Water Framework Directive & Hydropower

Common Implementation Strategy Workshop
Berlin, 4-5 June 2007

Issues Paper

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This issues paper was prepared by Ecologic on behalf of the workshop co-organisers of UK, Germany, Austria and the EC.

Contents

1 Background and introduction to the aims of the workshop

At their last meeting in Inari/Finland (30 November - 1 December 2006) the Water Directors agreed to continue the CIS activity on “Water Framework Directive and hydromorphological pressures”. The focus of the continued activity (Phase II 2007-09) should be on the exchange of information via workshops rather than on the production of further documents. The workshop on Water Framework Directive (WFD) & Hydropower (Berlin, 4-5 June 2007) is the first to be organised by the lead countries UK/DE of the CIS activity in cooperation with Austria, as part of the programme of the German EU Presidency.

The focus of the workshop is on hydropower use and the relationship to hydromorphological changes. Especially major key issues should be discussed, which are not or are only partly covered by the existing documents of Phase I of the CIS activity (Technical Paper and Policy Paper) and therefore need increased attention.

The workshop aims at reaching common understanding among the participants on:

- Instruments to maintain as well as promote hydropower use and in the same time improve the ecological water status/potential.
- Effective measures enabling hydropower plant operation to be compliant with the WFD water body environmental objectives, including ecological criteria & technical standards.
- Strategies and priorities for the improvement of hydromorphological conditions in catchments used for hydropower generation. The aim is to discuss and formulate recommendations on possible strategies of prioritisation of water bodies and measures within the scope of the WFD implementation.

The exchange of information at the workshop will facilitate the implementation of the WFD by enabling Member States to share each other’s relevant expertise and by contributing towards the development of more consistent approaches. The workshop will also serve as a forum to identify key knowledge gaps on the use of water for hydropower and WFD implementation.

At the end of the workshop, participants will develop a set of key joint conclusions.

2 Aim of the issues paper

The workshop is intended to be a working meeting and will require the active participation of delegates. The purpose of this paper is to stimulate workshop discussions. On the one hand, it introduces the key issues and problems at hand which will be put up for discussion and, on the other, it points to possible solutions and alternatives. The paper also presents the main questions to be addressed at the workshop.

In the following, section 3 introduces the issue of balancing hydropower development and different environmental protection targets. Sections 4-6 outline the three main themes to be discussed in 3 moderated parallel sessions on day 1 and day 2 of the workshop:

- Instruments to promote hydropower use & to improve water status (parallel session 1)
- Technical approaches for good practice in hydropower use (parallel session 2)
- Strategic approaches & priorities on catchment level (parallel session 3)

In each parallel session, participants will have the opportunity to briefly present a summary of the relevant approaches and views of their Member State or their organisation.

3 Hydropower: Towards a balance of different environmental protection targets

To secure energy supply and tackle climate change, the European Union has developed a policy of renewable energy sources. Key developments in this respect have been the Green Paper on “A European Strategy for Sustainable, Competitive and Secure Energy”, COM(2006) 105, the new Road Map for renewable energy sources in the EU (January 2007) and the Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal market (RES-E Directive). The RES-E Directive requires Member States to set national indicative targets totalling a 21% share of renewable electricity in total electricity consumption in the EU by 2010. In this context, hydropower is an important source of renewable electricity, whose production can make an important contribution to the reduction of CO_2 emissions in Europe within current climate protection policy.

The construction and operation of hydropower (HP) stations is however linked to unavoidable impacts on the water bodies and the adjacent wetlands. Thus, besides the advantage of almost emissions-free energy production through hydropower, there is a need to optimise HP facilities in order to strike a balance with the ecological needs of the affected water systems, adjacent land ecosystems and wetlands. Several EU policies set ecological/environmental requirements on HP facilities. Examples are EU policy requirements for environmental impact assessment as well as nature protection requirements of the Habitats Directive. Additionally, the further use and development of hydropower should consider the environmental objectives of the EU WFD, which aims at the achievement of good ecological status (GES) in European waters. Especially the hydromorphology and fish fauna of water stretches affected by hydropower are adversely impacted. Often the GES of such water bodies cannot be achieved due to substantial hydromorphological changes and these water bodies need to be designated as heavily modified (HMWB). This is the case particularly for reservoirs and impounded rivers affected by chains of transverse physical barriers.

