The EU Water Framework Directive - and its Possible Effects on Hydropower

I. Summary

The EU Water Framework Directive, which came into force in December 2000, represents a new framework governing the water policies of the European Union. The goals defined in the directive are purely ecological by nature, which leads to a conflict with the largely historical use of waterbodies in practically all member states. The problems this causes are very different by region, whereby the usage of hydropower is one of the areas most affected, because the usage leads to a hydrological and morphological intervention in the waterbody regime and the Water Framework Directive defines the "natural" waterbody as the target condition.

The fact that the goal is not the “very good condition”, which would be practically identical to the natural condition of the water, but only the “good condition” and the possibility to recognise a section (or body) of water as a “heavily modified waterbody”, for which the use of the water is recognised according to an economic analysis and for which a lower goal – the “good potential” is to be achieved, does not mean that implementation of the Water Framework Agreement represents no significant risk to the use of hydropower.

The risk factors are largely concentrated on the following issues:

- The directive demands undisturbed migration of fish. For hydropower, this means the erection of fish ladders and connection to adjoining waterbodies.
- The demand for adequate residual flow according to ecological criteria. For the use of hydropower, there are generation losses associated with this that can be 30% and more, above all for smaller discharge plants.
- The surge issue has become a focal point of the debate, above all for the Alpine storage power plants. The demands presently being discussed for a surge restriction would drastically restrict the free utilisation of the storage capacity, which would mean the loss of valuable control and reserve output to the supply system. The contradiction with the energy policy objectives of the European Union becomes especially clear.
- The waterbody deterioration ban established in the directive makes further expansion of hydropower still possible only in special cases. A viable expansion of the still available hydropower potential will hardly be possible.
- The question of coverage of cost for water services may negatively impact the use of hydropower and limit competition.

However, as the national implementation of the Water Framework Directive still leaves some room for manoeuvre, the following demands on the part of the hydropower operators must absolutely be met in the implementation process:
Comprehensive involvement in the forthcoming implementation processes at an early stage. Securing the future of hydropower energy generation as a long-term energy industry and climate policy option

Avoidance of competitive disadvantages both at the national and at the international level

No additional financial burdens for hydropower

Total costs perspective in the economic analysis and evaluation of alternative energies as part of the economic analysis called for.

This report is intended to demonstrate what effects the EU Water Framework Directive may have on hydropower. The issues arising from the Water Framework Directive are presented and documented by way of case studies. Because of the examples available, a pan-European overview is not possible. Nonetheless, the reader will be able to draw conclusions also relating to other plants based on the various case studies.

This report is also intended to serve to focus the view on the topic of implementation of the EU Water Framework Directive and to clearly show the contradictions, above all in the implementation of the European energy policies (promotion of renewable energies, security of supply etc.).
II. General

1. Introduction, goals

The objective of this paper is to present and discuss the character of the EU Water Framework Directive, and on the other hand to demonstrate the concrete effects on hydropower based on case studies. This document takes into account the position papers presented up to now by the German Electricity Industry Association (VDEW) and Eurelectric, which largely contain qualitative statements and furthermore are public and official by nature. Based on that this paper will point out the conflict between a restrictive implementation of the EU WFD and other political objectives (increase in power generated from renewable energy sources, the Kyoto Protocol, reduction in dependency on imports in the energy field etc.). The document serves the member companies as a basis for discussion and a basic argumentation aid in the urgently required lobbying process to accompany the implementation of the WFD in the individual European member states. It is also intended to demonstrate that, because of the principle of subsidiarity within the scope of implementation, differing national approaches in implementation will lead to substantial competitive distortions in the liberalised European energy market so clearly sought politically.

As an introduction for those readers who have not yet dealt with the Water Framework Directive in detail, the underlying principles of this directive will first be briefly presented.

The Water Framework Directive has created an extensive instrument with the goal of protecting all bodies of water, whereby its perspectives very strongly emphasise the environmental side and deal with water users only in a subordinated manner. It uses the undisturbed, natural body of water as the reference condition. This naturally implies substantial potential risk for all forms of water usage.

The development of mankind and civilisation was always very closely associated with the use of our waterbodies. Above all in densely populated Europe, the character of our waters is very strongly marked by the requirements of the population living in settlement areas. These requirements may be protection against floods and natural disasters, the development of new transport and traffic routes, measures in the field of population water supply, general infrastructure measures and, of course, the use of water to generate energy, from purely mechanical usage up to the modern hydropower plant.

The Water Framework Directive, objectives, instruments, deadlines for implementation


The Water Framework Directive applies across the board to all European waterbodies – to surface waterbodies including the coastal waters, as well as groundwater – irrespective of their use. The directive looks at the waterbodies themselves, their floodplains and catchment areas as one unit. At the same time it covers the interaction between ground and surface
water. The directive therefore accounts more strongly than before for the ecological function of waterbodies as a habitat for the most different species of plants and animals, and thus also includes nature conversation objectives.

The basic principles in the area of surface waters can be summarised as follows

**Ecological focus**

In contrast to previous directives, the WFD is not usage-oriented but has an ecological focus. In the forefront is the objective of restoring or preserving the habitat for water type-specific biotic communities.

**Across-the-board approach**

The directive is not limited only to larger bodies of water, but applies across the board to all waterbodies in the EU.

**Catchment-related approach**

Bodies of water are seen in context with the corresponding catchment, which is especially relevant to harmonisation of the work to create water type-specific model zones and development of management plans.

**Water type-specific approach**

Rivers, lakes, transitional waters and coastal waters are to be characterised according to the criteria listed in Annex II to the WFD and assigned to waterbody types. For rivers, for example, the use of the following criteria is mandatory: Ecoregion, altitude, catchment area size, geology. Other criteria can also still be applied, such as flow category and stream order number.

**Bio-indication**

The focal point in assessing the ecological condition of waterbodies is on examination of the aquatic ecosystems; in the case of rivers, for example, phytobenthos, macrophytes, phytoplanktons, macrozoobenthos and fish are to be examined. The assessment is made based on a comparison of the status quo with a water type-specific reference condition, which corresponds to the largely natural waterbody condition with, at most, minimal disturbance.

**Evaluation of the ecological condition**

The ecological condition is evaluated within a five-stage classification scheme, whereby Class I (high ecological status) represents the water type-specific reference condition and Class II (good ecological status) the minimum quality standard to be achieved.

**The key objectives of the EU WFD:**

- “Good ecological condition” or “good ecological potential” and good chemical condition of surface waters
- Good chemical and volume condition of groundwater
- Broad cost coverage for water services (including the economic analysis of water usage)

These objectives are to be achieved Europe-wide within specified deadlines (see implementation deadlines).

The Water Framework Directive provides for the following tools to achieve the goals:
Preparation of management plans, which are to be coordinated for the entire river basin area and must contain programmes of measures to attain the objective.

Compliance with a general ban on deterioration and the demand for a turnaround in the trends in pollution of waterbodies.

A combination of the emission and imission approaches.

Extensive involvement of the public in planning and implementing the measures.

For implementation and goal attainment, the framework directive provides for a certainly very tight time plan with the following deadlines:

- **Within 3 years (by end of 2003),** the directive must be **transposed into national legislation.** (Up to now this objective has only been fully achieved by 4 member states).

- **The stocktaking and analysis** for the river basin units must be concluded within 4 years (**December 2004**). Reporting to Brussels must take place by March 2005.

- **Building of monitoring programmes and monitoring institutions** based on the status quo analysis **by the end of 2006.**

- **Preparation of the management plans with the programmes of measures by end of 2009.**

- **Implementation of the programmes of measures** in the river basin units by **December 2012.**

- **Achievement of “good status”** for surface waters, groundwater and in protected areas by **end of 2015.** With appropriate grounds, the deadline for achieving “good status” can be extended by 2 x 6 years – i.e. until 2027 at the latest.

![Figure 1: Schedule for implementation of the EU WFD (Source: Ministry for the Environment, Austria)](image-url)

2. **Key aspects of the EU Water Framework Directive from the perspective of hydropower**

From the perspective of hydropower operators, the following aspects of the EU WFD have proven to be relevant:
The requirement for a **flow regime according to ecological criteria**. Above all, this requirement is to be interpreted in such a way that the discharge, both in quantitative terms and with respect to its dynamics, must meet the needs of the waterbody ecology. For operation of hydropower plants this leads to the residual flow problem and the surge problem.

The requirement for **undisturbed migration** is one of the central demands of the EU Water Framework Directive. The ability of fish to pass migration hindrances, both for upstream and downstream migration, is a heavily debated topic. However sediment transport can also play a role in connection with the undisturbed migration issue.

A further criterion with which hydropower will be massively confronted in connection with the implementation of the EU WFD, are the **morphological changes to rivers** caused by use of the waterbody. Morphology plays a decisive role with respect to the evaluation of waterbodies.

With regard to these criteria - morphology, undisturbed migration and ecological flow regime - the Water Framework Directive specifies very stringent objectives because of the fact that one orientates oneself around the “natural water condition”. To now also permit rational implementation, the framework directive has introduced another waterbody type – the **“heavily modified waterbody”** (HMWB). For a stretch of water, where there is significant use of the water, there is the option of classifying it as a Heavily Modified Waterbody and the objective is then no longer “good ecological status” but “good ecological potential”. According to the EU WFD, good ecological potential also represents goal attainment, whereby it also takes the use of the waterbody into account.

