SMALL-SCALF POWER PLANTS

Information from NVE

SOME RELEVANT FIGURES

1 MW (megawatt) = 1000 kW (kilowatt)
1 GWh = 1 million kWh (kilowatt-hours)
1 TWh (terrawatt-hour) = 1000 GW h (gigawatt-hours)

An ordinary household heating system will produce about 70 kWh from 1 litre fuel oil. This means that a hydro-electric power station which produces 20 million kWh per year (20 GWh) produces an amount of power equivalent to 2.85 million litres of fuel oil.

FOREWORD

This brochure is intended to give a brief and simple description of what is meant by a small-scale power plant, how it functions technically, and how much it contributes to the country's power production.

A major part of the brochure is devoted to a small-scale hydro-power station project in the Rakkestad river in the county of Østfold. This project, initiated with the special intention of gaining experience of this kind of planning, will illustrate how a water course can be utilized for power production by constructing small-scale power plants. The Rakkestad project also demonstrates that a water course may serve other interests than power production, and describes the attempts to take care of these interests in the best possible manner.

Department of Water Power Research Information Office
NVE, September 1981

WHAT IS A SMALL-SCALE POWER PLANT?

As the name implies, small-scale power plant is the term used to describe the smaller water power plants. In NVE the present definition of a small-scale power plant is a water power plant with a generator installation of 10 MW or less. Most of them have a much lower installation, often less than 1 MW.

It is possible to develop a head down to 3-4 metres if there is enough flow. 1 MW can be produced if we for example utilize a flow of 1 m^3 per second at a head of 120 metres. If we increase the flow to 10 m^3 per second and reduce the height of the fall to 12 m, we still get 1 MW. (It is worth noting for purposes of comparison that at Eleverum the River Glomma has a mean flow of approx. 240 m^3 per second).

HISTORY

From the turn of the century up to 1940, more than 2000 water power plants were built in this country. Most of them were small rural power plants supplying electricity to a limited area. After World War II, the development of the large power plants started in earnest, and with them the construction of high voltage lines to transmit the power. Furthermore, many of the older, small power plants were becoming very worn down, and the electricity from these was very expensive and unreliable in relation to that produced by the new, large power plants. Most of the smaller plants - the small-scale power plants - were therefore gradually closed down.

But in the 1970s the trend turned. There was increasing resistance to the development of large power plants, which resulted in an interest for alternative ways of obtaining energy, for example from small-scale power plants.

THE TECHNOLOGY IN BRIEF

In A small-scale ower lant the intake consists of a small dam with a gate which can be closed when there is no need of water to the power station. The water is led from the intake dam through a pipe or tunnel to the power station. The choice of pipe or tunnel depends on the situation at the site of the power plant, the soil conditions, the head, water flow etc. From the pipe or tunnel the water enters the power station where it is led to a turnbine. In the generator, which is connected to the turbine, the mechanical energy is converted into electrical energy. The electricity is transformed to the desired voltage and is sent out via the power line grid to the consumers.

In Norway, larger power stations are usually built underground (blasted into rock). Most of the smaller power stations, however, are located above ground.

For a small-scale power plant to be able to compete economically with the larger power plants it is necessary to reduce the operating staff to a minimum. This can be achieved by fitting the equipment (that is to say the turbines, valves, generators etc.) with automatic devices which enable the operations to continue without constant monitoring. This also implies that the power plant will be stopped automatically if any fault occurs. Large power stations either have to be manned, or are controlled from an operations centre, because the consequences of a stop are much greater than in the case of the small power stations.

Another way to reduce costs is to standardize and simplify the equipment. Most producers of equipment for small power stations nowadays offer standardized "package"-solutions.

OLD POWER PLANTS

Some of the power plants which have been closed down can be rebuilt and again made to produce electricity. In some cases, however, the water is now being used in larger hydro-power plants. In other cases the capacity may be too small to justify rebuilding in the near future.

We often find that the old power stations only use a small part of the available head and water.

Today it often pays to utilize more of the head of the river. When redeveloping older power stations this can be done either by moving the intake higher up the river of by moving the power station further downstream.

THE NATURAL LANDSCAPE AND SMALL-SCALE POWER PLANTS

The same environmental problems can be expected whether the hydro-power project is a large one or a small one.