The overarching aim of the Berlin Workshop on WFD and Hydropower is to discuss:

> *How do we reconcile existing and future hydropower generation with the WFD environmental objectives?*

In principle, the use of water to gain energy is not ruled out by the EU WFD. In order to reconcile climate protection, water protection and nature protection objectives, hydropower should be generated in such a manner as to maintain the ecological functions of the affected water stretches.

4 Instruments to promote hydropower use & to improve water status (parallel session 1)

The energy sector (including hydropower) is characterised by high and long-term investments. Thus, HP operators need a certain level of investment security and certainty. Except for the high investments involved in HP generation itself, investment costs for the improvement of water ecological status at HP facilities (especially at existing facilities) can be considerable. Nevertheless, although costs related to necessary restoration/mitigation measures are often a barrier to the protection of water ecology, different instrument options can be considered to provide solutions for both the HP operators and the water ecosystem managers. Relevant financing instruments can be complemented with other types of incentives (such as eco-abelling, simplification of authorisation, compensation options).

The Berlin workshop shall focus on the exchange of information and experience with different relevant instruments applied in European countries. Delegates of the workshop are encouraged to briefly present the specific instruments used in their Member States.

Before presenting a selection of possible instruments, this paper introduces the need for consistent definitions on “hydropower as a renewable energy source” and on “hydropower as green electricity”.

According to the RES-E Directive 2001/77/EC, ‘renewable energy sources’ mean renewable non-fossil energy sources including hydropower. ‘Electricity produced from renewable energy sources’ means electricity produced by plants using only renewable energy sources as well as the proportion of electricity produced from renewable energy sources in hybrid plants using also conventional energy sources, and including renewable electricity used for filling storage systems but excluding electricity produced as a result of storage systems.

The specific implications of these definitions for hydropower should be clarified. For instance, in Germany, the revised Renewable Energy Sources Act[1] excludes from its scope storage power stations whose inflow comes from one or more reservoirs in such a way that the power stations’ use is mainly asynchronous relative to water inflow into the reservoir. This applies in particular to pump-fed power stations whose reservoirs are wholly or partly supplied by pumped waters. The Act distinguishes between these pump-fed power stations and their run-off-river power counterparts, which use their reservoir inflows for the most part synchronously.

As concerns “hydropower as green electricity”, there is still no straightforward definition in Europe. For the purpose of this paper, “green” hydropower is considered as environmentally compatible hydropower production, whereby electricity is produced in view of reducing or compensating local ecological impacts on water.

EU level support

The EU has set targets for the further promotion of hydropower (especially small hydropower, SHP)[2] in the context of its policies to protect the climate and to promote renewable energy sources. DG TREN indicates that its forecast, based on an average annual increase of 2%, should lead the EU to a total of ca. 12786 MW of SHP in 2010.

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1 See http://www.bmu.de/english/renewable_energy/doc/6465.php.

2 There are no consistent criteria for the definition of small hydropower (SHP) across Europe. Although the European Union defines SHP as installations with capacities of less than 10 MW (http://ec.europa.eu/energy/), there are different definitions and approaches in the Member States referring to size thresholds of 10 MW, 5 MW or 1 MW.

Furthermore, the “Sustainable Energy Europe” campaign[3] sets targets for the installation of 2000 MW of new SHPs in the EU-25 between 2005 and 2008.

The financing of renewable energy in the EU is largely in the hands of the Member States. Nevertheless, even national support schemes often partly depend on EU funding, especially the Structural Funds and the Cohesion Fund. After 2006 and in the context of recent reforms of the European cohesion policy, assistance from the Cohesion Fund will also cover projects in the fields of energy efficiency and renewable energy.[4] The EC plans to exploit fully the possibilities offered by the Community’s financial instruments – notably the Structural and Cohesion funds - to support the development of renewable energy sources in the EU (Renewable Energy Road Map, 1/2007).

The European Commission also intends to put forward a first European Strategic Energy Technology Plan (SET-Plan) at the end of 2007.[5] The aim of this Plan is to accelerate the market introduction and take up of low-carbon and efficient energy technologies. The strategic element of the plan will be to identify those technologies for which it is essential that the European Union works in an integrated manner.[6]

Other types of support of renewable energy (including hydropower) on the EU level relate to efforts to promote the facilitation/simplification of authorisation procedures for renewable energy generators, to facilitate grid access and access to the energy market for renewables (overcoming barriers of feeding renewable energy into the market and of market competition with conventional energy sources).

