Zeitschrift: Wasser Energie Luft = Eau énergie air = Acqua energia aria

Herausgeber: Schweizerischer Wasserwirtschaftsverband

Band: 71 (1979)

Heft: 1-2

Artikel: Stromdalen Hydro Power Plant

Autor: Tøndevold, Erik

DOI: https://doi.org/10.5169/seals-941429

6 Kaplanturbinen, die 1952 bis 1954 in Betrieb kamen, werden die Laufräder erneuert mit schlankeren Naben und 5 statt 6 Laufradschaufeln pro Maschine. Dies ergibt 14 % Leistungserhöhung durch Erhöhung der Schluckfähigkeit und Verbesserung des Wirkungsgrades der Turbinen von ca. 2 Punkten.

Bild 4 zeigt anhand von durch Escher Wyss durchgeführten Umbauten, welche Grössenordnung der Leistungserhöhung zu erwarten ist. Über der Anlageleistung vor dem Umbau ($P_{tot\ alt}$) ist das Verhältnis der Erhöhung der Anlageleistung (ΔP) zur Anlageleistung vor dem Umbau aufgetragen.

In Bild 5 ist das Verhältnis der Erhöhung des Wasserstromes (ΔQ) zum Wasserstrom der Anlage vor dem Umbau ($Q_{tot\ alt}$) über der Anlageleistung vor dem Umbau ($P_{tot\ alt}$) dargestellt.

Diese Diagramme zeigen, dass bei Francis- und Kaplanturbinen durch geeignete geometrische Änderungen und durch Verwendung neuer kavitationssicherer Laufradprofile der Wasserstrom im allgemeinen um etwa 10 % vergrössert werden kann. Bei der Leistung ist wegen der Wirkungsgradverbesserung eine noch stärkere Steigerung möglich. Die in den Diagrammen Bild 4 und 5 einzeln dargestellten Punkte zeigen Umbauten, bei denen die Wassermenge und/oder die Fallhöhe wesentlich erhöht werden konnten. In der Regel werden bei Umbauten Maschinen mit höherer spezifischer Drehzahl verwendet. Bei Peltonturbinen ist dies z. B. mit der Erhöhung der Düsenzahl möglich.

Bild 6 zeigt das Verhältnis der Verbesserung des Wirkungsgrades ($\Delta \eta$) zur Anlageleistung vor dem Umbau ($P_{tot\ alt}$) in Funktion der Anlageleistung vor dem Umbau.

Während bei kleinen Ausbauleistungen bis zu etwa 20 MW Wirkungsgradverbesserungen im Mittel von 5 bis 8 % erreichbar sind, ergeben sich bei grösseren Ausbauleistungen im Mittel 2 bis 5 %, die aber wegen der grösseren Totalleistung um so bedeutender sind.

2.3. Arbeitsbeschaffung

Die Ausnützung der Wasserkräfte durch Umbau und Erweiterung ist auch wichtig für die Arbeitsbeschaffung in den entsprechenden Industrien. Bereits vor 35 Jahren, als die Wasserkraft noch bei weitem nicht so ausgenützt war wie heute, wurde dem «Umbau bestehender alter Wasserkraftanlagen» zur Arbeitsbeschaffung grosse Bedeutung beigemessen [6].

Literatur

[1] Schweizerischer Wasserwirtschaftsverband: Ausmass und Bedeutung der noch ungenutzten Schweizer Wasserkräfte. Studie Nr. 13, Schriftreihe der Eidg. Kommission für die Gesamtenergiekonzeption, 1977

[2] E. Mühlemann: Grosse Kaplanturbinen. «Escher Wyss Mitteilungen» 1969/1

[3] E. Mühlemann: Turbines, Pumps, Pumpturbines, Valves and Penstocks of recent design as supplied by Escher Wyss for Hydroelectric plants. Congreso Panamericano de Ingenieria Mecanica, Electrica y de Ramas Afines. Bogotá — Agosto 1973, Paper No. 13

[4] K. Höller und H. Miller: Rohrturbinen und Straflo-Turbinen für Niederdruck-Kraftwerke. «Escher Wyss Mitteilungen» 1977/2

[5] W. Nüssli, S. Jacobsen, V. Bohun: Erneuerung alter Wasserkraftwerke. «Wasser, Energie, Luft» 69 (1977), Heft 10, S. 235—243

[6] Schweizerischer Energie-Konsumenten-Verband: Der Beitrag der Elektrizitätswirtschaft zur Arbeitsbeschaffung, Vorträge, gehalten an der Generalversammlung 14. März 1944.