The very topic of “heavily modified waterbodies” has, however, created strong debate with contradictory views and interpretations. During the implementation process, one can observe that the HMWB category is more and more strongly regarded as an exception and as a “failure to attain the objectives”. This development must be viewed very critically, as one is obviously not aware that the European water industry must also exercise caution with a view to partially narrow settlement areas. In Alpine areas, for example, where the main settlement areas are in valley landscapes, waterbodies have always been adapted to the needs of mankind. Appropriate flood protection forms the basis for any civilisatory development. Of course, here and there one has overshot the target. These “sins”, which arose from quite different objectives, need to be remedied, but the opinion that a natural water regime can be restored is far wide of the target. The possibility for extensive classification as HMWB would be one way to successfully implement the Water Framework Directive in such areas. For hydropower, the issues are very similar. Forgoing or limiting the use of our waters to generate energy cannot represent a solution because of the developed structures and the significance of hydropower as the most important source of renewable energy in Europe. Here too, implementation must be by way of HMWB classification with moderate targets; otherwise there is the risk of missing other significant European targets (see Section 3).

A further point which may represent a burden on hydropower is the aspect of **cost-covering prices for water services** per Article 9 of the directive. In the first instance,
this involves recharging external costs to users of waterbodies. Thought is also being given in some cases to a “water tax” by which hydropower plants would finance the measures for (all) waterbodies. Such forms of cross-financing must be viewed as highly problematic. Within the EU, this topic is presently being treated very differently. This results from the very different approaches as part of the expansion of hydropower. In Austria, for example, there is no “water tax” as there is in Switzerland for instance. However, extensive investments in local infrastructure were made in Austria as part of power plant construction. This system has by all means proven itself over the long term, as such investments were a sound basis for the future development of a region. Further ongoing cost burdens would also have negative effects on the competitive situation between hydropower and other energy sources, which must be regarded as contradicting the “renewable targets” of the EU (also see Section 3).

3. Conflicts with other European targets

Perhaps not in terms of its statements, but certainly in terms of its possible consequences, the EU Water Framework Directive stands in clear contradiction to other European targets.

On the one hand, this contradiction can be seen in one other environmental target of the Union, namely compliance with the Kyoto commitment. Against this background, the EU itself has increased the share of power to be generated from renewable energy sources by 2010 from 15% to 22%. This target is defined in the Directive on the promotion of electricity from renewable energy sources in the European Union’s internal electricity market. In this directive, hydropower is generally, i.e. without limitation by means of an output limit, recognised as renewable energy, which in the end also corresponds with its physical characteristics. Among sources of renewable energy, hydropower occupies by far the most significant position, not only because it has largest share in control output, but also because it has lowest generating costs in comparison with other renewable energy sources, and above all because of the “quality” of the energy provided. Under “quality” one understands in the first instance the high availability, the provision of reserve and control power and the enormous reliability of the plants. These qualities must of course be differentiated depending on the size and type of the plant.

On the other hand, the contradiction with pure energy policy targets of the European Union is also apparent. Apart from the promotion of renewable energy sources, these are:

- Reduction in Europe’s dependency on imports in the energy sector
- Increase in supply security within the EU.

Alongside other measures, all three objectives – renewables directive, supply security and reduction in imported energy – would also lead to further, optimised, expansion of hydropower in Europe. The Water Framework Directive, which pursues purely ecological goals, contradicts this decisively. On the one hand, the EU WFD includes a ban on deterioration or, where goals have not been achieved, an improvement requirement. This makes further exploitation of the still available expansion potential very unlikely and, when complying with the economic viability aspect, practically impossible. On the other hand, with implementation of the Water Framework Directive one must even fear a decline in hydropower generation and, above all, a restriction on the free use of power plants.
4. Effects on hydropower

Section 2 of this report presented those aspects that affect hydropower generation directly. How great these effects will actually be cannot presently be stated definitively as the goals to be attained, namely the ‘good status’ and above all the “good potential”, have yet to be defined. Implementation of the Water Framework Directive must be regarded as an implementation process over a longer period. However, there too lies a decisive problem for the hydropower plant operators. There is no planning and investment certainty over a long period of time. Furthermore, the implementation process must be monitored over the entire trajectory, as decisive questions of detail constantly need to be clarified at national and international level. During this process, one can observe how the freedom for national implementation, as provided for in the directive, is successively being limited by the “Guidance Documents” accompanying the elaboration. One example was the decision by the Water Directors that hydrological changes alone are not sufficient to classify a waterbody as an HMWB – there must be changes in the hydromorphological characteristics.

However, the risk potential to be expected for the individual plants can be estimated. As part of this study, an attempt was made to obtain a general overview of the potential risk based on individual plants.

In general, the following effects relevant to hydropower are becoming apparent:

- **No new hydropower plants?**
  
The deterioration ban will permit viable exploitation of the still available hydropower potential only in certain individual cases: in the first instance in locations where the water situation will not be influenced (for example for pure pump storage power plants) or where the present aqua-ecological situation can be improved by an energy industry application because of existing burdens.

- **High investment costs for eco-measures?**
  
In particular, this includes the retroactive equipment of old plants with fish ladders, and the connection of secondary waterbodies in dam areas. But structural measures in dam areas and morphological improvements in discharge stretches are also an issue.

- **Generating losses because of higher residual flow discharges?**
  
Generating losses as a result of higher residual flow specifications are a tricky subject in the case of weir power plants and with Alpine storage plants. The residual flow approaches presently being discussed by ecologists (e.g. LAWA) would mean generating losses of over 50% at individual hydropower plants. Above all in the small hydropower plant area, such demands would mean the financial “end” of the plant. In the case of plants at larger waterbodies, the percentages are of course lower (5% to 20%). But even there valuable renewable energy is lost. With Alpine storage plants, the residual flow issue in conjunction with the stream courses must also be regarded as problematic. On the one hand, the system would lose valuable peak energy, on the other hand, at individual plants, it could mean that by reducing the usable water supply the storage chamber, which represents a very high investment, could no longer be fully exploited.
• **Loss of peak-load power due to surge restrictions?**

The topic of surge restrictions, in particular, hides a very great risk. Both the large storage power plants and the barrier chains, are designed in such a way that energy can be generated when it is needed to the maximum possible extent. Above all, the storage and pump storage power plants occupy a special position in the European grid system. They provide grid services to the system in the form of reserve and control power. This need will grow even more in the future. The reasons on the one hand are the increasing energy needs in Europe and the shift of load peaks even in the summer (air conditioning on the increase in Europe). On the other hand, the expansion of other renewable energy forms such as wind and photovoltaic means more use of so-called balancing power because of their stochastic, generation-driven rather than needs-driven grid feeding. Storage and pump storage power plants, above all, are ideal for that purpose.

Any limitation of these qualities because of surge restrictions would be fatal for many plants. Those plants with high output (reservoir water volume) and a small outfall channel would be especially hit. The consequence of these types of restriction would be the increased use or construction of fast-controllable thermal plants.

5. **First experience with the implementation process**

It is presently apparent that implementation in Europe is very inconsistent. As of summer 2004, 15 member states (including the new accession states) have managed transposition of the directive into national legislation. Four states (Germany, Belgium, Slovakia and Malta) have only partially completed implementation, also because of a federal structure (Germany). Implementation is still outstanding in Portugal, Finland, Slovenia, Italy, the Netherlands and Luxembourg. However, the EU is making massive efforts to impose EU law and already sent warning letters on 27th January.

In technical terms, however, it is also apparent that the various states are approaching the issues very differently. The status quo analysis must be communicated to the Commission by March 2005. Apart from risk classification, this also involves the HMWB candidates. This process is already significant to hydropower, as the Commission has announced that retroactive reporting of “heavily modified waterbodies” will be very difficult. In international comparison, Austria and Scotland have progressed the furthest in this process. Both states are presently reporting a very high share of HMWB candidates. The present status (first draft by the Federal Ministry) in Austria is that 41% of waterbodies are certain HMWB candidates and 42% are possible HMWB candidates. At a reporting limit of > 100 km² some 664 detailed waterbodies were defined, with an average length of 16 km (maximum – 163 km; minimum 1 km). The breakdown into certain risk and potential risk is derived from the assumption that any waterbody for which there is insufficient information available is assessed as a potential risk and a potential HMWB candidate. In Scotland, the percentages and the number of waterbodies is similar in proportion to the surface area. The high share of HMWB candidates leads to a certain political pressure, above all on the tourism side as, because of the lack of expert knowledge, the prevailing opinion is that HMW is something negative. In general, however, one should note that one is by all means trying to reach a compromise with hydropower with these high percentages, whereby the reason is the high significance criteria (for residual flow, undisturbed migration etc.). In terms of the requirements for the
programmes of measures, there is little to be said at this time. The implementation authorities want, above all, to await the first results of the monitoring programmes before discussing potential measures in detail.

In Austria, the topic of a “water tax” is limited to the fields of water supply and sewage only.

- In contrast to other EU member states, a restrictive implementation is to be expected in Germany. See the LAWA tool, guidelines in individual federal states.

Among other things, this is apparent from the standards set and the current form of the status quo stocktaking in the state of North Rhine-Westphalia, for example, where practically all waterbodies have been classified as at risk in terms of achieving a good status. For the future, this implies a substantial demand on measures for monitoring, and on the future programmes of measures. As already mentioned at the beginning, the WFD uses ecologically idealised models to the greatest possible extent in defining ecological objectives. At some points, this leads to models being used for the quality of the waterbody structure, which represent the condition of the waterbody based on historic data prior to the industrialisation in central Europe. This approach is especially prevalent in Germany.

