

# REFURBISHMENT OF TWO SMALL HYDROPOWER PLANTS

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Abstract: A weir at the River Gail, which was used for floating timber in the 1960s has been modified to produce electricity at HPP Wetzmann. The rehabilitation required implementing several sediment and flushing channels, new automatic gates, an improved intake as well as a new fish bypass, waterproofing measures in the basin and a raised reservoir level.

HPP Hochsteiner was damaged through scouring of the weir foundation which caused a malfunctioning of the gates. The question of whether the plant should be removed or rehabilitated was evaluated in conjunction with the planned flood protection measures. Examinations showed that a new and wider weir with a deeper weir top height and a new flap gate as well as a partial lowering of the river bed by dredging could fulfill the flood protection and energy production requirements.

## 1 Small Hydro Power Plants Wetzmann

The river Gail has its source in Eastern Tyrol and runs through the Lesach Valley which is deeply carved into the southern limestone alps. Due to a lack of streets it was quite difficult to access the Lesach Valley in the past. Therefore, water played a highly important role as a means of wood transportation. The floated trees were disembarked at the so-called floating weir Wetzmann at the valley exit and then subjected to further processing. Wood floating essentially ended in the Gail and Lesach Valleys with the creation of road infrastructure and was completely stopped in the mid-1960s.

The first small hydro power plant Wetzmann I – which was built in 1923 and had a capacity of 24 KW – as well as the expansion in 1927 with a drop height of 5 m and an energy output of 90 KW were closely connected to the wood floating.

The prerequisites for extending and modifying the power plant for additional power utilization were ideal after the wood floating was stopped. Thus, a second small hydro power plant with a capacity of 556 KW and an average output of 3.6 GWh was built in 1988. Since then, the former floating weir is only used as water intake, sedimentation basin and reservoir for the two small hydro power plants Wetzmann I and II.

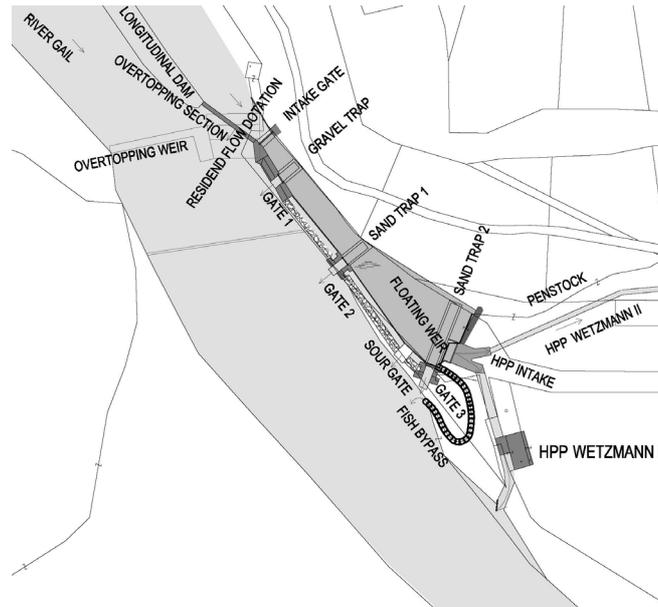


Fig. 1. Position of floating weir and river diversion

The river diversion to the weir was situated at the outer curvature and therefore ideal for wood floating. Since the river Gail is extensively carrying sediments, a large amount of coarse sediments was deposited each year which was stored above the weir and only transported into the successive flow section of the river Gail via the weir during larger floods. These edge conditions were partly not satisfactory for operating a hydro power plant. Thus, a channel had to be excavated at the outer curvature of the river at least once a year. In order to improve the hydro power operation, a longitudinal dam was additionally banked up from river sediments in the river bed of the Gail. Even though the longitudinal dam was annually overtopped and partly displaced again during medium water flow, the situation was improved during normal water flow. In addition, a concrete leading toe wall was implemented immediately before the intake. Supplying the intake with the river flow is difficult without a deep channel (talweg), a longitudinal dam based on river sediments and a concrete leading toe wall and not guaranteed due to the constantly changing river bed conditions. Due to operational reasons and despite the improvement measures in the inflow area, it was and still is necessary to close the intake during medium and larger floods to prevent an increased amount of coarse sediments and driftwood etc. from entering the floating weir.