Adresse des Verfassers: Dr. Ernst H. Mühlemann, dipl. Ing. ETH, Direktor, Escher Wyss AG, Postfach, 8023 Zürich.

Stormdalen Hydro Power Plant

Erik Tøndevold[1])

Synopsis

Many diversion tunnels have a large head between intake and outlet. For the diversion purpose alone all this head is only required during short periods when the inflow is large. During the rest of the year extra hydro potential is available, and this will be utilized in the proposed Stormdalen project.

Résumé: Le projet hydro-électrique de Stormdalen

La différence de niveau entre l'amont et l'aval des collecteurs forme une chute considérable dans certaines projets hydro-électriques. Cette différence de niveau est exigée seulement pendant les périodes brèves quand le débit est riche. Hors de ces périodes il existe un potentiel supplémentaire de production d'énergie électrique qui sera utilisé dans le projet proposé de Stormdalen.

Zusammenfassung: Das Wasserkraftprojekt Stormdalen

Bei Zuleitungsstollen ergibt sich meist ein Höhenunterschied zwischen Einlauf und Auslauf, der für die Energienutzung verloren geht. Beim vorgeschlagenen Projekt Stormdalen soll auch dieses Gefälle genutzt werden.

[1]) Paper submitted to the International Symposium on Reconstruction and Extension of Hydro-Electric Power Plants, Subject g) Technical and economic evaluation of reconstruction projects, availability of old plants, design data. This Symposium will take place February 28, to March 2, 1979, in Zurich.

Introduction

The Norwegian river Ranaelva (66—67 ° N. lat.) still has undeveloped hydro potential. The tributaries on the South-East side were included in the Rana project commissioned in 1968. In the main river only the head below el. 43.7 is developed in the Langvatn project commissioned in 1964.

Recently the 4 TWh/year plan for Svartisen/Saltfjellet was submitted by NVE — Statskraftverkene for approval by the authorities. The plan consists of five separate developments, and one of them is Nord-Rana, see figure 1.

Nord-Rana utilizes tributaries on the North-West side of Ranaelva. The rivers Bjøllåga and Tespa is diverted to the river Stormdalsåga where the Stormsjø reservoir is proposed. The head from Stormsjø is utilized in Røvatn power station, and the water flows to Langvatn.

So far Nord-Rana is conventional. The topic of this paper is the new idea to utilize the head in the water diversion to Stormsjø.

Basic concept

Many diversion tunnels have a large head between intake and outlet. For the diversion of water all this head is only required during short periods when the inflow is large. During the rest of the year the water level is far down in the intake shaft. To utilize the head between the intake level and the water level must be considered an extremely favourable development as far as environmental problems are concerned.

This is not an ordinary run-of-river station because the station must be designed in a way not impeding the main function of the tunnel, which is to divert water from one river to another. Therefore the station is equipped with a by-pass which is used when the inflow is too large.

Hydro potential

HWL (high water level) at intake Bjøllåga is el. 465. At the outlet in Stormsjø the water level varies between HWL el. 395 and LWL el. 320. Mean annual inflow to the diversion tunnel is 786.5 mill. m^3. According to the preliminary calculations Stormdalen will yield 113 GWh/year.

Intake reservoir

A minimum *surface* of the intake reservoir is necessary to control the water level by means of wicket gate opening. Then the station is operated according to the inflow at the moment, which is the exact definition of an unregulated station.

Looking at the inflow duration curve, however, we see that this minimum requirement alone is unsatisfactory for two reasons:

1. At inflows below the best point the water is used less efficiently. (Best point: The turbine flow giving the largest kWh/m^3.)
2. Below a certain inflow the station must operate in a state causing large cavitation. Consequently it must stop, and this loss is shown in figure 2.

Therefore we always investigate an alternative to try to utilize the inflows below the best point by means of intermittent operation switching from stop to best point operation and vice versa. Such a procedure requires a minimum reservoir *volume* depending on the lengths of time needed for start and stop.

Each transient phase, start and stop, has a cost consisting of energy loss and wearing of the equipment. Fortunately, in Bjøllåga it is possible to establish a reservoir large enough to avoid excessive start/stop costs.

Above el. 465 the valley is flat. To avoid infringing on a proposed natural park el. 465 was chosen as HWL. The dam increases the intake level 25 m.

At HWL the reservoir is 0.3 km^2. Only the upper part will be utilized. For the time being the live storage is supposed to be appr. 1.0 mill. m^3.

