‘Fish friendly’ turbines

Recently the discussion often involves what is referred to as ‘fish friendly’ turbines in hydraulic power plants. The term ‘fish friendly’ turbines originated in the United States of America, where the government and companies such as Alden Research conducted numerous studies in this field. Mainly due to a changed design of the turbines and the guide paddles, a lower percentage of fish mortality could be achieved. This is often at the expense of the return of these turbines, resulting whereof the energy companies are – generally - not enthusiastic to integrate these in the turbines. Moreover the term ‘fish friendliness’ is rather misleading. In practice it often involves ‘less-fish unfriendly’ turbines. In relation to smaller plants in shipping channels, etc., a type of reverse Archimedes screw turbine is now considered. The Archimedes screw has been used in pumping stations for centuries, and could be adjusted in a significantly fish friendly manner by means of a number of modifications. This principle can also be reversed; by having water run through, the screw can also be activated and function as a turbine.
How the efficiency of these ‘corkscrew’ turbines relates to the existing Kaplan and Francis turbines and whether they are suited for plants in the major rivers is yet unclear.

The European Anglers Alliance (EAA) and hydro power

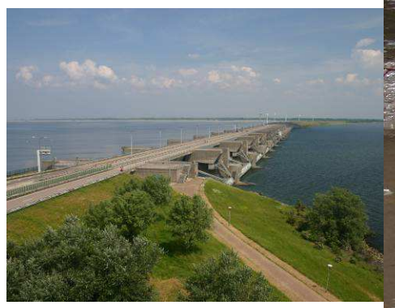
The European Anglers Alliance (EAA) is unhappy with many of Europe's existing hydro power stations, which urgently need modification to reduce the fish mortality problem. The EAA is also extremely worried that in the near future we are to experience a considerable increase in investments in more European hydropower stations as (this might seem at a first glance) a sensible way for the EU to meet its increasing energy demands while complying with comprehensive environmental commitments. However these environmental commitments must include the necessary fish passes and guidance systems to protect and enhance the fish stocks.

What the European Anglers Alliance (EAA) wants:

1. The EU and member states should develop a consistent and harmonised policy on hydropower stations, taking into account all EU and national legislation regarding water management and the conservation of (migratory) fish species. The EAA wishes to note in this respect that the EU has agreed on eel emergency measures and a long term eel management plan, which will have consequences for about 125 European river basins. Both plans take precedence over other EU policies, like energy policies. So an energy development plan cannot be forced through while sacrificing objectives or measures of the EU plans regarding the eel.
2. Having regard to (and respecting) the implementation of the Water Framework Directive and the Liability Directive, the EAA foresees that some hydropower stations may have to be closed. The EAA urges that a comprehensive environmental and economic impact assessment be conducted on all proposed hydro power plants. Such an assessment should be required as a consequence of the above mentioned directives but also the Commission Resource Strategy of December 2005.
3. All existing hydro power plants should as soon as possible be provided with a proven effective fish guidance system (for downstream migration) and a fish passage (for upstream migration). The functioning of both systems should be evaluated. If they do not function, adjustment of the system, compensation of the damage, or closure of the plant should be considered.
4. No new hydro power plants should be built, unless it can be proven that the new to be built hydro power plants have no negative effects on the sustainable management of the fish stocks in the system. Because of their low energy production, their low cost-efficiency in relation to the enormous damage they cause to fish stocks and the virtual impossibility to equip them with effective fish guidance systems, small hydropower stations should have extra attention of all parties involved. In principle, no new small hydropower stations (< 10 MW) should be built in rivers that (could) have runs of migratory fish.
5. All new to be built hydro power stations (on the above mentioned terms) should be provided with a proven effective fish guidance system (for downstream migration) and a fish passage (for upstream migration). Consequently, national and European subsidies should only be awarded for the construction of hydro power stations if these conditions are met.

[1] ‘The Resource Strategy’ = ‘The Thematic Strategy on Sustainable Use of Natural Resources’, 21.12.2005 COM (2005) 670 final. This is a new approach with an objective to reduce the overall environmental impacts associated with resource use and to do so in a growing economy. In other words: it seeks to **de-couple environmental impacts from economic growth**.

A new hydro power station at this location in the Meuse would be very damaging for the recovery of salmon in Belgium.



Tidal power stations in the flood gates of such dams may become a new problem for several migrating fish species. In the future.

The new siphon type fish passage may be integrated in a fish guidance system.

Hydro power stations can be deadly for upstream migrating salmon as well. This salmon was severely wounded while trying to enter the outlet of a turbine time and again.

NASF North Atlantic Salmon Fund

DER ATLANTISCHE LACHS

EFFTA

EAA European Anglers Alliance

The high water levels in August / September 2007 revealed an annual catastrophe in the Netherlands: tens of thousands of silver eels snapped or chopped in German hydro power stations, stranded on the banks of the Rhine River.

Electricity by means of hydro power:
Green or Red electricity?