However, with the reporting of so-called heavily modified waterbodies and an appropriately applied aggregation rule, the WFD and the subsequent Guidance Documents do offer the option of selecting a pragmatic approach that takes account of the many uses of waterbodies as well as their conservation.

For instance, it is apparent that, in Germany, both the number of waterbodies classified as at risk is relatively high, and that classification as heavily modified waterbodies is being handled restrictively. In addition, the decisive delimitation and management component within the scope of the WFD is being selected as very narrow, so that the strong fragmentation and combination of the aforementioned parameters makes any lateral aggregation and averaging of the burdens largely impossible.

From this is derived a substantial need for measures already required as part of the stocktaking. The objectives of a number of federal states, especially North Rhine-Westphalia, to use the WFD to establish and achieve an idealised ecological condition of their waterbodies is made more than clear by this combination. Comprehensive and costly measures will be necessary here, whereby the question of who should carry the costs for these measures has not yet been finally clarified. One can expect, however, that states and water federations, as well as industrial users, will have to make a substantial contribution to covering the costs of the WFD.

In parallel to the stocktaking, NRW is presently completing the long overdue transposition of the WFD into national legislation with the re-enactment of the State Water Act, whereby, however, this is not confined to a 1:1 implementation of the WFD as would be called for from a pragmatic perspective. It is apparent that the lessons learned from the stocktaking have flowed into the state legislation, and that the legal instruments are being adapted to fulfilment of the ecologically idealized goals and principles mentioned above. Apart from the planned introduction of far-reaching instruments of state management planning that go far beyond the implementation called for by the WFD, use of hydropower will be subjected to enormous burdens by introduction of a repressive instrument to widely enforce undisturbed migration in streams and rivers. This couples the public welfare compatibility of hydropower restrictively to the presence of fish ladders and minimum flows, whereby one should note that there are presently no uniform technical standards for fish ladders and that the required measures to set
up downstream fish ladders, in particular, will burden hydropower with investment costs in the millions. Public welfare in this sense, however, appears to be purely ecologically driven fish protection, especially for those fish that migrate over long distances, such as salmon and eel. Furthermore, the draft act implies that the resettlement of long-distance migratory fish can only be achieved by appropriate measures at hydropower locations. The other, partially highly complex, issues remain unaccounted for. Here there is a major risk that a source of energy will be subjected to extreme burdens through excessive demands in favour of one-sided protection of species; any certainty that the desired effect will be achieved is from today’s perspective doubtful.

6. Demands, expectations of the hydropower industry

- Early and extensive involvement in the forthcoming implementation processes
- Securing the future of energy generation by hydropower as a long-term energy and climate policy generating option
- Avoidance of competitive disadvantages both at national and international level
- No additional financial burdens for hydropower
- Fully allocated costs approach in the financial analysis of alternative energies as part of the financial analysis required

7. Discussion of the effects based on case studies

Within the scope of this study, a total of 14 hydropower plants of different sizes and types were examined with respect to the potential impact of the EU Water Framework Directive. The main aspects examined were the issues of undisturbed migration, residual flow and the limitation of peak power generation due to surge restrictions. Because the criteria to achieve a “good condition” or “good potential” are not yet established, this can only be an initial rough estimation. Some consequences of a stringent implementation, however, are already apparent:

The issue of unhindered flow means additional investments to most older plants, whereby the amount will strongly depend on the size of the plant and local circumstances. The measures at the Rhine power plant at Iffezheim, at some € 10 million, would probably represent an upper limit.

The generating losses for (additional) residual flow volumes at discharge power plants are between 6 and 50%. The energy losses to feed fish ladders are, as a rule, under 1% of the average annual generation. At smaller hydropower plants, this percentage may also be substantially higher. The large bandwidth of generating losses as the result of residual flow discharges is justified by differing residual flow approaches or whether residual flow is already discharged at the plants. For discharge power plants in Austria, an average generating loss of 12 – 15% is expected, whereby this value can even be as high as 60% at individual plants.
The issue of surge restrictions must be regarded as a serious concern, especially for the Alpine storage power plants. Because of the differing circumstances at each plant, a uniform approach to the calculation of the losses arising from the surge restrictions is not possible. For the large Alpine storage power plants that feed their drive water directly into a relatively small outfall ditch, one can expect a limitation to peak power generation of up to 60%. However, because these very plants, with their possibilities, represent a significant pillar for the electricity supply, this could become one of the main problems resulting from the implementation of the Water Framework Directive.

### Name of the Power Plant

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<th>Small Hydro</th>
<th>Run-of-river Power Plant</th>
<th>Storage Power Plant</th>
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<th>mean annual production</th>
<th>River continuity (add. Costs)</th>
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</table>

8. Consequences for electricity generation and for European energy policies

The share of hydropower in power generation within the European Union (EU 25) was some 11% in 2003. The share of the renewable energies (including hydropower) in total generation was 13.5% in the same period. Hydropower as a whole thus plays only a secondary role within the EU, even if the situation in the individual member states is very different (see Figure xx). Austria, for example, with a hydropower share of some 70%, at the same time demonstrates the highest share of renewable energy within the European Union. Not only in Austria, however, but across the entire EU, hydropower is the most significant source of renewable energy, not only in terms of volume, but above all thanks to its particular benefits in terms of availability and controllability. Europe’s hydropower plants are therefore an indispensable element of Europe’s power supply and, in turn, of European energy policy.

Energy policy goals, such as the promotion of renewable energies in Europe or improving security of supply can only be realised with the best possible involvement of hydropower (existing plants and potential expansion). Any limitation of these resources could fundamentally jeopardise attainment of the goals. Above all, a restriction would massively endanger peak load coverage in several countries. Because of the expansion of other renewable energy sources, such as wind power for example, which does not represent needs-driven generation, and the increasing demand for peak load coverage because of technological developments in Europe (e.g. air conditioning), the major storage and pump-storage plants would become even more important.
In the interests of a forward-looking and environmentally oriented European energy policy, therefore, the Water Framework Directive must be implemented in such a way that, in terms of volumes and quality, hydropower retains the position in Europe that it enjoys today.

9. Summary

With its requirement to create good conditions for waterbodies, the EU WFD contains prescribed standards, which, if rigorously implemented, would very seriously hinder, or even practically prevent, the continued use and expansion of hydropower. In other ways, too, the power supply industry has been subjected to general technical and financial burdens. In terms of its effects, the implementation of the WFD must be in line with European and national energy policies. Any further tightening of the WFD standards during national or state-specific implementation must be avoided. Overemphasis of the quality of the waterbody structure as a quality parameter for evaluation of a good ecological status or potential must, also in line with the general objectives of the WFD, be avoided. Here there is a major risk that costly measures will need to be taken as part of the implementation process to achieve a quality which, in the sense of the goals set, is of secondary importance. Such measures call well-meant objectives set in other areas into question, and will lead to absurd amounts of financial resources being applied when weighed up against the macroeconomic benefit.
III. Appendix: Case studies

1. The Niederhausen power plant on the Nahe river (run of river hydropower plant)

1.1 System description

The Niederhausen power plant is situated on the lower Nahe in the Rhineland Palatinate. It was designed as a run of river plant with a weir and upper channel. Above the plant is the Niederhausen dam reservoir. The reservoir forms part of the “Nahetal” nature reserve. By execution of a legal directive of the Koblenz district government of December 8, 1986, the Niederhausen reservoir was incorporated in the nature reserve. The border of the reserve runs close to the weir bridge of the Niederhausen dam. All work that is prohibited in the nature reserve was carried out subject to a catalogue of conditions. To maintain operation of the hydropower plant, a few tasks are named as exceptions to enable limited operations. There is no fish ladder, nor do any conditions exist for minimum reservoir water volumes in the old stretch of the Nahe between the weir and the power plant outflow. The key data of the plant are as follows:

**Niederhausen hydropower plant**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissioned:</td>
<td>18.03.1928</td>
</tr>
<tr>
<td>Type of plant:</td>
<td>Run of river plant</td>
</tr>
<tr>
<td>Annual output:</td>
<td>5.6 GWh</td>
</tr>
<tr>
<td>Rating:</td>
<td>1.8 MW</td>
</tr>
<tr>
<td>M I:</td>
<td>1.3 MW</td>
</tr>
<tr>
<td>M II:</td>
<td>0.5 MW</td>
</tr>
<tr>
<td>Height of fall:</td>
<td>5.8 m</td>
</tr>
<tr>
<td>Rate of flow ($Q_A$):</td>
<td>40.0 m³/s</td>
</tr>
<tr>
<td>Number of machine sets:</td>
<td>2 vertical Kaplan turbines</td>
</tr>
<tr>
<td>Number of weir sections:</td>
<td>3</td>
</tr>
<tr>
<td>Upper channel (length):</td>
<td>700 m</td>
</tr>
<tr>
<td>Outflow values - Niederhausen</td>
<td></td>
</tr>
<tr>
<td>HHQ:</td>
<td>1,450 m³/s</td>
</tr>
<tr>
<td>MQ:</td>
<td>22.8 m³/s</td>
</tr>
<tr>
<td>NNQ:</td>
<td>1.3 m³/s</td>
</tr>
</tbody>
</table>
1.2 Effects of the EU Water Framework Directive

1.2.1 Undisturbed migration

Because of the character of the Nahe as a typical low mountain range river with the corresponding spawning opportunities upstream for long distance migratory fish such as salmon and sea trout, the question of undisturbed migration represents one of the main criteria. The power plant does not presently have its own fish ladder. A possible solution is erection of a fish ladder as a technical structure in the area of the powerhouse between the upper channel and the power plant outflow. Against the background of the ability to find the fish ladder by ensuring a bait flow, its location there is necessary.

