

NORWEGIAN HYDRO POWER AND NEW FOCUS ON SMALL HYDRO POWER

Einar Ove Andersen
*Agder Energi Group
Norway*

INTRODUCTION

Norway and India are both in the Upper Ten list over countries with the biggest hydro power production in the world. A list where Canada is on top, Norway number 6 and India nr 8 and China number 4.

Norway is the biggest hydro power producer in Europe, and our hydro power industry has traditions over a 100 year long time. In this time we have reached an installed output in our hydro power stations of today 27.470 MW. We have 857 hydro power stations over the whole country to produce hydro electric power.

These 857 stations have a capacity in a middle production year to produce 119 TWhs. or 428 PJ (Petajoule) (119 000 000 000 kWh).

In Norway we had the peak time in our hydro power development from 1970 to 1985. In this 15 years we increased the installed output of 10.730 MW!. After 1990, we have had only minor hydroelectric or other renewable sources developed. This winter Norway is facing an essential rise in the prices for end costumers and industry for lack of water in the big mountain reservoir. This will lead to at least an increase in mini and micro power plants.

In accordance to your energy programme India shall within 2030 reach 50.000 MW of hydro electric power and a share of 30% in SHP's or 15.000 MW.

This is quite a challenge to achieve, but you have a better time and more hands to reach your goal, than we had to reach our, so I'm sure you will succeed. Especially when you open up for foreign investment. We did the same in Norway too.

I think it is rationally to open up for private investment and use of incitements for both Indian and foreign investments for renewable energy sources (RE). The world will need more and more RE production in the future.

For companies in countries like Norway and Canada, which have nearly fulfilled the hydro power possibilities in own countries, for them it will be more an more natural to contribute with theirs know how, investments, systems and routines in countries over the world in need for renewable energy and reliable power to people and industry.

To day we have moved our power industry to Asia, and we buy hydro power equipment from former USSR land and from Asia.

For many companies like my company, a combination of investment in SHP and in the equipment industry for power plants and infrastructure for distribution can be of interest if the conditions for a pay back is better than national alternatives for investments. India seems to be in a stage of making foreign investments attractive for RE projects.

Let us go back to Norway again:

In Norway we have 99% of all electricity production from hydro power plants. Wind, solar, thermo plays an immaterial role in our system for industry and consumers. The consumers in Norway use electrify for heating of house, cooking, and light and almost all other activities in a house that need electricity over a battery support.

When we look to the world list over the electric consumption for the world, Norway uses over 23.000 kWh per inhabitant, which is 35% more than Canada and over 50 times the consumption per inhabitant in India.

In Norway we now see a rise in planning for SHP plants over the country, as well as huge plans for wind power (wind mills) over the whole coast of Norway.

An SHP in Norway is in the range 1-10 MW, not up to 25 MW as in India.

The regulation of SHP in the last 5 years is a way to take out more hydro power with little impact to the local environment. The epoch of big hydro electric power schemes with big reservoirs, tunnel system, stream intake system is over I Norway. The ruling politicians of Norway have several times said we shall go for wind power and bio mass power and develop so called clean gas power stations, a technology not in common use today.

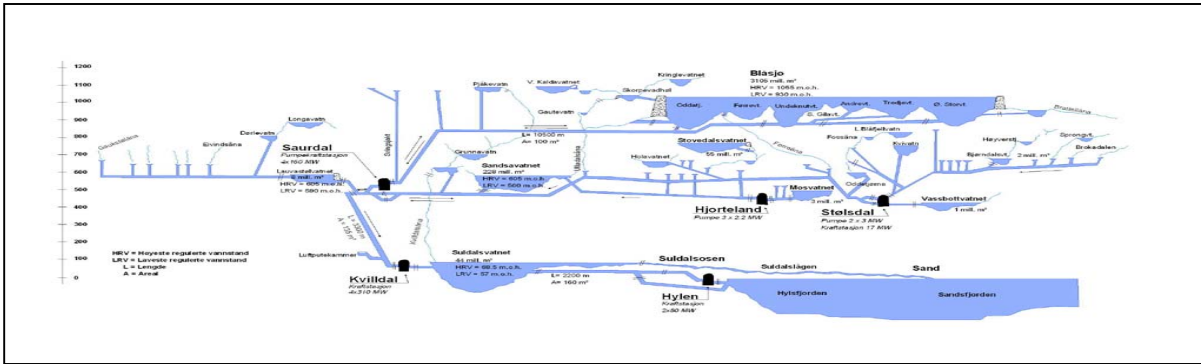
As you probably know we produce our own gas out of the North Sea, and sell it to Europe, where they produce electricity of the gas and sell it back to Norway over the trade pools and we still get the pollution from European winds we wanted to avoid and still have a CO2 problem to resolve.