Following the load curve

The next step is to consider whether Stormdalen is parasitic on the network. If the reservoir is large enough it is possible to follow the load curve by starting sometimes during the morning load increase and stopping sometimes during the evening load decrease.

Downstream considerations

Free use of intermittent operation is often impeded by minimum flow restrictions downstreams. At Stormdalen, however, this problem does not exist because the outlet is direct into a reservoir.

Strategy

A completely unregulated station doesn't need predictions about the future. However, Stormdalen has a short term reservoir, and the strategy ought to be based on the fact that the inflow is stocastic, not deterministic.

As a project with only short term regulation possibilities Stormdalen's strategy neglects the other stocastic aspects of a power system.

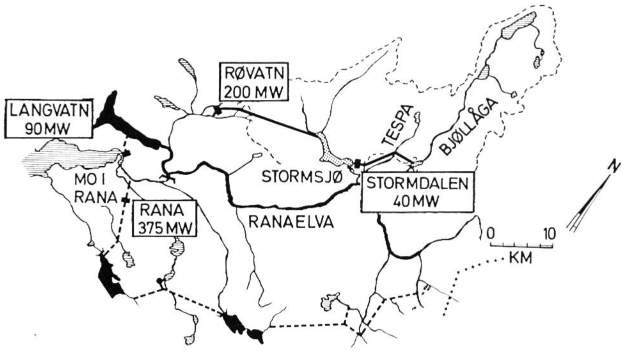

Figure 1. Map of the water power developments.

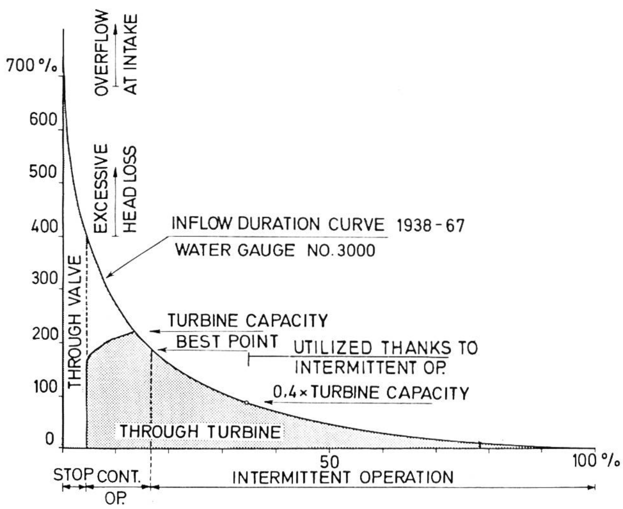

Figure 2. Operation of the Stormdalen power plant. Note: for descriptive purpose alone the variation of gross head is neglected.

Inflow prediction

The daily regulation can be improved by short term inflow prediction. This prediction is of help in two situations frequently occuring:

1. When the inflow is larger than the best point and it has a daily fluctuation, the operation tries to even out these fluctuations by means of the reservoir.
2. During intermittent operation following the load curve the station stops when the drawdown reaches a level determined by the predicted inflow. The start is when the reservoir is full. The deviation from the last prediction is counteracted each evening by the choice of stopping time.

Power station

Due to the large energy production one can afford a complicated arrangement, see figure 3.

But the same principle may be used at several other sites with a smaller hydro potential, and therefore it is mandatory to develop a simple solution.

Small projects may be destroyed economically by just scaling down a large project.

Efforts are now being made in Norway to find simplifications. The results may also be a help to reduce the cost of Stormdalen.

Control

The question is whether Stormdalen shall have an ordinary governor, thereby participating in the frequency regulation. Maybe sufficient regulation can be carried out cheaper in other stations, and then it would be an idea to save investment by choosing a simpler governing device.

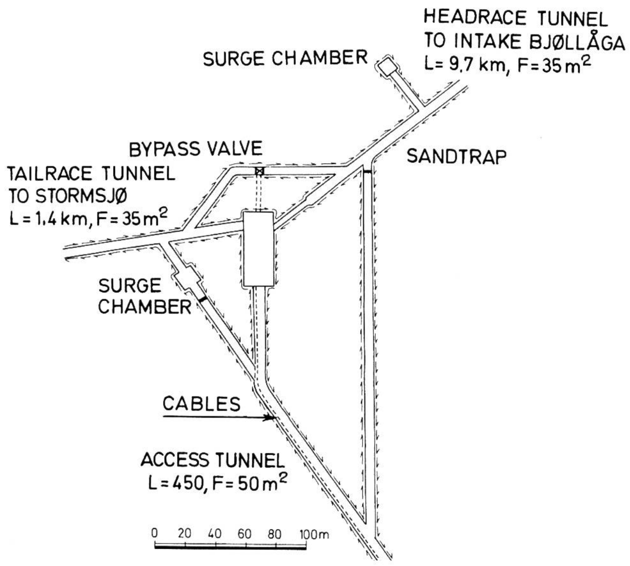

Figure 3. Arrangement of the power station.