Fig. 2. Upstream longitudinal dam with concrete leading toe wall

The inspection of stability and impermeability of the existing floating weir and the side wall showed that parts of the structure had larger leakages and that the stability was not assured in some areas of the supporting wall. In addition, it became evident that important operational installations such as the flushing gate sealings, mechanical gate controls as well as timber sluice gates etc. had to be rehabilitated immediately. The lateral stone wall of the floating weir and the floor were sealed and covered with timber boards. Parts of the plant were damaged or completely destroyed and did not fulfil their original functions anymore. Furthermore, the concrete and steel constructions in the intake section and sediment flushing channel showed deep tracks and were damaged due to sediment abrasion.



Fig. 3. Sediment abrasion in concrete and granit lining at the intake



Fig. 4. Damages in gravel flushing channel

The owner decided that the plant should undergo an overall rehabilitation and that the sediment transport facilities, gate controls, inflow conditions as well as the efficiency of both plants should be improved by increasing the energy production and reducing the ice drift problems. In addition, a residual flow dotation should be implemented by means of a fish bypass.

The existing stone wall was rehabilitated by building a new reinforced concrete wall in-front of it. New reinforced concrete was implemented in the floating weir floor which was protected against abrasion with timber boards.



Fig. 5. New weir floor with timber boards and gravel flushing channel

The gravel flushing channel which was damaged the most due to bed load and abrasion was completely renewed and reinforced with a steel lining. In addition, a new gravel screen was added. The two other sediment traps and sand flushing channels were newly concreted; a steel lining was added to the channel edges and the floor was covered with larch boards. A larch boarding was applied on the entire new reinforced concrete floor as well as on the lower reinforced concrete walls. From experience, this type of timber boards is considerably more resistant against fine and coarse sediment loads than conventional concrete. The application of special concrete was not an option due to financial reasons.

The existing flushing sluice gates made out of timber and a steel frame were generally in a relatively good condition, however, the sealings were partly heavily damaged and the racks and cogs were strongly used. The bearings were strongly damaged particularly at the gravel flushing gates. Therefore, the owner decided to replace all of the three existing sluice gates with new steel sluice gates with heatable sealings and to use Niro steel for the bearings. In order to remove floating debris more easily, the sluice gate was designed with a flap gate before the HPP water intake. Hydraulic lifting devices with modern control units were installed for all of the three gates.



Fig. 6. Steel lining of the flushing channels



Fig. 7. Sluice gate with flap gate

The existing fine screen at the HPP water intake was also fully rehabilitated and was equipped with heatable special formed rods. The heating is provided by the biomass heating system of the owner and should prevent the screen rods from icing up. The existing wooden retention bar was replaced by a new coarse screen with screen rods which can be pulled out in winter as well as a catwalk. The existing screen cleaning machine as well as the small grab dredger did not have to be adjusted or changed.



Fig. 8. Coarse screen with pullable rods and grab dredger

In order to increase the energy production and to improve the inflow conditions at the intakes of both power plants, a number of alternatives were considered, and it was concluded that an increase of the top storage level would be economically as well as technically reasonable and viable. Evaluations of the power plant Wetzmann II showed that the existing generator limited the plant's capacity as well as an increasing of the cross head and design flow. Because of the electrical limits of the plant, the bulb turbine was restricted to a maximum output of 556 KW at the generator shaft. According to the manufacturer Andritz, the turbine's permanent total output could be increased to 621 KW. The gear mechanism also provided additional reserves.

To upgrade the generator from the existing limited output of 700 kVA to the required output of 850 kVA, the generator bearing had to be exchanged; an adjustable  $\cos\phi$ -control unit had to be installed; the generator bus bars and generator transmission lines as well as the wiring to the main transformer had to be strengthened and a stronger synchronisation switch had to be installed.

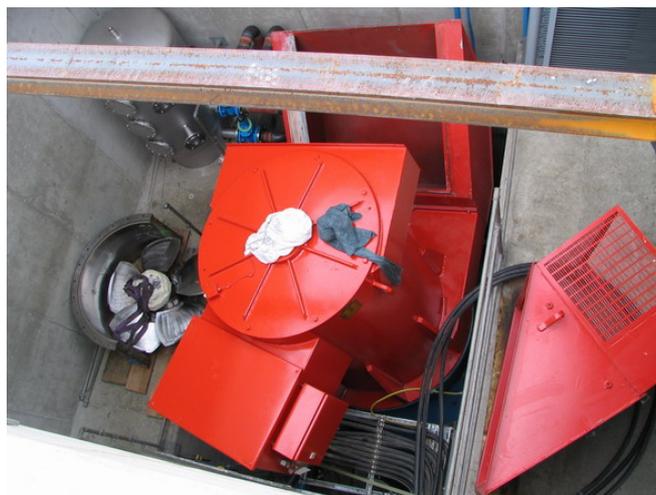


Fig. 9. Installation of the modified generator

These measures enabled an optimized utilization of the electrical and mechanical parts of the plant at a top storage level increase of 30 cm and a design flow increase