The overall costs for this measure are estimated at some € 0.5 million. With a corresponding feed to the fish ladder of between 0.5 and 1 m³/s generation losses of 170,000 kWh to 340,000 kWh (3 – 6% of annual output) are to be expected.

1.2.2 Residual flow

As this is a run of river plant the residual water outflow below the weir also plays a role. As residual water output via the weir sluice gates is out of the question for technical reasons, and undisturbed migration can possibly also be assured along the old stretch and in the weir area, a fish ladder could also be erected there in an extreme case, but then as a diversion channel (ecostream). Based on the LAWA standards for residual water outflows (0.3MNQ or h>0.3 m water depth and v>0.3m/s), this diversion channel must be dosed on a scale of approx. 1.5 m³/s. Thanks to relatively favourable construction conditions in the area of the weir, one can expect costs of € 0.3 million and additional generation losses of another 510,000 kWh.

1.2.3 Surge

Surge does not play a role in connection with pure run of river power plants.

1.3 Conclusion

Depending on the design variant, the total investment costs are around € 0.8 million and generating losses are between 680,000 kWh and 1,020,000 kWh (12 - 18% of annual output). Furthermore, one must consider that because of the relatively shallow hydraulic profile of the plant, machine operations in the summer months from May to September will not be possible, because the minimum water volumes for machine operations will not be reached. Even when accounting for the Renewable Energies Act allowances, the plant’s economic survival would be at risk.
2. Ruhr river basin unit (North Rhine-Westphalia, Germany)

41 Hydropower plants (run of river power plants, discharge power plants)

2.1 System description

The Ruhr belongs to the Rhine catchment area. The northern edge of the Ruhr catchment area represents the natural border between the “Rhine-Schiefergebirge” mountain range and the Westphalian basin. The Ruhr sub-catchment area comprises major parts of the Schiefergebirge on the right bank of the Rhine with the Sauerland and Niederbergisches Land regions, parts of the southern edge of the Münsterland chalk basin (Hellweg-Haarstrang) and a small part of the Lower Rhine plain. The total surface area of the catchment area comprises 4485 km², the running length of the Ruhr river is 219 km.

Overall, the flow regime of the Ruhr depends largely on the control of the 5 major dams in the Sauerland. Furthermore, more than 1000 cross-river structures exist on the Ruhr and its ancillary waterbodies. In the middle and lower reaches, the Ruhr is also stocked up by the five Ruhr dam reservoirs – the Hengstey, Harkort, Kemnader, Baldeney and Kettwiger reservoirs - and in the lower reaches by the Ruhr weir in Duisburg-Meiderich and the Raffelberg weir system.

Along the main stretch of the Ruhr river there are 41 small and medium-sized hydropower plants with a total installed rating of 68 MW.

2.2 Impact of the EU Water Framework Directive

2.2.1 Undisturbed migration

Because of the Ruhr’s character as a typical low mountain range river, with the associated spawning opportunities in the upper reaches for long-distance migratory fish such as salmon and sea trout, the issue of undisturbed migration represents one of the main criteria. None of the above power plants presently possesses its own fish ladder. However, the focus in terms of the Ruhr is not only on long-distance migratory fish, but also some catadromous species, and here primarily the eel. Besides the upstream fish ladder, the downstream passage, in particular, is important to these species. While the technical problems of upstream fish ladder systems are largely solved, the downstream passage, and here primarily preventing the fish penetrating the turbines, represents a problem for which there is no technical solution or only solutions involving major expense.
Depending on the dam height, one can assume the following specific costs to create undisturbed migration (fish ladders) at the power plants reviewed:

**Up to 3.5 m dam height: € 80,000 per metre, >3.5 to 5 m: € 115,000 per metre, > 5 m: € 150,000 per metre.**

For the plants reviewed one can assume investments of **€ 20 million**. An additional investment of at least **€ 40 million** will be necessary for erection of downstream fish passages.

### 2.2.2 Residual flow / generating losses

The generating losses estimated for both the residual flow and to feed the fish ladder installation for the above power plants total some **17 million kWh p.a.**, assuming an average feed of 1000 litres per sec. per fish ladder. No differentiation for discharge power plants was made as the data situation did not permit it.

### 2.2.3 Conclusion

This review makes clear what substantial financial resources are required for waterbody structural quality improvement in this specific case. In some points, however, the requirements of the WFD are even substantially higher. If one considers the aforementioned 1000 cross-river structures for the Ruhr catchment area and further improvements (e.g. waterbody edge zones, renaturation measures, flood meadow development etc.), a study by the Ruhrverband association in 2003 for the Ruhr catchment area showed total investments of **€ 864 million** that can be derived from the requirements for a good ecological condition or potential.
3. **Donaukraftwerk Melk**  
(großes Laufkraftwerk; Flußkraftwerk) – AUSTRIA  
(English Translation will follow in short time)

### 3.1 Systembeschreibung

Das Donaukraftwerk Melk ist eines von 9 rein österreichischen Wasserkraftwerken an der Donau. Flußabwärts schließt die freie Fließstrecke durch die Wachau, einem kulturhistorisch und landschaftlich bedeutsamen Engtal zwischen den Orten Melk und Krems, an, ehe bei Krems der Stau des Kraftwerkes Altenwörth, dem leistungsstärksten österreichischen Donaukraftwerkes, beginnt. Die wesentlichen Kenndaten der Anlage stellen sich folgendermaßen dar:

**Donaukraftwerk Melk**

<table>
<thead>
<tr>
<th>Kennzeichen</th>
<th>Wert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kraftwerkstyp:</td>
<td>Laufwasserkraftwerk</td>
</tr>
<tr>
<td>Regelarbeitsvermögen (RAV)</td>
<td>1.221,6 GWh</td>
</tr>
<tr>
<td>Engpaßleistung (EPL):</td>
<td>187,0 MW</td>
</tr>
<tr>
<td>mittlere Rohfallhöhe:</td>
<td>9,6 m</td>
</tr>
<tr>
<td>Ausbaudurchfluß ($Q_A$):</td>
<td>2.700 m³/s</td>
</tr>
<tr>
<td>Anzahl der Maschinensätze:</td>
<td>9 Kaplanrohrturbinen</td>
</tr>
<tr>
<td>Anzahl der Wehrfelder:</td>
<td>6</td>
</tr>
<tr>
<td>Schiffsschleusen</td>
<td>2x 230 x 24 m</td>
</tr>
</tbody>
</table>

![Map of Donaukraftwerk Melk and surrounding areas](image)
3.2 Auswirkungen der EU-Wasserrahmenrichtlinie

3.2.1 Thema Durchgängigkeit

Aufgrund der besonderen Situierung des Kraftwerks Melk unmittelbar im Anschluß an die freie Fließstrecke und der Tatsache, daß in den Stauraum der Anlage die Nebenflüsse Erlauf und Ybbs münden, stellt die Durchgängigkeitsfrage eines der Hauptkriterien dar. Derzeit verfügt das Kraftwerk über keinen eigenen Fischaufstieg. Der Auf- und Abstieg über die Schiffsschleusen ist gegeben, jedoch nicht entsprechend nachgewiesen und auch nicht quantitativ erfaßt.


3.2.2 Thema Restwasser

Nachdem es sich um kein Ausleitungskraftwerk handelt, spielt die Restwasserabgabe nur im Zusammenhang mit dem „Ökobach“ eine Rolle. Bei einer dynamische Dotation des „Ökobaches“ würden die jährlichen Erzeugungsverluste rund 1,1 GWh betragen (rund 0,1 % des RAV).
4. Kraftwerksgruppe Zemm Ziller (Jahresspeicherkraftwerk) – AUSTRIA
(English Translation will follow in short time)

4.1 Systembeschreibung


**Kraftwerk Häusling (Oberstufe)**

<table>
<thead>
<tr>
<th>Spezifikation</th>
<th>Wert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kraftwerkstyp:</td>
<td>Speicherkraftwerk</td>
</tr>
<tr>
<td>Speicher:</td>
<td>Jahresspeicher</td>
</tr>
<tr>
<td>Regelarbeitsvermögen (RAV):</td>
<td>179 GWh</td>
</tr>
<tr>
<td>Engpaßleistung (EPL):</td>
<td>360 MW</td>
</tr>
<tr>
<td>mittlere Fallhöhe:</td>
<td>396 m</td>
</tr>
<tr>
<td>Ausbauwassermenge (QA):</td>
<td>65 m³/s</td>
</tr>
<tr>
<td>Nutzinhalt:</td>
<td>86,7 Mio. m³</td>
</tr>
</tbody>
</table>

