# Do Small Hydro Power need to be a scaled version of Large Hydro Power?

**Mads Grahl-Madsen**
**President, CEDI Sp.zo.o**

## *Introduction*

At first let me state that this by no means will be a scientific paper, this paper express nothing else then some thoughts about the future of Small Hydro Power, and Hydro Power in general, that solely is on the account of the author. Further, more questions will be asked then answers given.

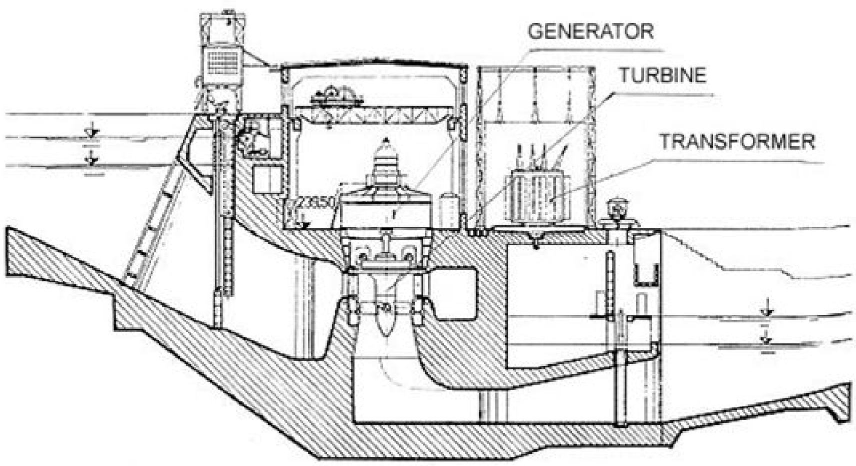


**Figure 1 Traditional layout of low head power plant**

Figure 1 shows the traditional layout of a Low Head Hydro Power Plant, and it is mainly the same whether the installed power is 100 MW or 100 kW.

**Figure 2 Oftedal Small Hydro Power Plant (Norway) 2006**

Hydro Power has a long tradition, centuries back, and probably the discovery of electricity changed the business more then any other happening through the history. Electricity enabled the transmission of power over relative long distances, with out significant losses compared to the old mechanical transmission system. At the same time it introduced the large power schemes which produced more energy then the local community could consume. However, nothing else has changed much. Oftedal Power Station (3MW) was opened in southern Norway in 2006, and went into the history as another Hydro Power Station with a architectural prize for design. Through history one could sometimes believe that achieving such prizes were the major force for any Hydro Power Development. Engineering pride, instead of engineering creativity has been the case much too often.

Returning to Figure 1 it is easily recognized that all components that together make up the power station, dam, generator, turbine runner, turbine guide vanes, spill gates, other gates, is therefore a purpose. An approach to reforming the structure of a Small Hydro Power plant would obviously be to look on the functionality of each of these components in a framework of a power station that is not dominating the grid, but only supply a fraction of the power that supply the grid. There must be a difference between the specification to be complied with between a power station that deliver 300 MW to the grid, and the power station that supply 1 MW to the grid.

What is the purpose of a Dam in a low head power station placed in or by a river, as illustrated in Figure 3? The answer is rather obvious. It is going to focus the water towards the turbines rather then allowing it to flow down the river. If the topology allows it can also be used to gain Head, and therefore increase the energy output of the power plant. Which factors decide on the dam’s construction, again there is an obvious answer to that? The local geology and the water pressure acting on it.

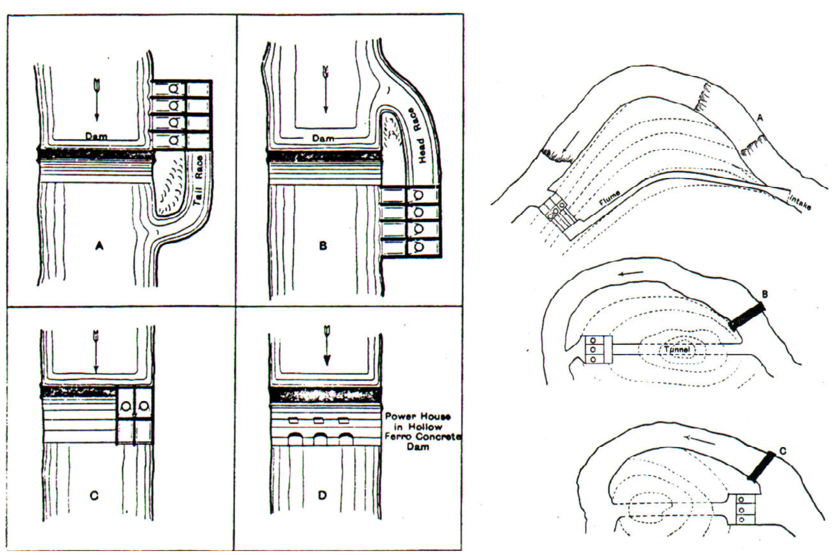


**Figure 3 Configuration of Low Head Power Plants**

What if there is coming more water down the river then the turbines can swallow? Well there is an obvious answer to that too, the water level behind the dam will increase and eventually flow over the crown of the dam. To have a controlled flow through the dam, that will not harm it spill gates are installed. In large dams where the hydrostatic pressure on this gates are substantial hydraulic operated sector gates made of high quality steel is often installed. On a small dam where the hydrostatic forces are smaller, this can not be necessary. An American company has come up with a smart solution, shown in Figure 4, which combines the dam and spill gates where it is taken benefit from the low hydrostatic pressure in the selection of materials and actuating system. The gates can be placed directly on a concrete foundation (step) an will form the actual dam itself. Compared to the balloons we use in Poland, this system is active and more wear resistant than the balloon is. The system is patented, and shows engineering creativity.