at Wetzmann II from 5.0 m<sup>3</sup>/s to 6.0 m<sup>3</sup>/s. After the changes were authorised by the public authorities, the proof of increasing the standard energy capacity by at least 15 % according to § 3 subparagraph 2 of the Green Electricity Law was furnished and therefore, the increased electricity rate for the energy supply was achieved. In relation to the average production in the previous years, the standard energy capacity was increased by approximately 20 % to about 4.4 GWh. In the course of the revitalization, a consensus was reached for the power plant Wetzmann I to increase the amount of water from 2.5 to 2.8 m<sup>3</sup>/s.

In order to fulfil the water framework directive and to maintain a continuous water flow of the river Gail between the weir and the power house as well as to enable the fish migration, a permanent released flow of 740 l/s was requested. 250 l/s of water have to be released via a new fish bypass and 490 l/s have to be released along the floating weir.

A basin passage with specially designed and constructed accesses and exits was implemented for the new fish bypass. The consultation of a fish ecologist for design and detailed structuring suggestions was very helpful.



Fig. 10. Fish bypass as basin passage

The revitalisation works at the power plants and the construction of the fish bypass were performed in 2003 as well as 2004. The entire construction measures were finished in summer 2005. The overall costs of the revitalisation amounted to about € 600,000.-.

## 2 Small Hydro Power Plants Hochsteiner

The small hydro power plant at the river Gurk was put into operation in 1904 and has unlimited water rights. The reconstruction from a mechanical plant with a water wheel to an electrical plant by installing a Francis turbine was performed in 1942. In 1988 the weir and partially the HPP were refurbished and a minimum water flow release was requested by the authorities in order to dotate the river Gurk between the weir and the tailrace channel. The design flow of the HPP is 2.5 m<sup>3</sup>/sec.; its cross net head is approximately 3 m and its installed capacity 55 KW.

The old weir had two mechanically powered wooden flood sluice gates and was situated on the right bank of the river Gurk. The whole weir was constructed out of timber and based on timber piles. The weir fields had a net width of 2 x 5.15 m. Subsequent to the gated weir, a overflow section with a length of about 30 m was constructed by means of a crib weir which was renovated several times during decades of operation. The water used for energy production is fed to the power house via a wooden headrace channel with a coarse screen as well as a subsequent sand trap with a flushing sluice and an additional sedimentation section as well as a fine screen and the mechanical screen cleaning machine. The sand trap as well as both flushing sluices are made of timber and the whole structure is based on timber piles.

The Francis turbine (manufactured by Voith, rotation speed approximately 100 R/min.) consists of a vertical shaft and is regulated automatically depending on the reservoir water level. The generator has a rotation speed of 750 R/min. and is connected via a gear unit. The water used for energy production flows via is returned into the river Gurk via a siphon pipe and an open tailrace channel.

In recent years a deep scour was formed downstream of the old weir which caused an uncontrolled settlement of the weir. Due to the inclination, the lifting devices for the right gate malfunctioned. In 2009 the weir had to be opened and no further HPP operation was possible. The river Gurk was diverted via the open damaged weir.



Fig. 11. Situation of the malfunctioning weir before rehabilitation

In connection with the flood protection project at the river Gurk, the municipality of Weitensfeld considered to abandon the existing hydro power plant, since the available river bed was not sufficient in size for the new higher design flood (HQ<sub>100</sub>). Due to the high reservoir level during floods and the partial sedimentation in the reservoir, it could not be guaranteed that a main bridge would have sufficient flow capacity or not be overflowed.

Because the flood protection project, the river embankments, the road bridge and the existing small hydro power plant are interrelated, any possible fringe conditions for the continued existence of the power plant as well as for the implementation of the new flood protection measures and the freeboard of the bridge should have been generally examined and evaluated.

For this reason, extensive hydraulic calculations for different alternatives had to be carried and evaluated. These evaluations lead to the conclusion that if the existing weir is abandoned, the available freeboard at the bridge could not be reached for the standard HQ<sub>100</sub> flow without creating a river bed lowering.