**Kraftwerk Roßhag (Oberstufe)**

<table>
<thead>
<tr>
<th>Spezifikation</th>
<th>Wert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kraftwerkstyp:</td>
<td>Speicherkraftwerk</td>
</tr>
<tr>
<td>Speicher:</td>
<td>Jahresspeicher</td>
</tr>
<tr>
<td>Regelarbeitsvermögen (RAV):</td>
<td>313 GWh</td>
</tr>
<tr>
<td>Engpaßleistung (EPL):</td>
<td>231 MW</td>
</tr>
<tr>
<td>mittlere Fallhöhe:</td>
<td>630 m</td>
</tr>
<tr>
<td>Ausbauwassermenge (QA):</td>
<td>52 m³/s</td>
</tr>
<tr>
<td>Nutzinhalt:</td>
<td>126,5 Mio. m³</td>
</tr>
</tbody>
</table>

**Kraftwerk Mayrhofen (Unterstufe)**

<table>
<thead>
<tr>
<th>Spezifikation</th>
<th>Wert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kraftwerkstyp:</td>
<td>Speicherkraftwerk</td>
</tr>
<tr>
<td>Speicher:</td>
<td>Wochenspeicher</td>
</tr>
<tr>
<td>Regelarbeitsvermögen (RAV):</td>
<td>671 GWh</td>
</tr>
<tr>
<td>Engpaßleistung (EPL):</td>
<td>345 MW</td>
</tr>
<tr>
<td>mittlere Fallhöhe:</td>
<td>470 m</td>
</tr>
<tr>
<td>Ausbauwassermenge (QA):</td>
<td>92 m³/s</td>
</tr>
<tr>
<td>Nutzinhalt:</td>
<td>6,8 Mio. m³</td>
</tr>
</tbody>
</table>
4.2 Auswirkungen der EU – Wasserrahmenrichtlinie

4.2.1 Thema Durchgängigkeit


4.2.2 Thema Restwasser

Aufgrund der zahlreichen Gewässerausleitungen spielt die Restwasserfrage eine wesentliche Rolle. Bei Fassungen in niedrigeren Horizonten findet bereits jetzt eine Restwasserdotation statt. Inwieweit in hohen Fassungshorizonten eine Dotation sinnvoll ist und der Verhältnismäßigkeit entspricht ist noch unklar. Unter der Annahme einer generellen Restwasserabgabe nach der deutschen LAWA würden dem System für die energiewirtschaftliche Nutzung rund 42 Mio. m³ Wasser verlorengehen. Das entspricht einem Verlust von 7 % bzw. rund 47 GWh Spitzenenergie.

4.2.3 Thema Schwallbegrenzung

5. Kraftwerksgruppe Obere Ill – Lünersee (Jahrespeicherkraftwerk) – Vorarlberger Illwerke AG
AUSTRIA
(English Translation will follow in short time)

5.1 Systembeschreibung


Anlagenkonzept
Silvrettasee:
  Typ: Jahresspeicher
  Lage: 2030 m, auf der Bielerhöhe
  Nutzungsinhalt: 38,6 Mio. m³
  Energieinhalt: 134,69 Millionen kWh

Vermuntsee:
  Typ: Wochenspeicher
  Lage: 1743 m, auf der Alpe Vermunt
  Nutzungsinhalt: 5,3 Mio. m³
  Energieinhalt: 15,13 Millionen kWh

Kopssee:
  Typ: Jahresspeicher
  Lage: 1809 m, im Bereich Zeinisjoch / Silvrettagebiet
  Nutzungsinhalt: 42,9 Mio. m³
  Energieinhalt: 127,45 Millionen kWh

Lünersee:
  Typ: Jahresspeicher
  Lage: 1970 m, Brandnertal / Schesapiana
  Nutzungsinhalt: 78,3 Mio. m³
  Energieinhalt: 262,16 Mio. kWh
Obervermutwerk:
Regelarbeitsvermögen (RAV): 45 Millionen kWh
Engpaßleistung: 29 MW
Rohfallhöhe: 291 m
Ausbauwassermenge Turbinen: 14 m³/s

Vermuntwerk:
Regelarbeitsvermögen (RAV): 260 Millionen kWh
Engpaßleistung: 156 MW
Rohfallhöhe: 714 m
Ausbauwassermenge Turbinen: 26 m³/s

Kopswerk:
Regelarbeitsvermögen (RAV): 392 Millionen kWh
Engpaßleistung: 247 MW
Rohfallhöhe: 780 m
Ausbauwassermenge Turbinen: 37,5 m³/s

Rifawerk:
Regelarbeitsvermögen (RAV): 8 Millionen kWh
Engpaßleistung im Turbinenbetrieb: 7 MW
Aufgenommene Motorleistung im Pumpbetrieb: 8 MW
Rohfallhöhe: 34 m (bezogen auf Absenkziel)
Ausbauwassermenge Turbinen: 30 m³/s
Ausbauwassermenge Pumpen: 30 m³/s

Latschauwerk:
Regelarbeitsvermögen (RAV): 22 Millionen kWh
Engpaßleistung: 9 MW
Rohfallhöhe: 28 m
Ausbauwassermenge Turbinen: 40 m³/s
### Lünerseewerk:
- Regelarbeitsvermögen (RAV): 371 Millionen kWh
- Engpaßleistung im Turbinenbetrieb: 232 MW
- Aufgenommene Motorleistung im Pumpbetrieb: 224 MW
- Rohfallhöhe: 974 m
- Ausbauwassermenge Turbinen: 32 m³/s
- Ausbauwassermenge Pumpen: 28 m³/s

### Rodundwerk I:
- Regelarbeitsvermögen (RAV): 332 Millionen kWh
- Engpaßleistung im Turbinenbetrieb: 198 MW
- Aufgenommene Motorleistung im Pumpbetrieb: 41 MW
- Rohfallhöhe: 353 m
- Ausbauwassermenge Turbinen: 60 m³/s
- Ausbauwassermenge Pumpen: 10 m³/s

### Rodundwerk II:
- Regelarbeitsvermögen (RAV): 486 Millionen kWh
- Engpaßleistung im Turbinenbetrieb: 276 MW
- Aufgenommene Motorleistung im Pumpbetrieb: 260 MW
- Rohfallhöhe: 354 m
- Ausbauwassermenge Turbinen: 87 m³/s
- Ausbauwassermenge Pumpen: 75 m³/s

### Walgauwerk:
- Regelarbeitsvermögen (RAV): 356 Millionen kWh
- Engpaßleistung: 94 MW
- Rohfallhöhe: 162 m
- Ausbauwassermenge Turbinen: 68 m³/s
5.2 Auswirkungen der EU – Wasserrahmenrichtlinie

5.2.1 Thema Durchgängigkeit

Aufgrund der alpinen Lage wirkt sich die Problematik der Durchgängigkeit der Fließgewässer bei der Kraftwerksgruppe nicht so erheblich aus. Die zahlreichen Unterbrechungsstellen beruhen auf den natürlichen Gegebenheiten. Im Bereich Ill-Rodund und Partenen, wo Fischaufstiegshilfen möglich sind, belaufen sich die Kosten auf Grund von ersten Abschätzungen auf rund EUR 300.000,-.

5.2.2 Thema Restwasser


5.2.3 Thema Schwallbegrenzung

Die Verringerung der schwallartigen Wasserrückgabe in die Fließgewässer durch Betriebeinschränkungen und womöglich durch technische Maßnahmen stellt eine weitere
6. **Kraftwerk Langenegg**  
(Wochenspeicherkraftwerk) – AUSTRIA  
(English Translation will follow in short time)

6.1 **Systembeschreibung**

Das Kraftwerk Langenegg ist seit 1979 in Betrieb und bildet die größte Energieerzeugungsanlage der Vorarlberger Kraftwerke AG. Dabei wird das Wasser der Bolgenach und der beigeleiteten Subersach genützt. Die Kenndaten der Anlage stellen sich wie folgt dar:

*Kraftwerk Langenegg*

<table>
<thead>
<tr>
<th>Eigenschaft</th>
<th>Wert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kraftwerkstyp:</td>
<td>Speicherkraftwerk</td>
</tr>
<tr>
<td>Speicher:</td>
<td>Wochenspeicher</td>
</tr>
<tr>
<td>Regelarbeitsvermögen (RAV):</td>
<td>227 GWh</td>
</tr>
<tr>
<td>Engpaßleistung (EPL):</td>
<td>74 MW</td>
</tr>
<tr>
<td>mittlere Fallhöhe:</td>
<td>280 m</td>
</tr>
<tr>
<td>Ausbauwassermenge (QA):</td>
<td>32 m³/s</td>
</tr>
<tr>
<td>Nutzinhalt:</td>
<td>6,8 Mio. m³</td>
</tr>
</tbody>
</table>
6.2 Auswirkungen der EU – Wasserrahmenrichtlinie

6.2.1 Thema Durchgängigkeit
Das Sperrenbauwerk besteht aus einem 100 m hohen Kiesschüttdamm mit einem Dichtungskern aus Moränenmaterial. Die Durchgängigkeit des Fließgewässers an dieser Stelle zu realisieren ist, wenn überhaupt, nur schwer möglich. Die Frage der Verhältnismäßigkeit der Maßnahme wäre zu klären.

6.2.2 Thema Restwasser
An der Sperrenstelle wird derzeit eine Dotierwassermenge von 100 l/s abgegeben. Die Subersach wird bei der Wasserfassung jahreszeitlich abgestuft mit 100 l/s bis 400 l/s dotiert. Im Falle einer Restwasserabgabe in Höhe des MJNqt von jeweils 440 l/s ergibt sich ein zusätzlicher jährlicher Energieverlust von ca. 13,2 GWh. Dies entspricht in etwa 6% des Regelarbeitsvermögens des Kraftwerkes Langenegg.