It is important to ensure that existing and forthcoming EU instruments to support and promote hydropower as renewable energy clearly consider the ecological impacts on the affected water stretches. Especially EU programmes supporting scientific research and technological innovation combine HP development targets and environmental protection aspects. The main EU instrument for funding research and development is the Framework Programme for Research (currently the 7th Framework Programme - FP7). A specific FP7 objective concerning hydropower is to further improve the energy and cost-efficiency of hydropower plants, in particular smaller systems, while minimising adverse environmental impacts. This addresses the need for innovative systems, equipment and design practices, which could be at the same time economically and environmentally efficient (e.g. by supporting the development of new or improved hydroelectric turbines).

Selected instruments and experiences in European countries

The following illustrates in brief two examples of instruments used in specific European countries to promote hydropower generation and in the same time improve the water status.

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[3] The Sustainable Energy Europe 2005-2008 Campaign is a European Commission initiative in the Framework of the Intelligent Energy - Europe (2003-2006) programme. Its aims include the promotion of sustainable energy production and use among individuals and organisations, private companies and public authorities, professional and energy agencies, industry associations and NGOs across Europe.

[4] Council Regulation (EC) No 1084/2006 of 11 July 2006 establishing a Cohesion Fund and repealing Regulation (EC) No 1164/94.

[5] European Commission communication (COM (2006)847).

[6] See http://ec.europa.eu/energy/res/consultation/setplan_en.htm.

Feed-in tariffs

Feed-in tariffs can be used as an instrument to reward energy production from HP, when HP operators undertake specific ecological measures. Part of the financial burden involved in measures, e.g. for protecting migrating fish, can be balanced through the higher tariffs.

Such an approach is followed in Germany, where the revised Renewable Energy Sources Act (RESA of 2004) allows higher hydropower feed-in rates when there is proof that the use of hydropower either achieves good ecological water status or substantially improves it. Certain essential criteria for reducing the impact of HP generation (in terms of biological continuity, minimum flow, debris management and reservoir management) have been defined in a guideline of the German Federal Ministry for the Environment. In the context of this scheme, it is controlled whether restoration/mitigation measures are carried out according to current technical standards and ecological criteria and whether measures have resulted in a substantial improvement of the ecological status or ecological potential (GES/GEP). The assessment of “substantial improvement” lies in the judgment of the authorities. In order to be entitled to maintain the right to the increased feed-in rates, the HP operators need to provide proof of their official authorisation pursuant to German water resources legislation and the revised RESA. Submission of this authorisation, which is granted after investigating the improvement degree of GES/GEP, entitles the operator to charge a higher tariff for his output.

Certification and marketing of green electricity - Ecolabelling

Ecolabels are instruments recognising environmental efforts beyond existing environmental legislation. The ecolabel approach is voluntary for both suppliers and the consumers. One of the key issues is the selection of criteria and the standards that have to be met in order to justify a specific label. Initiatives for labeling electricity from hydropower in the European countries are being developed. These take ecological improvements into account, including environmental flows, sediment flushing, fish passages and wetland restoration. However, none of these criteria are agreed at EU level.

A scheme of green hydropower certification is running in Switzerland (greenhydro system). The greenhydro system involves criteria which allow the certification of alpine storage power stations as well as the ecological distinction of small hydropower facilities. A certified facility fulfills on a voluntary basis the following two conditions:

- The facility operates in such a way that central ecological water functions are maintained. The basic requirements involve criteria relevant to minimum flow, dam and debris management, intermittent power generation as well as the design of the facility itself.
- The facility invests a fixed monetary contribution per sold KWh of green electricity in the restoration, protection or ecological improvement of the affected catchment. These green electricity contributions guarantee a targeted, local ecological evaluation of the scheme requirements and allow credible communication with the green electricity customers.

Further possible instruments & incentives

Authorisation procedures

The development of clearer guidance on authorisation procedures for hydropower in relation to the WFD could also act as an instrument facilitating more “green” HP. Authorisation procedures should consider relevant European policy requirements more consistently[7], while authorisation procedures for the execution of measures promoting water ecological improvements should also be simplified.

Compensation options

Compensation options should serve to reduce energy production losses of hydropower facilities due to measures aimed at the improvement of water status. Such options may include, for example, the increase of flow at the hydropower facility, increase of the headwater level or deepening of the tailwater.