Hydro power as a durable energy source

Hydro power is often used to generate electricity, mainly in countries with mountains and significant differences in altitude with high gradients in flowing waters.
Hydro power is an infinite source of energy that produces few or no greenhouse gasses. However, hydraulic power has significant disadvantages as well. On an international scale, river valleys representing significant natural and cultural values are inundated, dams built, and rivers and streams rerouted by means of tunnels in order to generate energy from water.
This cuts off the migration route of threatened fish species such as the Atlantic salmon, Danubian salmon (huchen), eel, sturgeon and allis shad in Europe. In countries such as Sweden and Finland, the salmon stocks in virtually all rivers have declined significantly and even the last free flowing rivers are threatened by the construction of new dams. Only due to intensive breeding programmes has the salmon stock – be it in an artificial manner – been preserved. A large percentage of the green energy imported by European countries, originates from large-scale energy projects in those countries mentioned above. But at least one can argue that in those countries the damages done to nature are weighed against the yield of energy.
After all, in mountainous countries such as Sweden, Norway, Switzerland and Austria the generation of energy by means of hydraulic power plants can in most cases be profitable. In many other European countries, with a more open and level area, the situation is however quite different.

Small hydro power

Most European rivers have very low fall gradients and there is no space (and depth) available to construct large and deep storage reservoirs. Because of this, electricity from hydraulic power is generated by means of 'flow turbines', sometimes in existing weirs in rivers.
Nevertheless these turbines sometimes can have a considerable yield. But from an economic standpoint, the scope of the electricity production by means of hydro power plants under those conditions is relatively low due to the limited availability of (flow) energy in the water.
According to international standards these hydro power stations are classified in the category 'small hydropower' or 'kleine Wasserkraft'. The economic return of these plants is therefore rather limited, being put (or kept) in operation due to subsidies for "green electricity".

Fish mortality

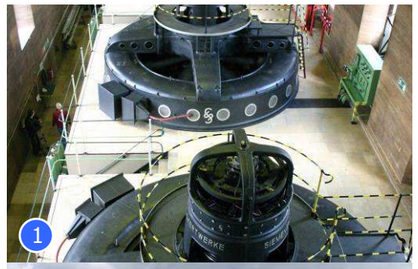
Meanwhile, research has demonstrated that turbines in hydro power plants cause fish mortality by a significant high percentage. For fish such as eel and salmon smolts (young salmon) or trout, the fish mortality percentage per plant is approximately between 5 to 30%, depending of the water velocity, turbine speed (r.p.m.) and the type of turbine used. Especially eels are very vulnerable to hydro power. In some cases all the adult eel migrating to sea are killed by the turbine(s) or dirt grids of a singe hydro power station. If a number of hydro power plants have been built consecutively in the same river, 'cumulative mortality' occurs, limiting the chance even more that salmon and eel populations migrate successfully from and to the sea.
Not only migratory fish are killed by hydro power, also resident fish fall victim to hydro power in great numbers. Fish are instantly killed or wounded by the impact of the turbine blades or runner (guidance) blades or their spine is broken by hydraulic (shear) forces. Many of the wounded fish die later as a result of these injuries (delayed mortality) or they are not able to complete their migration journey.
This problem could by and large be solved by the introduction of fish guidance systems.

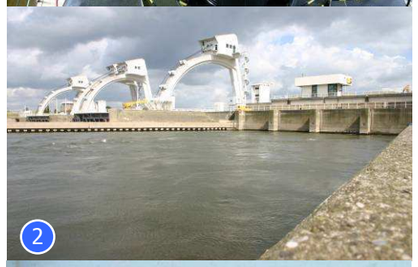
Ecosystems and environment affected

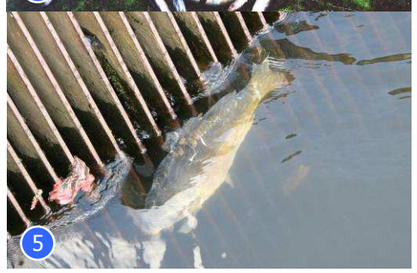
Hydro power not only changes the landscape, but also changes the whole ecosystem of a river. Because of the stagnant water, spawning places for stream fish are lost, water quality diminishes and each impoundment becomes a migration barrier of its own, besides the weir or dam. Changes in water temperature, oxygen content, and water velocity mean drastic changes in the micro fauna and macro fauna (i.e. all the living organisms) of a river. Both upstream and downstream from the weir or dam. Downstream migrating fish that orientate themselves on the direction of the water currents, are disoriented by the large bodies of stagnant water. They lose their way and - in most cases- fall prey to the many predators that thrive in the impoundments. Also below the dams or at the turbine outlets, migrating fish fall prey to predatory fish or birds.
Large impoundments also are an important source of methane (an even worse green house gas than carbon dioxide) by the decaying of trees or other organic matter. Especially during the early years the production of methane can be very high but also in older impoundments the decaying organic sediments on the bottom can produce substantial amounts of methane gas. Makes you think if hydro power really is a solution to prevent climate change!
In some cases hydrogen sulphide (a poisonous gas that smells like rotten eggs) is produced in the impoundments during the anaerobic rotting process.
Negative effects of hydro power:

