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HYDRO POWER – THE LOCAL EXPERTS

Proposal for underground hydropower

Background

Hydropower is the term used for the generation of electricity using the potential energy in water due to gravitational forces.

The first power plants ever constructed actually used hydropower and therefore hydropower is nothing new.

There are a number of different turbines on the market that uses water as the feedstock or source of energy. The formula for hydropower potential is straight forward. It is simply the volume of water in cubic metres per second available multiplied by the height (m) available multiplied by the gravitational force of the earth and then making allowance for the efficiency of the turbine and generator combination.

South Africa and the world have a vast number of mines of varying depths. Almost 90% of the mines in the world utilises water underground which is sourced from surface. We are all so used to mines pumping water and sludge out of mines that we have forgotten about the opportunities of recovering the energy from the water that we send underground.

Underground mines are very seldom less than a couple of hundred metres deep. Certain very deep mines are even up to 3 000m deep. If a mine of a depth of 3 000m uses only 100 litres of water per second, then that mine can easily generate 2,3MW of power from this meagre supply of water. One of the obstacles is the fact that with the above method of calculation the water after exiting the turbine is at 0 bar pressure. The mines send the water down to do some work and they normally require the water to be at pressures varying from as little as 5 bar to as high as 20 bar pressure.

This does not mean that you can no longer generate electricity we are able to deliver the water at the required pressure to the mine. 20 bar Pressure is for example equal to 200m of head and 5 bar pressure only equals 50m of head. Thus if we still take our example above, we can by delivering the water at 20 bar pressure still generate 2,2MW of power and at 5 bar almost no change to the 2.3MW of electricity.

How do we do this? This is quite simple. All we do is to install a back pressure turbine that exhausts the water at the required pressure.

For a more realistic mine having a depth of 500m to the working face and requiring 5 bar pressure and having still 100 l/s of water, we can generate 350kW of electricity.

NOW THIS IS ENERGY EFFICIENCY AT ITS BEST AND IT IS CLEAN ENERGY!!

What do we propose?

Profound Engineering is a turnkey engineering company specialising in small to medium sized hydropower plants (100kW – 5 MW). We specialise in the design, supply, installation and commissioning of the entire system.

Our in house engineers design everything from the mechanical piping, turbine, controls and instrumentation and the electrics required to tie the plant into the electrical underground system.

Profound Engineering has been involved in a number of power and mine projects throughout its existence and therefore know both environments in depth.

Profound Engineering thus proposes to interested mines the opportunity to procure hydropower plants in your mines underground for the recovery of the wasted energy. We will conduct an estimate of the full opportunity costs.

Currently mines utilise pressure reduction valves to drop the pressure in the piping to the desired pressure to enable them to receive the water at a reasonable or working pressure.

We will not replace your existing pipework at all. We will simply install our turbine/s in parallel to your pressure reduction valves. The pressure reduction valves will be closed once the turbines are operational and will remain in standby should our turbines trip or be stopped for maintenance. The exhaust side of our turbines will be connected again to your mines lower pressure supply system to provide the water at the required pressure.

The additional advantage is that the water does not need to be of potable water quality, but raw water can be used for the generation of the power.

We will install all the electrical equipment required to interconnect to the mines underground electrical infrastructure. We will also provide the synchronising equipment to ensure that we can safely synchronise to the mine power network.

We will supply all the necessary valves, pipes, turbines, civils, designs, etc. required to ensure a complete operational system.

Our turbines also have a very wide turn down ratio. It can normally handle anything from full flow up to only 10-20% of full flow before the turbine will be stopped. Under these extremely low water flow conditions you will be reverted back to your standard pressure reduction valve station. When the water consumption levels pick up the turbine generator will automatically be restarted.

What do we need from you?

The mine will have to provide us with access so we can investigate the true potential. We will also need flow measurements over time to prove the availability of the resource and the times that the water will be available.

We will provide the mine with a Lump Sum Turnkey quote for the turbine or turbines. If the mine accept our quote they will be required to provide an order. Typically it will take approximately 12 months to do the entire project from date of order.

Completed Hydro Projects

HARLESTONE POWER PLANT

This project consists of a 450m concrete lined canal taking the water out of the Mooi River in Kwazulu Natal, South Africa. The water is removed from the river at a weir stretching across the entire river and thus also providing slight head for water to be forced into the canal off take structure.



Weir in the Mooi River stretching 30m in total across the river.

At the side of the weir an off take structure exists with a gate valve to enable isolation of the canal and penstock.

The canal was an existing unlined canal, but the canal was cleaned and lined during this project to ensure that minimal silt transfer and erosion occurs.



Section of the Canal



Canal end with screening grid to remove foreign objects

From the end point of the canal to the turbine house we have a fall of approximately 40m in the vertical stretching over 120m of penstock (pipe). There was an existing steel pipe installed of 600mm diameter, but due to the increase in size of the power plant we required an additional penstock of the same diameter.

At the bottom of the hill the two penstocks are merged into one pipe via a Y-piece steel section, before the water flows through a main shut off valve into the Francis turbine. The main shut off valve is designed as a fail close valve with a hydraulic power pack keeping the valve open during normal operation and gravity together with the water pressure closing the valve if the unit trips or if there is a complete power failure.



