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Seminar-Workshop on the Exchange of
Experiences and Technology Transfer
on Mini Hydro Electric Generation Units

Kathmandu, Nepal, 10-14 September 1979

SWEDISH DEVELOPMENT OF MINI HYDRO ELECTRIC GENERATION UNITS*

by

Swedish Capabilities for Assistance

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Historical Background

In the history of industrial development in Sweden the abundant availability of waterfalls with suitable heads played a most important role.

Already in the sixteenth century a small steel industry had been started and simple water wheels were used to drive airblowers for the blast furnaces and forge hammers.

At the beginning of the eighteenth century the famous Swedish inventor Christoffer Polhem succeeded in transferring mechanical energy from water-wheels to mining pumps and hoists, kilometers away.

The movement from the water-wheel was carried by two parallel wooden bars hanging in hingelike, low friction supporters.

Fig. 1. shows an example of how the transmission could be arranged.

With this device one of the first "long-distant" energy transmission in the world was a fact!

The real big step forward came with the water turbines and the use of electricity.

At the end of the nineteenth century small hydro electric power stations were built all over Sweden. That marked the start of a more large scale industrialization and formed a base for a steady raise in standards of living for the whole population.

When big water and thermal power stations were built during the first third of the twentieth century and a power grid was completed, covering the main part of the country, the small water power plants lost their importance. The industries many times had outgrown their own power resources and had to buy electric energy from other suppliers. Most of the small water power stations were abandoned.

Todays energy situation

The energy crises of today has created an interest from Swedish state authorities in using all resources which in the new energy situation are economically motivated.

One study about MHP has been worked out by VAST - the Swedish Power Association Development Section regarding the range 100 to 1 500 kW.

A [illegible] W has been done by the Na[illegible] Board for Technical Development. This prestudy is specifically aiming at MHP for developing countries while the VAST study in the first place deals with MHP for Sweden, but also has a wider applicability.

Some [illegible] from the VAST study may be of interest:

VAST has drawn up a list of suitable plants and taken part in standardization work together with manufacturers of the mechanical and electrical equipment for small hydro-electric power stations. The standardized units are propeller turbines with fixed or alternatively with adjustable blades. State aid has been granted through SIND, the Swedish Industrial Board, to the prototype plants.

It is anticipated that the development work will be completed during 1979.

Proposed types of turbines

The development work carried out by VAST on behalf of mini-power stations has been concentrated partly on reducing costs of mechanical and electrical equipment and partly on lowering the costs for supervision and operation by means of automation and remote control. The possibilities of cutting building costs must be judged from case to case and cannot be based to any extent on standardization.

In the course of development it has turned out to be expedient to design the unit with an axial turbine in the form of a propeller turbine with fixed or alternatively adjustable blades. The turbine is fitted with a fixed guide vane.

By means of a tooth transmission gear designed to increase the number of revolutions the turbine is connected to a standard asynchronous generator which is adapted to the maximum attainable turbine capacity.

The generator is connected via a transformer to the local distribution net. The generator voltage is normally 400 V.

The headrace to the turbine is closed by means of a gate at the intake in the dam or by a butterfly valve in the headrace tube, if such is used. The gate and butterfly valve respectively are fitted with a hydraulic servo-motor for opening operations. Closing takes place automatically by a valve being opened in the hydraulic system and the gate (valve) being closed by its own weitht (counterweight).

The unit is started by the slow opening of the gate (valve). After the unit has been linked up, which takes place automatically, the number of revolutions is controlled by the network. The starting and stopping of the unit take place automatically and are guided by a level indicator in the upper storage in the case of units with fixed blades. If a turbine with adjustable blades is installed, the automatic operation can be adjusted to both the water level regulation with the level indicator and also to a device ensuring a certain amount of draw-down.

If the voltage of the net disappears the gate or altenatively the valve is closed automatically. During the closing process the unit attains runaway speed. To ensure the quickest possible closure, the unit is fitted with two overspeed relays - one magnetic valve and one mechanical hydraulic valve.

If conditions permit the running of the unit intermittently with a full load and of utilizing an upstream storage for regulation, a unit with fixed runner blades is chosen. The unit can be given maximum degree of efficiency when fully loaded and thereby the maximum possible production. When the dam water level has reached the lower storage limit the unit stops and starts again when the upper limit has been attained.

If regulation of this kind cannot be permitted on account of conditions in the stream etc., the unit is equipped with automatic runner regulation. The unit can then be operated with constant upstream water level, i.e. utilize the available flow or be regulated within the limits permitted by the circumstances by means of automatic regulation and with the prescribed minimal draw-down in the stream. The mean rate of efficiency during the operation time is somewhat lower with units having runner regulation than with units without such regulation. On the other hand, intermittent running with the utilization of the upstream storage implies a certain loss of head for the power plant.

For the erection of turbines there are various alternatives depending on local conditions and the head to be utilized.

The following three main types are relevant:

<u>Type 1</u>	Generally for 2 - 8 m head.
(Appendix 1)	Propeller turbine with vertical shaft:

Turbine erected in a open turbine chamber in close proximity to the dam.

Closure by gate in the intake. (In some cases it may be desirable to place the turbine runner above the lower water level and it may be possible to design the turbine headrace as a siphon. The intake gate is not then required).