From the intake and down to the power station the water passes through a pie or a tunnel. This means that the flow of water in the river is reduced, or at worst is stopped completely. This stretch will normally be shorter for Small-scale Power Plants than for larger developments. Nowadays it is usual to specify a lest permissible water flow. This can be more difficult in the case of smaller plants because the reduction may then be reduced to such an extent that the development is no longer profitable. Water reservoirs are also sometimes built in connection with Small-scale Power Plants, with the consequences this implies.

Old power stations which are no longer in operation can often be an eyesore in the landscape. To put these in order will have a positive effect on the environment. As well as general cleaning up, the old dams can be repaired and the water raised to its earlier level.

When planning a power plant it is necessary to consider the development of the water course as a whole. In cases where the water course is already greatly affected it is particularly important for the life in and around the river that parts of the course are left untouched. This makes the landscape more alive, and means that the possibilities for leisure time activities and recreation will not be destroyed.

Sometimes, small-scale power plants can be built without any great consequences for the natural or local environment. But in general it cannot be said that the impact on the environment per kWh produced will be any less for small power stations than for larger developments.

REGISTRATION OF SMALL-SCALE POWER PLANTS

In the last few years the NVE-Directorate of Water Courses has surveyed all waterfalls in the country where it is technically possible to build a small-scale power plant. The work has been carried out in collaboration with the Electricity Boards in the different counties. The registration covers the possibilities for constructing new small-scale power plants in places where power stations have existed before.

A total of about 1000 projects have been considered, and of these, about half would be able to produce electrical energy at a cost lower than that of thermal energy. These are distributed in the counties as follows:

County	No. of projects	Mean annual production[1)] GWh
Østfold	7	38
Akershus	10	81
Hedmark	22	233
Oppland	30	446
Buskerud	20	262
Vestfold	3	121
Telemark	38	643
Aust-Agder	22	382
Vest-Agder	33	346
Rogaland	30	483
Hordaland	39	835
Sogn og Fjordane	66	1 271
Møre og Romsdal	99	785
Sør-Trøndelag	19	307
Nord-Trøndelag	27	518
Nordland	65	1 229
Troms	29	564
Finnmark	9	110
Total	508	8 654 GWh

In addition we estimate a further potential of about 100 GWh from power stations of less than 0.1 MW, which are not registered, and about 200 GWh from water works which can be converted into combined power stations/water works. Thus the sum total is approx. 9000 GWh.

1) mean annual production means the average production per year over a number of years.

By comparison, all developed water power in Norway per 1 January 1981 gives a mean annual production of approx. 89 700 GWh.

The registration of small-scale power plants gave little attention to the consequences for the environment. Sc it is too much to expect that it will be possible to develop all of them. The Government White Paper on Energy estimates that by 1990 the energy contribution from small-scale power plants will be in the region of 2000 GWh.

PILOT PROJECT IN RAKKESTAD

A lot more experience is required in connection with the registration, design and construction of small-scale power plants. In the Rakkestad river in Østfold it is possible to develop five such stations. Three have been in operation earlier, while two will be completely new. The NVE-Directorate of Water Courses found that the planning of these power stations would provide valuable experience as regards both technical solutions and costs. Funds were therefore provided for a pilot project in the Rakkestad river, and consulting engineers were comissioned to carry out the planning and design. A project group was also established with representatives from Rakkestad municipality, the consulting engineers and the Directorate of Water Courses. In autumn 1980 the planning and design was completed and an application was submitted for permissio to develop.

The precipication area of the Rakkestad river is located almost entirely in Rakkestad municipality. The river is important to the municipality in many ways. It serves as a source of potable water, for irrigation of agricultural areas, as a recipient for emissions and for the production of electric power. Further, the river runs through central parts of the municipality and is an important feature of the landscape. The mean water flow at the mouth of the Rakkestad river (at Brekke) is about 7 m^3 per second.

The Rakkestad river is poorly regulated, and at times the flow is very little. There are a few small reservoirs high up in the precipitation area which will be used primarily to cover the needs for drinking water and irrigation. It is not expected that any of the reservoirs can be used for power production. Nevertheless, power production from the Rakkestad will become valuable. It is estimated that the five power stations will be able to produce about 1/3 of the present consumption of electrical energy in the municipality of Rakkestad, with its 7000 inhabitants. Mean annual production is estimated at about 20 GWh. The five power stations included in the pliot project are described briefly below.