In some cases, it could be deemed important to decommission small HP plants which are located in ecologically important stretches or in stretches whose ecological status could be significantly improved by removing the few barriers present. In such cases, instruments should be developed to compensate HP operators for their loss of energy production. For instance, the affected HP operator could be given the option to increase his energy production at another location. Alternatively, the HP operator could receive monetary compensation for giving up his HP concession at the particular location.

Definition of “go” and “no-go” areas for hydropower development

The Communication on the support of electricity from renewable energy sources (COM(2005) 627) recommended the development of pre-planning mechanisms to allocate suitable areas for new hydropower projects. Practical examples could be allocating suitable areas for hydropower development by identifying sites where new plants would be both acceptable in terms of water protection and economically beneficial. Such pre-planned HP areas could be the target of financial support schemes for hydropower development. Additionally, the authorisation process in such areas could be reduced and implemented faster, provided WFD article 4.7 is respected. In this frame, some of the remaining unregulated rivers in areas of high ecological value could be designated as “no-go” areas for hydropower schemes. Connection to the sea would be an additional criterion for migrating fish species. The acceptance for designating “no-go” and “go” areas for hydropower should be based on a dialogue between different competent authorities, stakeholders and NGOs.

The definition of “no-go” areas and investments for hydropower development in “go” areas also need to take account of future climate change impacts. Given the long lifetime of HP infrastructures and the magnitude of investments involved, climate change adaptation has to be included in such pre-planning. For hydropower in Europe, climate change impacts mean that in some areas (e.g. southern European countries but also Switzerland), the hydropower potential could decrease. Other areas (e.g. Scandinavia, northern Russia) may benefit from an increased hydropower potential, but may have to deal with more frequent and intense flooding. Thus, areas allocated to HP development (“go” areas) may in the long-term no longer be suitable for HP due to climate change, while other ecologically-sensitive (“no-go”)

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7 The following EU environmental regulations and directives contain provisions that apply to the design, construction and operation of hydropower installations: 2001/77/EC (renewable energy), 2003/35/EC (environmental impact assessments for specific projects), 92/43/ EEC (preservation of natural habitats, flora and fauna), 79/409/EEC (bird protection), 2000/60/EC (Water Framework Directive).

areas may become even more attractive for energy production. Possible future conflicts with the aims of the WFD to achieve GES should be taken into account early in the pre-planning.

Main questions
- What is defined as "hydropower as renewable energy source"? - What is defined as "hydropower as green electricity"? - What are the different definitions of small hydropower (SHP) used across Europe? - What is the role of hydropower use in the electricity generation of Member States (installed capacity in MW, average annual electricity production in GWH, % of electricity generation)? - What is the potential for further hydropower development in the Member States? Is this potential influenced by global climate change? - What is the % of financial support/promotion for hydropower in the EU Member States compared to other renewable sources (solar, wind, etc)? - Should instruments to support and promote hydropower development generally be linked to ecological standards (relevant to compliance with the WFD environmental objectives)? - Which links already exist between EU/Member State support schemes for hydropower and environmental criteria? E.g. fulfilment of minimum ecological demands for eligibility to receive support for hydropower plants? - Which instruments exist to promote hydropower and in the same time assure the implementation of the WFD objectives? Which are especially suitable and successful? - What do HP operators require from financial instruments to ensure legal and investment security? Which criteria are of crucial importance for legal and investment security? - What views are there on voluntary schemes to improve water status (e.g. ecolabelling)? Should criteria for ecolabelling schemes of hydropower be agreed at EU level and which form could they take? - What kind of reductions in the authorisation process or faster implementation would you consider to be helpful or acceptable? - What role could the option of periodic re-certification of hydropower facilities play? - Could/should a green hydropower fund be set up on EU or Member State level, based on monetary contributions by HP operators non-compliant with the WFD? (adaptation of the "polluter pays principle" to hydropower; contributions ear-marked for river restoration elsewhere) - Can priority sections for energy generation from hydropower be defined (sections with still economically and ecologically sustainable potential for hydropower use)? Should water sections which achieve GES and are still not used for hydropower be used for energy generation? Can consensus be reached on the necessity to define "no-go" and "go" areas for HP schemes?

5 Technical approaches for good practice in hydropower use (parallel session 2)

The use of water for hydropower is unavoidably related to hydromorphological alterations of the water bodies.[8] Key impacts of hydromorphological alterations, typically associated with hydropower (HP), include primarily:

- Impoundment and diversion of the water course associated with disruption of the aquatic habitat, sometimes leading to a change of water category and type;
- Disruption of the upstream migration of fish and invertebrates;
- Disruption of the downstream migration of fish as well as damaging of fish through raking systems and mechanical installations of the hydropower plant;
- Other nationwide impacts on the water balance and hydromorphology due to storage effects, retention of bed load, hydro-peaking and so on.