6.2.3 Thema Schwallbegrenzung
Durch die Schwallbegrenzung auf das Maß von 1:3 kann das Kraftwerk nicht mehr in vollem Umfang entsprechend den Anforderungen des Netzes gesteuert werden, was zur Folge hat, dass die besonders attraktive Produktion von Strom zu Hochzeitpreisen nur in stark verringertem Ausmaß möglich ist. Als technische Alternativlösung zum Ersatz der verloren gegangenen Leistung kommen Pumpspeicherwerke und schnell startende Gasturbinen in Frage. Ob Gasturbinen eine wesentlich bessere Umweltoption darstellen ist auf Grund der CO2-Problematik fraglich.
Mit großer Wahrscheinlichkeit darf aber angenommen werden, daß es möglich ist, Pumpspeicheranlagen so zu errichten, daß ihre ökologischen Auswirkungen durchaus verträglich sind und damit eine alternative Umweltoption darstellen.
Je nach Szenario liegt die Pumpenergie für das Kraftwerk Langenegg, welches zum Ausgleich des Leistungsdefizits benötigt würde, zwischen 12.000 und 27.000 MWh.
7. Medium run-of-river power station
   Eichicht run-of-river power station

7.1 System description

The Eichicht run-of-river power plant is situated on the Saale River, the largest tributary of the Elbe, and is part of what is known as the Saalekaskade or “Saale Cascade” in the German state of Thuringia. The Saalekaskade is a system of dams and power stations comprising several parts, which was built over several decades (1920-1960) as flood protection and for the generation of energy. It consists of the pumped storage power stations Bleiloch and Hohenwarte I and II, the Wisenta reservoir power station and the Burgkhammer and Eichicht run-of-river power stations.

The major characteristics of the system are as follows:

**Eichicht power station:**
- Power station type: Run-of-river power plant
- Normal generating capacity: 7 GWh
- Maximum continuous output: 2 x 1.7 MW
- Average head: 9 m
- Turbine nominal flow: 2 x 15 m³/s
- Quantity and type of generating sets: 2 Kaplan turbines
7.2 Impacts of the EU Water Framework Directive

7.2.1 Continuity

In our view, the guarantee of continuity in respect of migrating species and the sediments cannot be a rational requirement as the Hohenwarte dam reservoir is situated just a few kilometers upstream (approx. 4 km). It is separated from the Eichicht dam reservoir by a concrete dam having a height of 75 m (!) and a crest length of 412 m. In so far as continuity should nevertheless be required for this short section, only a fish ladder would come in for consideration owing to the narrow shape of the valley. The costs purely for the fish ladder (access, edge strip widening, possible blasting, tunneling under roads, etc.) are estimated at approx. EUR 200,000 to 500,000 depending on the type chosen. On top of this would come the costs for possible mitigation measures and maintenance.

Owing to the heavily fluctuating water level in the Eichicht lower basin, a fish pass would only ever be in operation for a few hours at a time. In between these times it would fall dry.

7.2.2 Residual water

As part of the water rights permit, an ecological minimum stream flow is specified, but this is used continuously for the generation of electricity. In this respect the topic of residual water is
not significant for this run-of-river power plant.

### 7.2.3 Splash

The splash issue plays no part in relation to pure run-of-river power stations.

### 7.2.4 Cost-covering water prices

The Water Framework Directive provides for water prices to cover the cost of water services. These include the damming of waters – although primarily for purposes of supplying drinking water. To what extent the purpose of “generating electricity from water power” is also to be assessed is in our opinion not definitively defined. For example, the state of Schleswig Holstein levies a surface water fee of EUR 0.0077 / m³ for the operation of a pumped storage power station. If this guide value is transferred to the Eichicht run-of-river power station, then with average annual generation of 7 GWh and a flow rate of 12 m³/s in the yearly average, additional costs of around EUR 3 million can be expected.

However, that would need to be offset against costs for tasks normally incumbent on the federal state as part of its flood protection remit, which Vattenfall Europe has previously performed free of charge (it’s only fair that the principle of covering costs should apply in both directions). On the one hand this concerns the keeping in principle of a flood control area, and on the other hand the necessary structural redevelopment and monitoring of the concrete dams.

The management plans are being drawn up by the Ministerium für Landwirtschaft, Naturschutz und Umwelt (Ministry of Agriculture, Nature Protection and Environment) and by the Staatliches Umweltamt (National Environment Agency) for implementation with respect to hydroelectric power stations. The specifications for managing the Saalekaskade (e.g. increased water output without using it to generate energy) are often contrary to the interests of Vattenfall Europe as the operator and owner of the peak load power stations.
8. Two small power plants (run-of-river power stations) on the Gurk River (AUSTRIA)

8.1 Description of systems

The necessity to change energy generation from the use of coal to the use of water power first occurred after the First World War. Since then the development of such power plants along the Gurk River has had its consequences on the Klagenfurt region.

8.2 Example: The Passerling Power Plant (River Power Plant)

The Passerling power plant was put into operation in 1922. Since then the concrete constructing the basin of the weir has been repaired several times. The Gurk River is dammed up by a weir of approximately 7 m and consists of three weir fields. From the almost 300,000 cubic m of original storage capacity only a fraction of it still exists due to the extensive silting that has occurred throughout the power plant’s more than 80 years of operation. The sediment management, to which authority representatives and residents agree, corresponds to a minimum flood volume which is regulated by official assessment. The essential details concerning the power plant are presented as follows:

**The Passerling Power Plant:**

- Type of power plant: run-of-river power station built in 1921/22
- Mean generating capacity: 4.0 GWh
- Maximum capacity: 0.84 MW
- Gross head: 7.8 m
- Maximum flow: 6.5+10.0 cubic m/s
- Number of hydroelectric generating sets: 2 Francis turbines
- Number of weir fields: 3
- Fish ladder: none
- Length of water permit: until 2012

Powerhouse, weir from angle of tailwater
A surveyor’s plan of the Passering (above) and Launsdorf Power Plants along the Gurk River:

Section of Gurk

Legend:
Water Flow Withdrawal
Large Barrage
Small Barrage
Powerhouse
Run-of-River Power Station
Water-retaining Power station
Special Kelag Signs
Section of the powerhouse and weir:

Schützenhebeeinrichtung
Elektrisch – Umbau
Sliding Lock Device
Electrical Conversion

Rechen
Screen

Oberwasser
Headwater

Turbine
Turbine

Turbinenregler
Turbine Regulator
8.3 Example: The Launsdorf Power Plant (Water Diversion Power Plant)

The Gurk River is diverted five kilometres downstream of the Passering Power Plant by the use of an 850 m long headwater channel which decreases a bend in the river. The channel which is lined with concrete is 6.5 m wide along the bottom and in 1984 the concrete on the embankment was completely repaired. With a water depth of two metres, a freeboard of approximately 30 cm still remains in the channel. The channel measures 11.5 m wide along the embankment. The power plant was built in 1926.

**The Launsdorf Power Plant**

- Type of power plant: run-of-river power station built in 1926
- Mean generating capacity: 4.5 GWh
- Maximum capacity: 0.94 MW
- Gross head: 7.8 m
- Maximum flow: 8.15 + 8.15 cubic m/s
- Number of hydroelectric generating sets: 2 Francis turbines
- Number of weir fields: 1 fish belly flap
- Headwater channel: Trapezoid cross section (20 sq m)
- Fish ladder: since 1996
- Length of water permit: unlimited

Section of the powerhouse

Weir
8.4 **Effects of the EU Water Framework Directive**

8.4.1 The Issue of Unlimited Passage

The storage area of the Passering Power Plant has suffered siltation over the decades due to its special location along a narrow passage of the Gurk River as well as to the fact that it retains up to seven metres of water at a time. A sediment drift was only moderately possible due to the absence of flood waters in the last decades. Due to the fact that the water permit will be expiring in 2012, further regulations concerning the operation can be expected with the issue of a permit renewal at the latest. At present, a fish ladder does not exist at the Passering Power Plant. The construction of a fish ladder is estimated to be at least €100,000; the financing for using other people’s land has not yet been taken into account in this estimate.

The Launsdorf Water Diversion Power Plant was constructed after the Passering Power Plant in 1926. In 1994/95 a fish ladder was built by means of which residual water of about 300 l/s is now diverted. The fish ladder, however, does not extend the entire length of the reservoir. Special measures are also necessary for fish ladder maintenance especially when water is retained in the headwater channel. For maximal function, the fish ladder would have
to be extended another 200 m approximately in order for it to reach the end of the reservoir. Costs could run about € 20,000.

8.4.2 The Issue of Residual Water

Because of the low water storage volume in both systems it is necessary for both power plants to be in operation simultaneously. Both new and higher demands of residual water could cause losses on both the management as well as on production levels. The production loss caused by a residual water release of 300 l/s means that each system will lose approximately 100,000 kWh per year, which calculates to 0.05 €/kWh or € 5,000 for each power plant.

In the worst case scenario, if the LAWA (Working Group of the Federal States on Water) guideline applies, the average amount of water that will be transferred through the power plants will fluctuate between 4 and 5 cubic m/s, which means the year’s lowest water level average. This would cause a reduction of over 50% in annual production. With a mean generating capacity of 4 GWh for each power plant, the loss of production can be estimated according to the above mentioned calculations of € 100,000 for each.