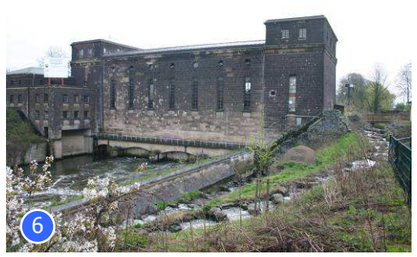
- high mortality of fish by the turbines; disorientation of migrating fish in impoundments;

increased fish mortality by predation in impoundments and below the weirs, dams or turbines;









- chemical, physical and biological changes in water quality;
- negative changes in the environment and aquatic fauna of rivers;
- production of noxious gasses like methane and hydrogen sulphide.

Fish guidance systems

Fish mortality in the turbines of a hydro power station can be prevented or reduced by a fish guidance system. By means of a fish guidance system, downstream migrating fish are diverted past the turbines of a hydro power plant. The reason that until now so very few hydro power stations are equipped with fish guidance systems is that not many tried and tested fish guidance systems are available in Europe. However a much more important argument is the fact that due to the low economic return of the plants, virtually no financial room for additional investments is available. In other words: hydraulic power plants generate too low of a return to install proper fish guidance systems.
Diverting the fish near hydro power plants is not an easy task. Some species (for example young salmon with a length of 15 to 20 cm) migrate to the sea in spring, while other fish species (for example the silver eel with a length of 30 to 100 cm) migrate in autumn. Some species are scared by light, whereas others are attracted by light. It is hard to find a well functioning system that meets all the requirements related to the individual fish species of various sizes. An additional complexity is the requirement that the system should function in extreme changing conditions (high/low dispatch, troubled/clear water and high litter transport).
However, more recently a number of promising fish guidance systems was developed in Europe and the U.S.A.

Conflicting policies

To combat climate change, which is attributed to excessive emissions of greenhouse gasses by the burning of fossil fuels and in an attempt to comply with the Kyoto protocols, the use of alternative energy sources is promoted by most European governments and the European Union.
Hydro power is definitely a renewable resource. However, especially the smaller hydro power stations (< 10 MW) or the ones that are situated in rivers with populations of migrating fish can have a very damaging effect on the environment as a whole and on the migrating species in particular. On the other hand, the European Union and its member countries try to safeguard migrating fish species by legislation and directives like the Habitats Directive, Water Framework Directive, and the Eel Management Plan. Because the European Union and national governments indiscriminately promote the production of electricity by hydro power, not taking into account the negative effects in relation to the sometime small benefits (profitability) of the power stations, a serious conflict between policies arises. The fact that the construction of fish guidance systems is not mandatory, in combination with subsidies for the construction of new hydro power stations, the production of so-called green electricity only adds to this problem.

New phenomenon: 'tidal power plants'

In recent years, the possibilities to generate electricity in the drainage chutes of the various drainage sluices, via what is referred to as 'tidal power plants', were discussed. In relation to these plans, a few locations in the Netherlands (Afsluitdijk, Haringvlietsluizen, and the waterway passages in the Grevelingendam and Oosterscheldedam) and Germany were referred to as possible candidate sites for these types of power plants. It is the intention to install turbines into the drainage chutes of these sluices, which will generate electricity from the water flowing into the sea. The term 'tidal power plants' is misleading in these cases, as it involves standard 'river plants' discharging water from various rivers. These locations are therefore of importance in relation to the migration of threatened fish species, such as eel, salmon, sea trout and houting (whitefish).
True tidal power plants operate on water drained by means of the outgoing tide only. This would be applicable in relation to the waterway passages in some sea arms or fjords (haffs). However, here it is observed that sea fish are continuously entering and leaving those waters, going with the flow of the tides. By installing turbines in this area, a significant fish mortality and disruption of fish migration may occur. The effect of the hydraulic power plants on sea mammals such as seals, dolphins and porpoises is yet unknown. It is important to understand that the construction of the hydraulic power plants in drainage chutes of sluices is contradictory to the intention of governments to – specifically in these areas – encourage fish migration by means of adjusted sluice management or new to be built fish passages.

1. Siemens generators in a German hydro power plant. **2.** Dutch hydro power plants are often integrated in the locks of major rivers and represent an additional obstacle for the upstream migration of fish and are harmful for downstream migrating fish. **3.** Small salmon having entered the turbine of a hydraulic power plant, while migration to the sea. **4.** A large number of eels will never even arrive at the turbines; they die on the waste grids and are discharged in containers together with all other waste. **5.** A carp is irrefutably sucked into a waste grid at the inlet of the turbines. **6.** Even if a fish ladder and a fish guidance system are in place, the amount of water used for this purpose is yet no comparison in relation to the water running through the hydraulic power plant. The effectiveness of the fish passage is as such seriously put at a disadvantage.