MJØRUD

The highest power station is at Mjørud, and it is also the smallest. The head is a little more than 6 m, and the generator capacity is somewhat over 0,5 MW. Mjørud has been in operation earlier, but it was found that it did not pay to use any of the old plant in the new power station.

The river head which can be utilized at Mjørud is so concentrated that the power station can be located in direct connection with the intake. In this way a pipe or tunnel is avoided. The remains of the old power station lie on the north bank of the river. Even though this cannot be used, the new power station will also be placed there. Old parts of the installations will have to be removed in any case in connection with the building of the new station. Emphasis was also placed on the fact that there is already some industrial activity on the north side of the river, while the south side at Mjørud is still fairly untouched.

Data:

Height of head:	6,3 m
Generator capacity:	550 kW
Mean annual production:	1,6 GWh

STEMME

Stemme power station is the only one of the five in operation today. However, the station utilizes only a very small part of the total water flow in the river, and the power station itself is old and worn down. Furthermore, the old power station also uses only part of the head. It was therefore found that it would pay to place a new station some distance below the old one. The plan is to use a wooden pipe, 2.2 m in diameter, with a total length of about 225 m. The present pipe is 30 m long. The intake dam is in fairly good condition and only minor repairs will be needed in the rebuilding.

Data:

Height of head:	8.3 m
Generator capacity:	700 kW
Mean annual production:	2.2 GWh

BUER

The entire head at Buer has been earlier used for power production. The old station was closed down in 1962, by which time it had been in operation for 50 years.

Both the intake dam and the power station are still in existence and it is planned to put them in order and partially convert them for continued operation. From the purely economic standpoint it would probably be just as favourable to build an entirely new power station. But emphasis was placed on the fact that the old station is a familiar feature in the landscape, and it was therefore decided to rebuild the power station completely inside. Also in this case a new wooden pipe of diameter 2.2 m is planned. The total length of this pipe will be 540 m and it will follow the alignment of the old pipe.

Data:

Height of head:	16.8 m
Generator capacity:	1600 kW
Mean annual production:	5.1 GWh

GAPESTAD

The Gapestad waterfall has a concentrated head of approx. 15 m. In addition, some small drops below the waterfall will be utilized by means of channelling. In this way, the exploited fall will again be nearly 17 m. If soil investigations in the area permit, a long shaft about 100 m long will be built to take the water from the intake to the power station. The Gappestad waterfall has not been used before for the production of electrical energy, but there are remains of an old mill at the site. This will not be affected by the power station.

Data:

Height of head:	16.6 m
Generator capacity:	1700 kW
Mean annual production:	5.3 GWh

BREKKE

The head at Brekke is split into two, an upper part with a fall of 7-8 m and a lower fall which varies with the level of the water in the Glomma. Here too there are remains of an old mill. These include the remains of a ditch where the water pipe to the mill was located.

The ditch can be used again in the planned power station. The pipe has to cross the river between the two falls, and here the intention is to use steel pipes, and in connection with these construct a footbridge. The rest of the pipe will be of wood, with a diamter of 2.2 m.

Data:

Height of fall:	13.4 - 15.5 m
Generator capacity:	1500 kW
Mean annual production:	4.9 GWh

FINANCIAL SUPPORT FOR THE PLANNING OF SMALL-SCALE POWER PLANTS

Financial support can be provided for project planning of:

- Re-equipment of power stations (also applies to larger power stations)
- Better utilization of the water in already regulated water courses
- Rebuilding of small power stations
- Building of new small-scale power plants.

Owners of power stations or waterfalls may apply for financial support for the planning of the above types of projects. The funds are intended to cover the costs of studies by consultants.

Rules and conditions for planning support for the re-equipping power stations and for building or re-establishment of small-scale power plants may be obtained from NVE-Directorate of Electricity on application. The Directorate will also supply the applicant with further information on the conditions and the form of the application.

CONCESSION PROCEDURES

There is no fundamental difference in the administrative procedures for larger and smaller water power developments. The same legislation applies to all such projects. NVE-Directorate of Water Courses receives and deals with all applications for concession.

Further information may be obtained from:

NVE-Directorate of Water Courses, Department of Water Power Research, or
NVE-Information Office
P.O.Box 5091, Majorstua, OSLO 3. Tel: (02) 46 98 00