8.4.3 The Issue of River Flow

The issue of river flow plays a secondary role in connection with mere run-of-river power stations.

8.4.4 The Issue of a Gurk Power Plant Chain

According to the public water record, there are a total of 22 power plant operators that stretch the over one hundred kilometres of riverbank along the Gurk River. Three plants are owned by the Kelag-Kärntner Elektrizitäts AG.

A water management plan is currently being worked out by the Carinthian provincial government. It is planned to integrate the interests of private power plant operators along with the processes of flood water management, etc. The implementations proposed by the Water Framework Directive have not yet opened to the realm of private operators therefore such corresponding measures have not yet been declared.
9. Annual Storage Power Station Group
Fragant (AUSTRIA)

9.1 Description of Systems

The Fragant Storage Power Station Group consists of a system of several storage power stations, which are connected hydraulically. Built between 1964 and 1985, this group serves primarily to provide top peak electricity to be either put on reserve or used for everyday purposes. It is a system that is constructed in stages and consists of four storage power stations and three smaller run-of-river power stations. The Zirknitz powerhouse, which is situated on the highest horizon, is a winter storage plant. The Großsee-Hochwurten is a double storage station that serves as the group’s main reservoir source whereas the Zirmsee station acts as a remote storage unit. The tailwater from the Zirmsee power plant as well as other stream channels feed into the storage station at Wurtenalm. At Wurtenalm the water can either be rerouted to the middle horizon or can be pumped into the largest reservoir holding of the other power plants, that is to say, in the Oschenik Lake. The Innerfragant powerhouse, located at 1,200 m above sea level, is the hydraulic centre of the entire power station group. At a lower level the Außerfragant power plant uses the tailwater from the Innerfragant and Wölla power plants. The details of the plants are presented as follows:

**Zirknitz Power Plant (upper horizon):**
- Type of power plant: Storage Power Station
- Storage: Annual Storage
- Mean generating capacity: 59 GWh
- Maximum capacity: 32 MW
- Gross head: 689 m
- Maximum flow: 5.6 cubic m/s
- Useful capacity: 38 million cubic m

![Zirknitz Power Plant Image]

**Innerfragant Power Plant (middle horizon):**
- Type of power plant: Storage Power Station
- Storage: Annual Storage
- Mean generating capacity: 184 GWh
- Maximum capacity: 108 MW
- Pumping capacity: 90 MW
- Gross head (Oschenik): 1,185 m
- Maximum flow: 23 cubic m/s
- Useful capacity: 31.7 mill. cubic m

![Innerfragant Power Plant Image]
**Außerfragant Power Plant (lowest horizon):**

- Type of power plant: Storage Power Station
- Storage: Annual – Daily Storage
- Mean generating capacity: 235 GW
- Maximum capacity: 66 MW
- Gross head: 488 m
- Maximum flow: 22.8 cubic m/s
- Useful capacity: see above

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**Figure: System Outline of the Fragant Power Station Group**

### 9.2 Effects of the EU Water Framework Directive

#### 9.2.1 The Issue of Unlimited Passage

In connection with the Fragant Power Station Group, the unlimited passage of running water becomes significant in that small power plants were later constructed around curbed streams located in the lower area from which the residual water can now be utilised. In total, nearly 30 mountain brooks have been recorded, which are, however, in the high-Alpine area. The disruptions caused by the power plants do not normally play a role in hindering the fish migration, as their migration routes are often already prohibited by natural obstacles. Would the unlimited passage be extended to small organisms, the question of proportionality would have to be resolved.

#### 9.2.2 The Issue of Residual Water

Due to the numerous stretches of water routes, the question concerning residual water plays an important role. It has been hardly discussed as to what extent it would be sensible to supply high capacity horizons with respect to their proportionality. According to the German LAWA, if a general residual water loss were to take place, the system would lose about 70 million cubic m of...
water for energy-generating utilisation. This would correspond to a **loss of approximately 17% or about a 90 GWh** loss of peak load energy.

### 9.2.3 The Issue of River Flow Limitation

The issue of river flow limitation creates the fundamental conflict between the implementation of the EU WFD and the requirements of the energy sector. It is currently being discussed that in Austria there is a significant borderline of artificial flow force of 1:3 which is necessary to reach a good status quo and 1:5 which is necessary for reaching a good potential. The Außerfragant power plant would be affected by this in particular, as it is a storage power station possessing both a large capacity and a large maximum flow rate which then ends in a relatively small stream channel. In the case of a flow limitation of 1:3 the use of the plant’s full potential as a main power station would only be possible periodically. A flow limitation of 1:5 would reduce these restrictions, but would also have considerable monetary effects nevertheless. At any rate, because of the low stream channel outlets and machine composition with which the power station is faced with any limitation regulations altering the character of the run-of-river power station are going to create difficulties.

Furthermore, monetary losses are caused both by the necessity to operate in the off-peak period (i.e. where there are far lower electricity prices than in the peak area) as well as by the necessary additional purchases for certain personal needs and/or requirements in the peak period.

According to the quarterly average water flows in the Möll stream channel, the losses that would occur by regulating a river flow limitation of 3:1 would be enormous, whereas the losses caused by the necessary operation in the off-peak period is 1/3 and the losses caused by additional purchases in the peak period would reach 2/3. With this regulation (1:3), 40% of the regular production would be taken from the top of the basic energy production and the system would lose **640 full load hours** about **150 MW** of precious top peak energy. Furthermore, **150 MW** – over just about **6,000 hours** – as regular energy (minute reserve) could no longer be sustained. A retaining power station, only possible since the liberalisation of the electricity market, would also have to be closed if the production capacity reached only **40 GWh/year**.

In the case of a river flow limitation of 5:1, the profit loss would decrease considerably, but still painful, in which the loss caused by the necessity to operate in the off-peak area would make up 1/10 and the loss caused by necessary additional purchases 9/10. With such a regulation (1:5), 12% of the regular production would still be taken from the top of the basic energy production and the system would still lose an immense **200 full load hours** **50 MW** of precious top peak energy. Furthermore, **50 MW** – over just about **6,000 hours** – as regular energy (minute reserve) could no longer be sustained. A retaining power station, once again, only possible since the liberalisation of the electricity market, would also have to be closed if the production capacity reached only **30 GWh/year**.

The plant would thus be rendered completely valueless as a main power station.
10. Hydro power plant “Bergheim an der Donau”  
(run-of-power plant)

10.1 System description
The four hydro power plants along the 40 km section of the river danube between the cities of Bertoldsheim and Ingoldstadt were built in the years 1967 up to 1971. The hydro power plants were built in the same basic principle. Thereby it was possible to obtain a mostly typecast for the buildings. Every barrage consists of a weir with three fields, a power station with 3 turbines, a boat lock and the storage, double-sided bordered with dams.

The rated capacity was chosen on a very high level because of the daily swell operation. The swell operation is operated according to the program of the Deutsche Bahn with a peak in the morning time and a peak in the evening time. Because of the swell operation the firm capacity – this is the capacity, which can be reached at minimum 330 days within the average year – can be increased from 36 MW in run-of operation up to 64 MW.

Technical data:

- Type of power plant: run-of-power plant
- Capacity at normal load: 144 GWh/year
- Type of turbines: 3 Kaplan
- Turbine capacity: 23.7 MW
- Nominal discharge: 500 m³/s
- Head: 6.0 m

Layout plan of the Barrage Bergheim
10.2  Effects of the Water Framework Directive

10.2.1  Topic Undisturbed Migration
At the hydro power plant Bergheim there is no bypass channel. The construction of a bypass channel costs about 500,000 EUR.

10.2.2  Topic Residual Water
For the operation of the bypass channel the rated discharge amounts to approximately 3 m$^3$/s. Thereby a loss of generation would amount to approximately 1,24 GWh/year.
11. Randersacker am Main (run-of-power plant)

11.1 System description

The characteristics of the flow rate of the Main correspond to the flow rate of rivers from the low mountain range of Germany, because the Main has in winter often bigger flow rates than in summer. This fact is contrary to mostly all other rivers of Bavaria, which have their biggest flow rates in the early summer and in the summer, because their springs are in the alps. The variations from the average flow at the river Main are significant. The highest known flood was measured at Schweinfurt in the year 1845 with $Q= 2000 \text{ m}^3/\text{s}$. The smallest lower high water was measured in the year 1964 with $Q= 11 \text{ m}^3/\text{s}$. The long time mean water flow in this river section amounts to approximately $Q= 100 \text{ m}^3/\text{s}$.

The Rhein-Main-Donau AG built between 1923 and 1963 along the Main a series of hydro power plants to make the river navigable between Aschaffenburg and Bamberg. The hydro power plant Randersacker was one of the first plants, which were built after the second-world war and was put into operation in the year 1950.

This power plant is almost constructed in the same way compared to the last plants, which were built before the second-world war.

**Technical data:**
- type of power plant: run-of-power plant
- capacity at normal load: 144 GWh/year 4
- type of turbines: 2 Kaplan with vertical shaft
- turbine capacity: 2 x 1 MW
- nominal discharge: 100 m$^3$/s
- head: 62,8 m

![View from downstream to the power station Randersacker](image)
11.2  Effects of the Water Framework Directive

11.2.1  Topic Undisturbed Migration
At the power plant Randersacker a bypass channel is planned to be constructed on order to improve the aquatic passing. The construction of the bypass channel costs about 300,000 EUR.