The evaluations also showed that the specifications for a sufficient freeboard of the bridge can be reached if the existing top of the weir is lowered to a height of elevation 696.05 m, a dredging of the river bed is carried out, the scoured foundation of a pedestrian bridge is renovated, the river bed is locally enlarged, the sedimentation on the left bank is removed and the top of the newly widened weir is lowered.

Based on the evaluations, the power plant owner and the authorities agreed upon reconstructing the weir which was not operated at the time. By lowering the top of the weir, a sediment transport can also be attained during floods.

A single-gated weir with a 2.25 m high hydraulic powered flap gate and a width of 12.50 m was suggested. This weir and the existing old overtopping weir can manage the new design flood collectively. It also ensures that the main bridge has a freeboard after a river bed lowering without overtopping at the design flood.

A stilling basin with scouring protection by using a concreted stone revetment was constructed below the weir. The minimum requested weight of the stones was 0.8 t and the medium weight was 1.2 t. In addition, a river bed stabilisation was secured down of the existing overtopping weir by backfilling gravel and constructing a new rock revetment with a width of 2 m. Both of the flushing gates were also secured locally by implementing a new stone revetment.

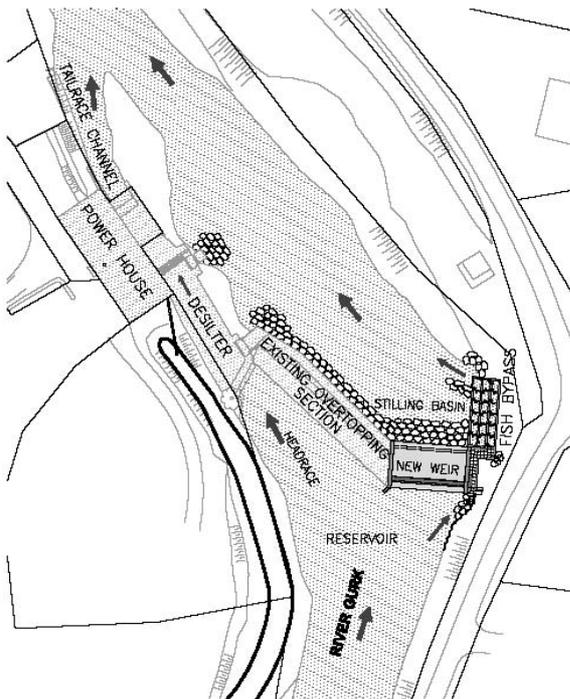


Fig. 12. Layout of the rehabilitated weir

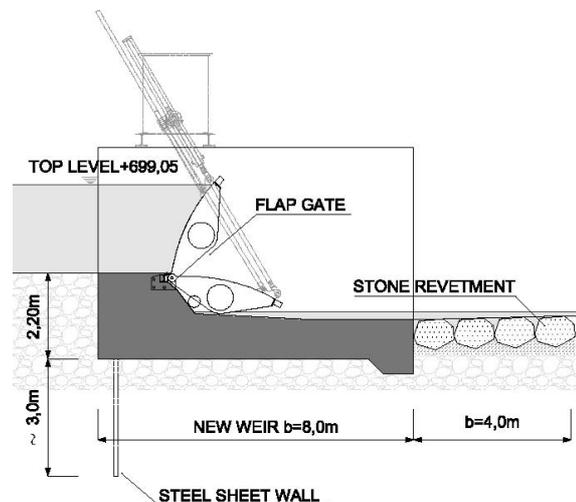


Fig. 13. Cross section of the new weir

To protect the construction of the new weir, a steel sheet wall and a dam were built. The main work was performed at low flow conditions in winter and spring 2010; the water was diverted via two flushing gates. During this phase, river flows of about 40 m<sup>3</sup>/s could be diverted via the existing crib weir and the flushing gates. Down of the weir, a protection dam was constructed with excavation and sedimentation material.



Fig. 14. Weir during construction

The previous residual flow dotation via the gate is substituted by a fish and microorganism mitigation bypass at the right river bank. Vertical slots with a difference in water level height of about 15 cm were planned and designed for the autochthonal fish stock.



Fig.15. Fish and microorganism mitigation bypass



Fig. 16. Weir after rehabilitation

With an additional rehabilitation phase, there is the possibility to increase the capacity and performance of the power plant by adapting the electro-mechanical equipment of the plant as well as by increasing the discharge of the turbine.

The overall costs of the rehabilitation were approximately € 360,000.-

## References

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