We have also a potential for increase production of HP in better use of the existing power plants. With new design for the plant with better waterway solutions, bigger tunnels, better generating units and use unused heads from dams and waterfalls; will all give increased productions, but then they often ruin the SHP plans the local farmers have in the same area.

So we see the beginning of a “struggle” between traditional hydro power owners, and the farmers/investors who want to find a new, good and secure way of income.

In fact we have to do both, but give a priority to the best plan in each group. This will be a good contribution to the thermal and wind plants production and will secure our aim to have both hydro power and good nature adventures in the future.

The power plants in Norway is of several types from SHP's to traditional hydro power plants like the biggest one in Norway : the Ulla- Førre power plant scheme. I was asked to give an example for a big power plat systems we have in operation on this summit even it not a SHP system of power plants. Of the over 857power plants we have most under 25 MW output and in India this is defined as a SHP plant.



Ulla – Førre hydro electric system model

Here is the biggest hydro power station in Norway located, Kvilldal, with a capacity of 1240 MW in the station.

This station alone produces over 3500 GWh a year. The biggest water reservoir “Blåsjø” contains 3100 millions of m³ of water that can be transformed to 7759 GWh when let through the tunnel system and in to the station system.

Agder Energi Group and AEP have a part in this plant.

This is a kind over water regulations for hydro power will not be seen more of in Norway. For the future it is more SHP and renovations or better solutions of existing plants to produce more in existing plants that will be accepted by all parts in the increasing power debate in Norway.

As an example for a SHP, I will introduce to you the latest SHP to the AEP SHP plants commissioned in 2007:



This is Uleberg Small Hydro Power Plant
 Francis turbines 2x4,6 MW from GE
 Installed 9,2 MW
 Head 180 m
 Annual Production 38 GWh
 Total Cost : 10.000.000 USD
 From start civil works to produce first kWh it took 16 months.

The station is built up of components from seven different countries. This tells us how international the SHP developing is. Among these countries we find Spain, China, Poland.



Uleberg machinery room



Uleberg outside

SHP IN NORWAY : POWER FROM THE DISTRICTS

SHP is the only alternative to achieve further hydro power plants in Norway and the electricity boards and private investors are looking for the streams in hilly sides of western part Norway and the lake systems as well for a plan of SHP.

This year the power prices is assumed to be the highest in the history of electrical distribution to costumers in Norway.

In fact the industry, having long term agreements (PPA) for electricity and therefore have very low price pro kWh, they have agreed with the Government to stop the factories and sell the power to the national player Statkraft.

Statkraft is by law the player given a certain role when a crisis in the market occurs.

So after 100 years of power development for the industry and our inhabitants, the prices can be so high that the industry earns more money to stop the factories and let the workers go in vacancy.

This is for Norway a one time situation, and will force SHP's, wind mills, and electricity out of gas turbines, waste projects and bio power projects to be built as soon as possible. The politicians have to find solutions on short time basis and long time basis, and this can lead to a change in hydro power based electricity used for heating of houses.

The prices for electricity has historically been very low, but will within a few year be alike the normal price in northern Europe like Denmark or Germany.

In fact the whole Nordic system is in a crisis with lack of water in the Norwegian and Swedish mountain reservoirs due to little snow in the mountains in winter time and a hot, dry and beautiful summer from the middle of may to the end of September. This summer is the best summer for over 100 year measured by temperature and the absence of rainy days and nights.

Sweden they can normally supply us with nuclear power, but this year failures came to their stations and they had to shut down or lower the production in these plants.

