flexible operation.
- Hydropower offers a means of responding within seconds to changes in load demand.
- A dam can be a useful resource for leisure, fishing, irrigation or flood control.

CONSTRAINTS ON HYDROPOWER

There are however some social, ecological and hydrological effects that have to be taken into consideration when planning a hydroelectric power station. These effects can be enormous if the system is very large.

- Hydropower is only suitable for sites with large volumes of flowing water. Decreased rainfall, due to climate change, would reduce the electricity available.
- Considerable capital investment is required, especially for large schemes.
- Dams cause large areas upstream to be flooded. This may cause displacement of people and will destroy animal habitat and flora.
- Flooded vegetation will rot anaerobically and emit methane, a potent greenhouse gas.

- The dams and diversion of water may also change the groundwater flows in the local area and this can change the ecology of the area (eg. Snowy River in Victoria).
- Damming the river reduces flooding which reduces the amount of silt carried downstream. It also increases the amount deposited in the dam. This may mean that the dam has to eventually be dredged while downstream there is reduced fertility in the soil.

Abbreviations

TWh – terra watt hours

TWh/year – terra watt hours per year

MW – megawatt

kw – kilowatts

GWh – gigawatt hours

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Further Information

For further information about “Types of Water Turbines” and the “Status of Hydro-electric Power World-wide’ visit the RE-Files

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