11.2.2  Topic Residual Water
For the operation of the bypass channel the rated discharge amounts to approximately 1 up to 6 m³/s. Thereby the loss of generation would amount to approximately 150 MW/year.
12. **Walchensee at the higher Isar (storage power plant)**

12.1 **System description**

The storage power plant Walchensee, which was put into operation in 1924, is one of the oldest and most efficient power plants of E.ON Wasserkraft. The original concept, that conducts water from the lake Walchensee to the lake Kochelsee, was developed further on in the fifties to a power plant system, reaching from the border of Tirol to Wolfratshausen. The intake structures into the Walchensee have been also used from the power plants Niedernach and Obernach for producing electricity.

**Technical data:**

- **type of power plant:** storage power plant
- **capacity at normal load:** 293,3 GWh/year
- **type of turbines:** 4 Francis, 4 Pelton
- **turbine capacity:** 4 x 18 MW, 4 x 13 MW
- **nominal discharges:** 84 m³/s
- **head:** 200 m
- **storage capacity:** 110 Mio. m³

![Map of Walchensee and its surrounding power plants](image)
12.2 Effects of the Water Framework Directive

12.2.2 Topic Residual Water
In order to use the lake Walchensee permanently as an energy storage water must be supplied. This is realized by inflows from the Isar and from the Rissbach, which are especially constructed for this purpose. By new respectively higher base flow discharge the power generation would be highly reduced. By an increase of the base flow discharge at the weir of Rissbach of about 0.8 m³/s and by the construction of a fish ladder at the weir Krünn at the Isar and at the weir Rissbach with a rated discharge of each 0.5 m³/s the loss of generation would amount to approximately 10,000 MWh/year. This is according to a total loss of 11 % respectively 31 GWh/year.

12.2.3 Topic Swell
The lake Kochelsee is used as the down-stream water of the storage power plant Walchensee. Because of the big size of the lake swell is not a problem at this power plant.

storage power plant Walchensee: view of the Kochelsee and inside of the power house
13. Large run-of-river power plant (river power plant)  
Rhine power plant Iffezheim

13.1 Description of the system

The Rhine power plant Iffezheim is the last power plant out of 10 successive run-of-river power plants on the upper Rhine, which forms the German-French border between Basel and Karlsruhe (see picture). From here the Rhine is flowing freely up to its estuary in the North Sea and is not retained at any other place at the moment. The important characteristics of the plant, on the German bank of the river, which was taken into operation in 1978, are as follows:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of plant</td>
<td>Run-of-river power plant</td>
</tr>
<tr>
<td>Standard working capacity</td>
<td>750 GWh/a</td>
</tr>
<tr>
<td>Maximum capacity</td>
<td>108 MW</td>
</tr>
<tr>
<td>Mean gross head</td>
<td>11 m</td>
</tr>
<tr>
<td>Turbine discharge capacity</td>
<td>1,100 m³/s</td>
</tr>
<tr>
<td>Number of hydroelectric generating sets</td>
<td>4 Kaplan bulb turbines</td>
</tr>
<tr>
<td>Number of weir fields</td>
<td>6</td>
</tr>
<tr>
<td>Shipping sluices</td>
<td>2 (24 x 270 m)</td>
</tr>
</tbody>
</table>
13.2 Impacts of the EU water framework directive

13.2.1 Continuity

The Rhine power plant Iffezheim plays a special role. After 700 km of the Rhine, it is the first obstacle for the migrating fish, such as salmon and sea trout, at swimming from the sea to their spawning grounds in the Black Forest (Germany) and Alsace (France).

Because of this extraordinary situation, both countries, together with the operating company, decided and financed the construction of the fish pass in Iffezheim, which is one of the largest in Europe. This vertical slot fish pass has been in use since June 2000. Constant monitoring shows that most of the approximately 45 fish species in the Rhine have, to a large extent, come back and use this construction, which cost about 10 million Euro.

13.2.2 Minimum flow

The Rhine power plant is a river power plant without an out-line-stretch, therefore, the question of of minimum flow requirements is not relevant.

13.2.3 Surge

The Rhine power plant Iffezheim is used as a balance for the series of dams, in order to moderate the discharge. Therefore, there is no surge below the power plant.
14. Small water-power plant (river power plant)
   Neckar power plant Kiebingen

14.1 Description of the system

The water power plant Kiebingen is located at the upper reaches of the river Neckar near Tübingen, Germany, surrounded by a series of successive water power plants (see picture). In between the individual plants there are short distances for the Neckar to flow freely. The important characteristic of the plant, which was put into operation in 1923 and renovated in 1996-2002, are as follows:

- type of plant: run-of-river power plant
- standard working capacity: 8,0 GWh/a
- maximum capacity: 1,56 MW
- mean gross head: 8,3 m
- turbine discharge capacity: 24,8 m³/s
- number of hydroelectric generating sets: 4 Kaplan-type turbines
- number of weir fields: 2 (weir tube)
- shipping sluices: none
14.2 Impacts of the EU- water framework directive

14.2.1 Continuity
The water power plant Kiebingen is part of a partially continuous chain of water power plants as well as other buildings, built across the Neckar. With the new permission and the subsequent renovation of the plant, the operating company, the Energie Baden-Württemberg (EnBW), requested the establishment of a fish pass. According to the local constraints, a basin-slot-pass was established in the Grayling-Barbel-Region at the cost of 1.4 million Euro.

14.2.2 Minimum flow
The power plant Kiebingen is a river power plant without an out-line-stretch, therefore, the question of minimum flow requirements is not relevant.

14.2.3 Surge
The power plan is being operated as a pure run-of-river power plant, therefore, there is no surge caused during operation.
15. WFD RELATED RISKS IN FRANCE ILLUSTRATED USING A FEW EXAMPLES TAKEN FROM THE FIELD
EDF Branche Energies – MH, Saint-Denis/F

The global objective to preserve or even restore the natural environment is in our general interest and any responsible industrialist can but subscribe to this, especially if the approach includes taking into account existing ways of using the water notwithstanding the economic dimension.

The main problem of the WFD comes from the definition of the references (good status, good potential) which, within a relatively short space of time (and without any possible exception being made for the chemical aspect), must be extended to include all the water bodies.

The description of the status of the current sites, which was virtually finalised in France at the end of 2004 and the aforementioned reference statements should of course first and foremost comply with a logical sequence (first the references, then the classification of the water bodies and finally the measurement programme). This should then lead to scientific rules that leave little room for interpretation.

It is interesting to note that on the contrary in France, water bodies were first classified without knowing the references. The indicators and measuring resources required to establish an objective and unquestionable schedule of condition of property are obviously missing.

As a result, for these two reasons, the approach loses part of its original “purity” and instead becomes eminently political. Behind the classification ‘curtain’, pressure groups and manoeuvres have begun to loom, bringing with them serious risks for energy plants.

A few examples from the field bear witness to this:

To begin with, let us consider the river where a powerful hydroelectric plant is installed, one capable of providing a level of power equivalent to that of a nuclear unit in just a few minutes. Several water stakeholders would appear to defend contradictory standpoints: the local authorities that are anxious to develop a ‘navigation product’ argue in favour of classification as a natural water body, which is more in line with the objectives of a tourist brochure, whilst at the same time calling into question the extensive artificial variations in the flow as a result of the energy use.

This hydropoaking would tend to designate the water bodies under examination as being strongly modified, especially if one takes into account the necessary preservation of the general interest of the energy plant present on this catchment area. Fishermen themselves are openly putting the pressure on in favour of natural water bodies immediately downstream of the hydroelectric chain by backing certain objectives and following this, hoping for a good status that involves more constraints for the operator.

We see through this example how pressure groups can pervert an approach and as a result, commit an entire catchment basin to a spiral that has every chance of succeeding in the short term and call into question all the hydropoaking of the hydroelectric chain and its very purpose, despite its inherently strategic nature.
The same situation has been experienced on another strategic hydroelectric chain of approximately the same size, or again on a small river where, in the name of the WFD, certain influential stakeholders such as elected officials and fishermen, or even certain administrative bodies, have concluded that it is necessary to demolish two 35 and 15 meter high barrages.

Let us move on to talk about a highly complex installation that makes it possible to produce hydroelectric energy of 300 GWh and to supply water to a catchment basin by diverting part of the water from another catchment basin. Of course, outside periods of minimum water levels. Clearly it is a question here of a multi purpose structure, capable of supporting minimum water levels on both the Atlantic and Mediterranean watersheds that are vital for potable water supply, irrigation and water sports, whilst preserving their initial and main energy vocation.

This installation uses galleries inside the mountain and outlets beneath the lakes to link up natural lakes of volcanic origin that store the waters until they are needed. Although no comprehensive rigorous method is currently available to precisely characterise the quality of the water areas, one of these natural lakes of volcanic origin has been classified as a natural water body despite the fact that it is totally artificial. Such a provision should logically forbid us from any range of tide that is detrimental not only to energy activities but also to the other uses. This type of almost ideological implementation of the WFD, very much disconnected from reality and the current challenges, is extremely worrying.

These two examples illustrate how, in order to protect the natural heritage, as is perfectly legitimate, one can, by use of calculations, automatic conclusions or poor assessment of the natural balance, call into question, without any possibility of adjustment, another heritage, that of hydraulics and energy, that is also vital for Man’s survival.