As this was not enough, one of the power transmission cables between the Nordic country Denmark and Norway went down.

These conditions give the owners of SHP's in Norway golden years. High prizes over time, a moderate investment cost (from 1 NOK/kWh or 6, 5 Rs/kWh up to 3 NOK/kWh or 20 Rs/kWh), will without any incitement from the Government, be a good investment to the owners over time.

THE SHP's GOOD VALUE FOR MONEY INVESTMENT

We see producing cost of 0,1 NOK which is under 1 Rs pr kWh produced in the plant and they sell it for more than 0,6 NOK/kwh or 4 Rs pro kWh to the grid. Myself as an end user pay with taxes and grid cost about 9 Rs pro kWh from the supplier.

NVE, the Norwegian regulator of hydro power, have now about 250 applications for building allowance for SHPs, and they already admit the time to get allowance will exceed. When they in 8 months managed to give acceptance to 20 applications for SHP; they have to get more resources and make a priority list.

It's not unusual that allowance will come after 3-5 years due to environmental conditions and the impact of the use of the area for dams, roads etc.

At the same time they have quite a big number of wind mills applications for construction in big wind mill parks.

In Norway NVE has mapped out the full potential for SHP projects possible to build for a totally cost before commissioning of 3 NOK/kWh or 20 Rs/kWh . Of this potential of 25 TWh; NVE think it is realistic to take out about 5 TWh for further development.

We have through use of digitalized maps, and have used a digitalized water model for 3D construction for waterways and simulated plants. This model came up with 5000 possible projects .

Mostly the SHP's are over 1 MW, with a considerable group of projects 5-10 MW. Totally this represent an increase in total production of hydro electrical for 2,7 TWh yearly renewable energy. That is 9,7 PJ(Petajoule).

In Norway this is considerable amount of energy, but this energy come from unregulated rivers and streams with a strongly reliance of rainfall for production or need of melted snow in the springtime.

The most interesting power plants for us are therefore stations based upon a dam based production, but these projects NVE hardly see to day.

We have also another problem for our SHP projects. If NVE should be left-handed (but they never are!) in their acceptance process, we will meet a capacity problem for the civil work, design and specially the equipment delivery group would not be able to handle in a short time 150 projects.

We have our own production of equipment for SHP, we buy in eastern Europe (former USSR countries) and of course from Asia. In fact a huge need for SHP components can be a challenge for equipment producers and a threat to SHP programmes for example in India.

AGDER ENERGI GROUP A LOCAL, NATIONAL AND GLOBAL PLAYER



1100 employees in AE Group

The AGDER ENERGI GROUP is located in the southern part of Norway and is an industrial player with the following business units : Energy , Distribution, Market, Services.

The Agder Energy Group have also within Market and Services daughters doing all kind of infrastructure installations for telecom and electricity boards on an offshore work (420 kV down to house wiring, broadband & fiber to the home (FTTH) and mobile phone sector)

Consultant for all steps in power plants, transmission lines and stations.

For power production we are using thermo, bio and wind beside hydro power.

AEP- is organized into two main units:

Ownership and development of power plants and projects *and* operating and maintenance of power plants and projects

AEP is the second largest operator of hydro power plants in Norway, measured in number of generating units.

We operate today a total of 36 hydro power plants and operate with the full responsibility more than 100 dams.

KEY FIGURES 2005

Hydro production p.a. (TWh)	7,4
Commissioned effect (MW)	1820
Operating result (M USD)	ca. 120
Total capital (M USD)	1050
Ca. 180 employees	
Sole ownership	30 power stations
Part ownership	16 power stations



AEP owns 20 % of the stock in Smaakraft AS, the leading turn-key SHP company in Norway. About 35% of all remaining SHP potential in Norway is present being developed by Smaakraft. AEP is involved in several of these SHP projects. We have focus on standardized, cost efficient turn-key projects of high technical quality.

We are now a national player for wind power development as well as bio fuel and waste projects in Norway.

In Norway we have a benchmarking project where the dominant power plant owners are participants on a voluntary basis.

It is essential to find the best model for cost efficiency for each produced kWh, to have money for further investments or pay back to the owners.