500NB Butterfly Main Isolation Valve

Loading of the turbine is controlled via guide vanes inside the turbine controlling the amount of water and thus the speed of the turbine. The generator is an asynchronous (induction) generator that works on the principle that the unit must be synchronised (connected) to the grid to be able to generate electricity.



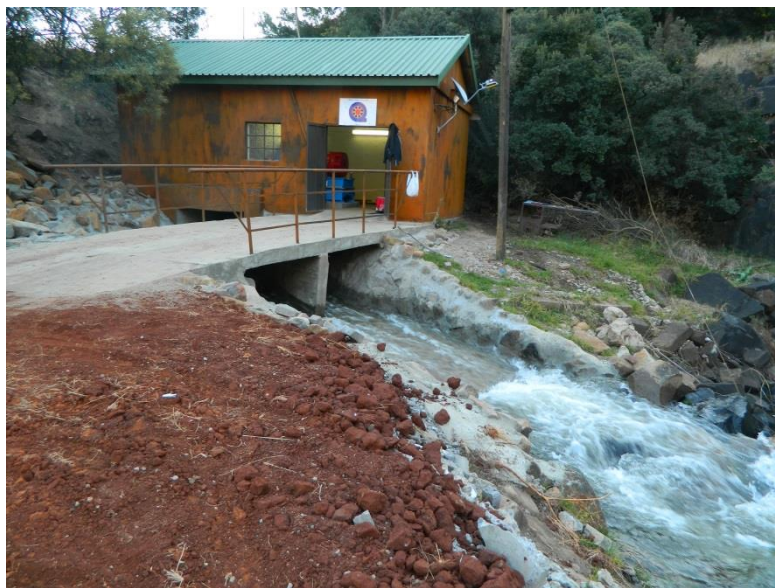
Turbine generator during cold commissioning

The turbine generator and control panel is housed inside a concrete turbine house with a corrugated roof structure.



Control Panel

All the equipment utilised inside the control panel is locally available, therefore ensuring maintainability of the system. Due to the remoteness of this plant, no cellular reception is available at the site. In order to overcome this problem, we installed a permanent satellite link, providing telephone and internet communication facilities.

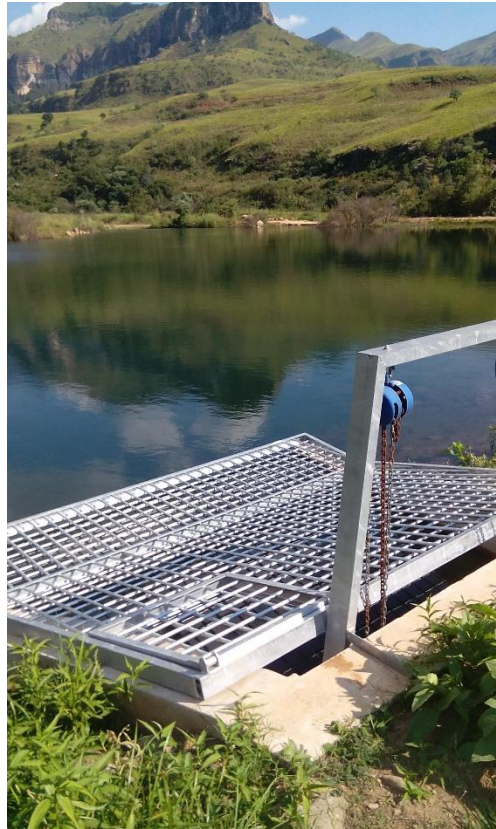


Turbine house with water flowing out of the turbine back into the river.

CATHEDRAL PEAK POWER PLANT

Profound Engineering has been tasked with designing, supplying and commissioning a hydro power generation plant at Cathedral Peak Hotel in the Drakensberg.

Water supply is derived from 2 sources the Mlambonja River and the Umhlonhlo River. The Mlambonja River feeds into the Trout dam via the trout farm and is considered to be the main source of water.



Water off take at Trout Dam

The design was based on inputs and outcomes as given by the client. A full aerial survey was done of the entire site to determine all the levels and thus to optimise the output of the power plant. In the end the design called for an operating level of the Trout Dam to be 2 meters of Head above the off take pipeline. This is required to ensure flow through the 2 x 600 NB pipelines to the surge tank. The total length of this pipeline is 875 meters and was installed completely underground.

Capacity of the Trout Dam was calculated to be 15 120m³ this is equal to 3 hours of 100% operation without any inflow. In the end we achieved a total of 4 hours running at peak power before the dam is drained.

The maximum power generated by the plant is 450kW, however once the level starts to drop in the dam the output falls as well until it stabilizes at around 400kW of power. To sustain this output the plant require approximately 1130 l/s water through the Penstock. The Penstock pipeline is also two by 600mm diameter pipes.



Penstock during construction

The generator is a synchronous machine meaning that the unit must always operate at synchronous speed. Synchronous speed is 750 RPM.



500kW Turbine Generator

The electrics consists of the 11kV switchgear as well as the control panel, which includes the synchronising equipment and control PLC.



11kV Switchgear



Control Panel being commissioned

The hotel now experience virtual “free” power as the hydro power plant generates most of its required power.

Conclusion

Profound Engineering has done power projects in excess of 400MW to date. With our now in house design of the hydro turbines we have proved that we should be your partner of choice for any power generation project.