**Figure 4 Pneumatic operated  Spill Gates forming the dam**

**Figure 5 Polish Power Plant with Balloon**

The wicket gate or guide vanes of a turbine, Figure 6, serve mainly to control the flow into the turbine runner and through that the output of the turbine. In High Head power plants where long penstocks occur they must be carefully controlled so no dangerous pressure transients occur during operation or close down on the turbine. In Low Head power plants this is not a problem and the wicket gate are mainly used to control the turbine output in accordance with the demand in the grid. In a small turbine that produce 1 MW, there normally is not a need to control the output because the produced power at all times will be lower then the minimum consumption in the grid it is connected to. The wicket gate could therefore easily be omitted without any consequences. However, there could be environmental constrictions that make controlling the flow (not output) and in these cases the wicket gate still will be needed. The above argumentation seems quite logical, at least to the author, but still most new Small Hydro Power Plants are equipped with conventional wicket gates, in fact the author only know one manufacturer in White Russia who offers Kaplan turbines without this controlling device. I might very well be wrong on this, but that only underline my continuously need for learning.

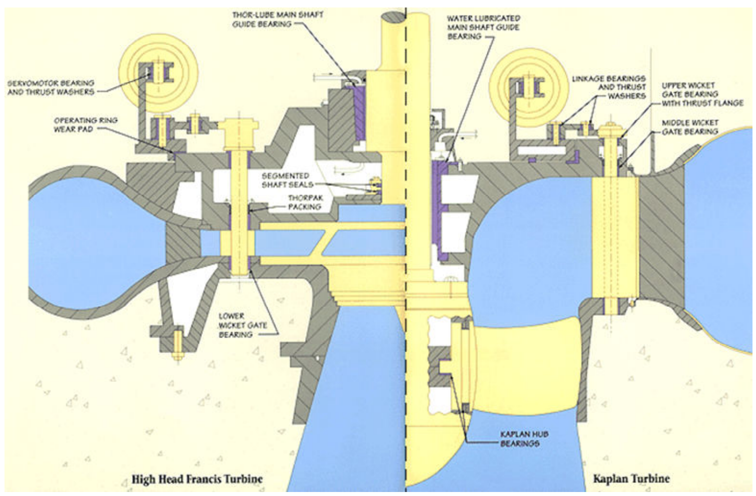


**Figure 6 Wicket gate of Kaplan and Francis Turbine**

Going around looking at Small hydro Power plants, the author have found that there a substantial amount of them that have quite long open supply channels. They are not only long but they are very nicely made, some of them even have sidewalls made of neatly laid natural stone. The association to Roman aqueducts feels quite in place when admiring the stone work. It is like the owner wants to leave a monument behind, a monument that can be admired a thousand years later like we to day admire the Roman aqueducts and Colosseum in Rome.

- However I see some problems.
- They are expensive
- They collect a lot of trash
- They must be frequently maintained to keep a low flow resistance
- They are a hazard to the public

**Figure 7 The author admires the flow through an supply channel for a power plant in the Polish Mountains'**

There is an obvious alternative, dig down a plastic pipe. There have to be some digging to make the channel anyway. This way most of the disadvantages listed above will disappear. Not only that the impact on the surrounding nature will be less obvious, and one could even create a park for people to enjoy them self.

**Figure 8 Modern Plastic Pipe they come in all sizes**

At last let us return to the turbine. Since Edison the Hydro Power business have taken constant speed operation as a law of nature. In relation to classical technology this was most certainly through, the generator had to operate at constant speed in order to maintain a constant frequency. Today, with the developments we have had in electronics this is by far a law anymore. Technically there is no necessity for the turbine to operate at constant speed, electronics fix everything before the energy is supplied to the grid.

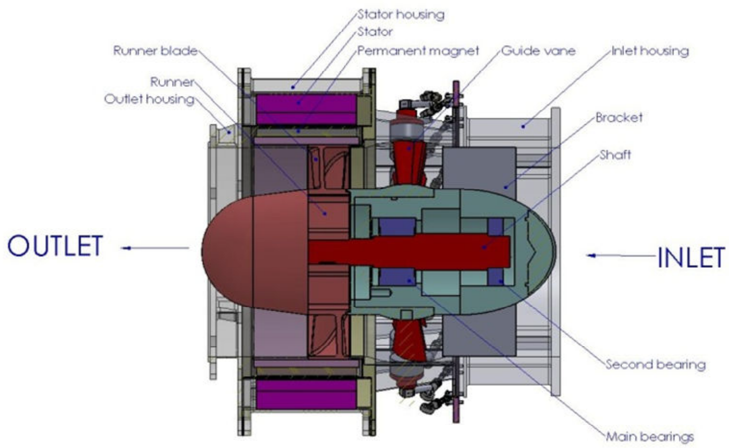


**Figure 9 Turbinova integrated variable speed turbine**

Figure 9 shows Turbinova's integrated generator and turbine. The turbine is operating at variable speed and equipped with fixed runner blades. Everything is changed, but not really.

It is the author's intention that the discussion above should make creative minds reflecting, not to give answer to the future challenges. I have probably missed essential things, but again that only shows that I as the rest still and always will be on the learning curve.