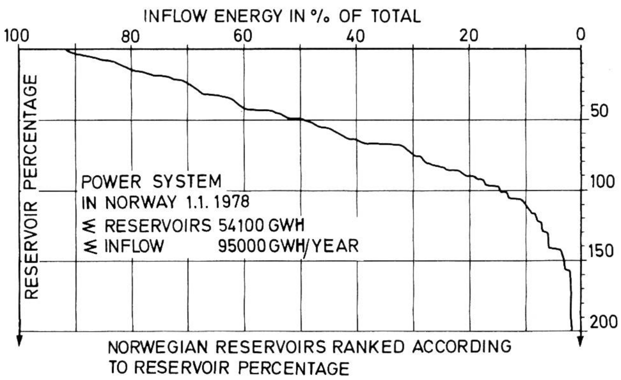

Figure 4. Distribution of the Norwegen reservoirs.

In that case Stormdalen would be an energy producer with a preset schedule as far as power is concerned. However, 40 MW is not a *small* station, and from a system point of view it is probably more economical to let Stormdalen participate in the frequency regulation instead of being parasitic.

Any set point (wicket gate position) and any by-pass operation can be chosen from the dispatch centre by remote control. The water level at the intake is telemetered.

Choice of turbine

The two main data are: maximum capacity and dimensioning head. Here dimensioning head is unusually difficult to choose due to the large variations of net head. These variations are caused by two factors:

1. Head losses due to inflow variations.
2. Variations in the water level at the outlet.

No. 1 depends on inflow statistics, and therefore this calculation is quite dependable. More suspect is the calculation of no. 2, which depends on water level variations in Stormsjø calculated by simulations of the whole Norwegian power system.

Stormdalen has been investigated by a detailed program tailor-made for Nord-Rana. As preliminary design data is used:

Intake, mean level:	el. 463
Stormsjø, mean level:	el. 370
Mean gross head	93 m
Mean head loss	5 m
Dimensioning head	88 m

When the head loss in the tunnel causes the net head to drop below 53 m (60 % of 88 m), excessive cavitation is expected. Therefore the unit is stopped, and all the water is sent through the by-pass, see figure 2.

Maximum gross head is 145 m and occurs when Stormsjø is at LWL. To operate the turbine at such a head would give a wide range of head, causing hydraulic problems. Because the largest net heads only occur during a short period in the spring, little energy would be lost if this range was reduced.

The conventional method is to move the outlet to a higher level, thereby saving submergence cost of the power house. Here, however, there is little to save because the access tunnel anyway starts at a low elevation downstreams the Stormsjø dam. Unwanted loss of gross head would occur when large inflow caused head losses large enough to get inside the wanted range of net head anyhow. An actual alternative is therefore to reduce the range by means of a throttling device. 125 m is a tentative upper limit for the net head.

Cost

The cost of Stormdalen is the increased investment compared to a pure diversion tunnel. At cost level 1976 this cost has been calculated to 104 mill. kr = appr. 20 mill. US $.

Value

Even unregulated energy is valuable in the Norwegian system. The reservoirs are well distributed, see figure 4. During periods of large inflow most of the electricity consumption is covered by unregulated hydro power while the remaining part comes from storage stations.

However, the current trend is towards more unequal distribution of reservoirs. For environmental reasons the new ones are difficult to establish, and they are concentrated where they are cheapest and cause the least damage. Alternative future systems are studied to find the risk of getting a system «saturated» on unregulated energy.

Another saturation problem is to find out whether the amount of summer energy is too large.

Should the future system suffer from large saturation problems, the value of Stormdalen drops. Until now, however, one has been optimistic.

The investment is 104 mill. kr, and the production is 113 GWh/year. 0.92 kr/kWh is considered feasible with a clear margin (0.18 US $/kWh).

Time schedule

To get a concession for the huge Saltfjellet/Svartisen plan is a complex procedure dominated by local and national politics. At least this will be going on until 1981. Consequently no detailing of Stormdalen has yet taken place.

Author's adress: Erik Tøndevold, Chief Engineer, Debuty Head of Hydro Power General Planning Division of the Norwegian State Power System (NVE — Statskraftverkene), Middelthunsgt. 29, Oslo 3, Norway.