Many of these impacts can be mitigated by different measures (restoration and mitigation measures). A detailed technical paper on "Good practice in managing the ecological impacts of hydropower schemes, flood protection and works designed to facilitate navigation" was prepared in Phase I of the CIS activity on WFD & Hydromorphology. The good practice technical paper also included several case studies that demonstrate measures which might contribute towards the improvement of ecological status/potential by restoration/mitigation.

Considering the great variety of restoration/mitigation measures which can be taken to reduce local impacts from hydropower, measures should be prioritised on the basis of local water management aims. The domains of biological continuity, minimum flow, debris management, hydro-peaking and habitat improvement are key aspects which should be considered in the identification of ecological criteria and measures for individual sites affected by HP development.

This section focuses on a few selected domains where intervention would be most effective to improve ecological status on the local level (site-specific level) and especially in water bodies directly affected by hydropower. Emphasis is also placed on the functionality of measures and on the need for technical standards to ensure HP plant operation compliant with the WFD environmental objectives.

The following domains have been identified as priority domains for the improvement of ecological status and are proposed as the focus of parallel session 2 at the Berlin workshop:

- **Biological continuity** (upstream and downstream migration);
- **Minimum flow**; and
- **Hydro-peaking**.

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[8] Possible alterations typically associated with hydropower dams are: Structural barrier to the movement of aquatic fauna; Altered water level fluctuations in reservoir; Altered structure of reservoir shore zone habitats; Altered physicochemical conditions in reservoir; Altered physicochemical conditions in downstream WBs; Altered structure and condition of bed, banks and riparian zone in downstream river; Altered sediment dynamics; Altered flow regime in downstream rivers (Technical Good Practice Paper of CIS activity on WFD & Hydromorphology, 11/2006).

Despite the focus of parallel session 2 on the local level, links certainly exist to the catchment level as well as to cost-effectiveness issues to be discussed mainly in parallel session 3 (see section 6 of this paper). In general, there is a need to improve our understanding of the ecological efficiency of individual measures in order to make better judgements about the most cost-effective measures to take.

Biological continuity

The evolutionary process has produced migration behaviours in numerous aquatic species that enable them to make optimal use of various habitats. For example, reproduction may require different flow conditions, temperatures and substrates. Thus, numerous native aquatic species such as salmon and eel undertake migrations of varying lengths within interconnected water systems to find the optimal conditions for their current biological phase. This makes the survival of such species dependent on continuity within their rivers as well as accessibility to other.

Biological continuity can be regarded from the standpoint of either upstream or downstream migration. Respecting upstream and downstream migration of fish according to their natural behaviour is one key criterion to counterbalance the disruption of river continuum by transverse structures such as HP facilities.

Upstream fish migration

Upstream biological continuity plays a key role in the preservation and development of characteristic biota in flowing water and the improvement of their ecological status or potential. The restoration of the upstream river continuum for fish is in principle possible through the construction of fish ladders or bypass channels for upstream migration. Fish passes are an important mitigation measure and are commonly used across Europe in relation to hydropower generation.

To date, different technologies have been developed for fish ladders. Key aspects to consider include the size and flow discharge of fish ladders, which should relate to the size of the respective water body in order to ensure that ladders are easily traced by fish without expending undue amounts of time or energy. The design of a fish pass should also take into account the behaviour of the target species. Water velocities in the pass should be compatible with the fish swimming capacity and behaviour. In Europe and North America, upstream passage technologies are well developed for certain anadromous species,[9] mainly salmonids. By respecting a certain number of design criteria regarding location, the position of intakes and the flow, it should be possible to design passes that are relatively effective in terms of percentage of the population able to pass without major delay.

In general, however, there is still a need for ecological guidelines and uniform technical standards for the design and construction of fish ladders. Specific species requirements as well as local conditions should be kept in mind. Secondly, fish passes should be systematically evaluated. Unfortunately, methods to monitor the effectiveness of fish passes lack widely recognised and binding rules as well as scientific-based standards. Thirdly, fish passes should be adequately maintained. Clogging of the fish pass with floating debris and insufficient maintenance are additional causes of delay or obstruction of upstream migration.