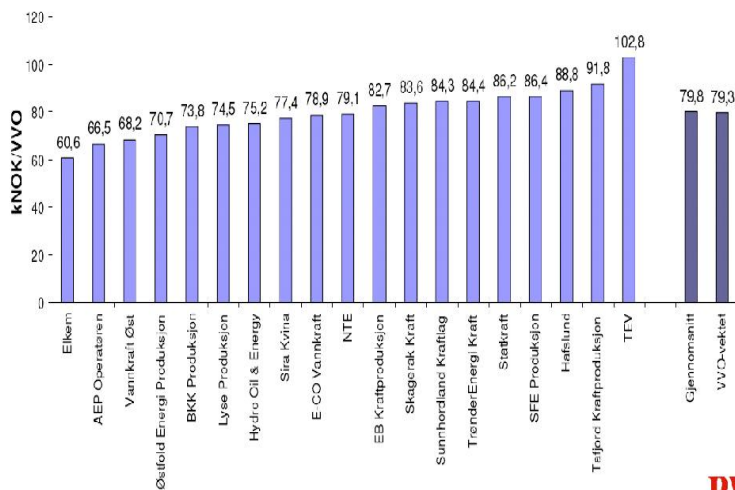
The benchmark is a cost efficiency metering method for each owner and a comparison for the whole group on an equal metering system of so called VVOs. Translated to English this is Balanced Maintenance Objects (BMO). These BMO's give us an equal measuring point for components in a station (or factory for that matter).

The group use today a new and better BM model than in the beginning of the method and now is included more measuring units in BM model than ever before.

To day 17 companies is participating in the BM

This lead to a more and more significant model to find out who is the best (have lowest cost of the BMOs) and then the task is to analyze why you are beaten this time, and take out a plan for improvements to be better for the next measuring point.

AEP use a maintenance data programme where every vital component in a power plant, dam tunnel and other parts in the system is registered for when installed, the manufacturer, special info for service and care and all kind of vital data what maintain program the item need to function for its purpose. All items is registered in a database.



The figure shows the total cost pro VVO unit for operating the plants, maintenance, the plants and rehabilitation.

From the table a cost in AEP controlled plants that cost 66,5 units will the same cost be 102,8 units.

This puts AEP on top in power plant operating and ownership .

PA AEP is pride of this position.

For land like India, with a huge program for installed MW in the coming years in SHPs, it is vital to have a benchmarking system like the Norwegian BM, and have a methodical way to both planning, operating, maintenance and rehabilitation work.

This is the only long term way to achieve lower cost pro kWh and reduce down time due to failure in the power plant components or due to human failure caused to weak routines.

You will with your plants have to make your own BMO's, but the system and the basic data and confirmed policy for maintenance will be the same.

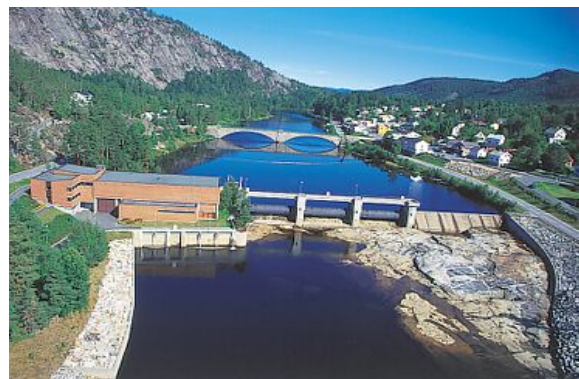
If this is not put into system like the way AEP did to manage operating all the different power plants in our system, you will have uncertain delivery of power to the grid and the expected economically result for the financial owner will be reduced.

Agder Energi Group is now looking for possible global challenges in the new strategic planning for the future. The new strategic document for the group will be active from January 2007.

We will, if it is a part of the strategic choice, use AEP to take part in projects abroad and find our place both as an investment part in foreign countries and as a buyer of all types of equipment for power plants and all kind of infrastructures.

Vital is to find good partners and profitable projects.

India seems to be an interesting choice in all these strategic perspectives if the global line is the line Agder Energi Group will use.



The Åmli Power Plant commissioned 1983 24 MW - 85 GWh