Type II (Appendix 2)

Generally for 5 - 10 m head.
Propeller turbine with horizontal shaft:

Turbine fitted with a closed turbine chamber and with a head-race tube from the intake in the dam.

Closure by means of a gate in the intake or a butterfly valve in the headrace tube.

Type III (Appendix 3)

Generally for 8 - 30 m head.
Propeller turbine with vertical shaft:

The turbine is fitted with a closed turbine chamber and with a headrace from the intake in the dam.

Closure by means of a butterfly valve in the headrace tube.

These three types can be fitted with fixed or alternatively adjustable blades. With these six combinations the entire range between 2 - 30 m heads and 100 - 1 500 kW can be supplied with suitable units.

The following standardized runner diameters are recommended: 0,5 - 0,7 - 0,9 - 1,15 - 2,0 - 2,3 m. The choice of runner diameter is dependent of many factors as flow rate, head and the position of the turbine in relation to the lower water level. The tenderer is not bound to the above mentioned diameters but is to propose the most economic diameter for which the guarantee for power and efficiency is valid. An effort to use any of the recommended diameters will imply a standardization which will be of value as well for the purchaser as for the supplier. In appendix 4 is shown the heads and the flow rates for which the three types of turbines normally are suitable. The sizes of the units have been limited in the diagram to 100 - 1 500 kW with runner diameters between 0,7 and 2,0 m.

The units are given the designation [illegible] as well as data indicating whether the turbines are fitted with fixed or adjustable blades (F or A) in addition to [illegible] diameter.

One unit of [illegible] with [illegible] diameter of 0,9 m [illegible]

The headrace to the turbine is [illegible] gates with intervals between bars [illegible] risk to fish passing through the turbine.

Headrace tubes [illegible] dimensioned economically with respect [illegible] types of tubes are of wood, steel [illegible] from the point of view of laying as well as [illegible] that plastic tubes have advantages [illegible] making comparisons.

Bearing in mind the [illegible] with relatively slow closure, the rise in pressure in the [illegible] relatively low, thereby eliminating the need for a surge [illegible].

The prestudy by the National Swedish [illegible] Technical Development in the range below 100 kW has the goal to evaluate the manufacturers of small water power stations in Sweden and to support projecting MHP specially adapted for developing countries. To achieve this [illegible] information is necessary and I will come back to that later.

I would like to show a couple of small turbines and converted pumps.

Fig. 2. First a small propeller turbine, diameter of impeller 315mm, 9 kW, H = 4 m, 1 035 r/m. Turbine-efficiency [illegible]. Total Eff. - 73%. Similar units up to 100 kW.

Fig. 3. Horizontal double suction, centrifugal pump converted into a turbine.

Fig. 4. A lowhead submersible propeller unit installed in the intake shaft.

Fig. 5. A centripetal unit installed for a higher head but still with a generator of submersible type that can be flooded without danger.

This may be enough in this paper. Further discussions and details may come in the workshops.

Individually running MHP have to have some sort of frequency and voltage-control. Several suggestions for solutions are underway and will be tested.

Necessary additional studies

The project MHP for developing countries may become very important provided that the use of produced energy is carefully planned.

In a village where a diesel-driven irrigation pump has been installed some people have to be taught how to run and maintain the pumping unit. The use of the pumped water in the fields is traditional agricultural knowledge since thousands of years. But in villages where few, if any people, have had any contact with electricity and related equipment the educational programme is bigger and concerns many more individuals.

In countries, where studies not already have been undertaken, it is of course necessary to make an integrated plan based upon special needs in the respective villages, available raw materials, further possibilities in the new energy situation etc. Traditional handicraft supported by some machines and an improved environment (electric light, heating) may create export possibilities.

Another aspect is a detailed study of available water power: head, flow and durability during the year distance between possible sites for the power stations and the villages. All this is important for the producers in their planning for standardized design, simple service and maintainance and to reach acceptable production volume to lower the costs. This in turn will be to the benefit of a greater number of plants from a certain sum of money.

A domestic production of MHP may be interesting later on, but may delay the start of the scheme and give initial troubles.

Conclusion

MHP has been of interest in Sweden quite a time. Several plants have been errected and are in use. The National Swedish Board for Technical Development supports a special project programme aiming at MHP sizes up to 100 kW. It is intended for use in developing countries. The delivery of MHP will be considered to be included in the aid programme of SIDA, the Swedish Industrial Development Aid.

Swedish water turbine and electrical industry has a long experience and was first in the world to design and produce big propeller-turbines. The first full-scale Kaplan turbine based on Professor Victor Kaplan's theories was designed, produced and delivered by Karlstads Mekaniska Werkstad to the State Power Board for Lilla Edet Power Station in 1921. The runner diameter is 5,[illegible] m and the turbine was started in 1925 and has been running ever since. The hub with the variable blades has never needed reassembling for service during 54 years!

<u>**Notes and References:**</u>

<u>Studsvik Reports:</u> <u>Energy in Developing Countries</u>

Main report: Problem analysis and policy recommendations for SIDA, Kjell Larsson.

Subject report: Development assistance in the field of energy, Olof Murelius.

Subject report: Energy characteristics of India and Kenya, Kjell Larsson, Roy Nilsson.

<u>Small Hydroelectric Power Stations</u>

Information publication from VAST - The Swedish Power Association Development Section.

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche

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