[9] Anadromous refers to species that live in the ocean and ascend rivers to spawn.

Downstream fish migration

In some water bodies (water flow permitting), weirs can be topped so as to enable fish to pass over them. This, to some extent, eliminates hindrance to downstream migration caused by such structures. However, fish also migrate even if weirs are not, or only partially, topped, and this can give rise to hazards from power plant abstraction intakes or simply from passing through hydropower turbines. Measures should be taken to eliminate or minimise such hazards to enhance water body ecological status or potential.

A large number of systems exist to prevent fish from being entrained into water intakes. They may take the form of physical barriers, which physically exclude fish from turbine intakes, or behavioural barriers that attract or repel fish. Physical barriers designed with a specific flow velocity and flow angle in mind and with fish-friendly intake bar spacing have proven to be a most effective safeguard for aquatic fauna. Bypasses are also an essential measure for downstream passage, in combination with physical and behavioural barriers. Many behavioural barriers that are currently under development select only certain species owing to the excessive flow velocities involved and the fact that various species show widely divergent behaviours.

According to current technical standards, effective protection of fish species during downstream migration is possible only at small-sized and middle-sized HP facilities. At large HP facilities, physical protection barriers with small bar spacing are not considered due to technical and financial reasons. At large facilities, migrating fish can be at least protected through appropriate management practices, e.g. eel-friendly operation of turbines in the migration period. Another way to improve downstream migration is by selecting or designing fish-friendly turbines. The mortality rates of fish that swim into hydroelectric turbines can be decreased by modifying the blade wheel diameter, the number of blades, turbine RPM (rotations per minute) and blade wheel and turbine stator angle. In chains of reservoirs, fish can be captured in the highest impounded section and released in the lowest (trap & truck, catch & carry).

In general, downstream migration is considered as more problematic than upstream migration. Technologies for downstream fish passage are much less advanced than for upstream passage.

Biological continuity for other types of fauna

If possible, fauna other than fish should also be considered in the design of local restoration/mitigation measures to improve biological continuity. For instance, bypass channels and fish ladders with appropriately structured, continuous and rough beds and sufficient water flow should be provided for invertebrate species.

Minimum flow

Water flow management is a measure compatible with hydropower use, including the redistribution of flow in time and ensuring minimum residual flow. Flow management at certain times of the year could be an indispensable measure, complementing fish ladders, for sustainable long-term preservation of migratory fish populations.

It is necessary to ensure that minimum flow is maintained in river stretches that are subject to abstraction over lengthy periods. Along with river continuity, achievement of an ecologically sound minimum flow counts as one of the key contributors to river restoration.

European countries use different approaches and criteria for the definition of minimum flow downstream of HP facilities.

In order to meet the criteria of GES or GEP, minimum flow should maintain and restore a river's characteristic biota, promote continuity of the original river bed as well as the fish ladder at its termination, achieve nearly natural flow dynamics and groundwater status in the floodplain and maintain distinct water exchange zones.

Hydro-peaking

Rapidly varying flows can be generated in a hydropower facility (hydro-peaking). This gives rise to conditions that are damaging watercourse hydromorphology and aquatic biota downstream, thus jeopardising the goal of achieving good ecological status or potential.

It is urgent to identify possible mitigation measures and criteria for hydro-peaking. Possible measures could include compensation reservoirs. The ecological status of the water body/bodies affected can be improved through operational modifications (e.g. downstream "buffer" reservoirs) that reduce the volume and frequency of artificially generated abrupt waves and avoid extreme water level fluctuations.

Main questions
Upstream migration - What kinds of national standards exist for measures to support upstream fish migration? - What are the characteristics/design criteria of the most effective installations for upstream migration (considering the importance of designing fish ladders which are easily traced and passed by fish)? What are confirmed conclusions? What further knowledge and further tests are needed? - Do we need harmonised technical standards for the design and operation of fish passes at EU level? If yes, how should such standards be set? - Are there alternatives/experiences with the standardisation of upstream fish passes to reduce costs? - Should technical fish passes or bypass channels be favoured? - How many days per year should a fish pass be passable – in view of WFD aims and of reduction of energy loss? - Are there differences between the approaches of the different international river basins due to ecology? - Are any specific criteria/requirements being used to ensure the efficiency of upstream fish passes? How binding are these criteria/requirements? - Is fish monitoring necessary to check the efficiency of upstream fish passes? Alternatively, would the setting of technical-hydraulic standards for the design/construction of passes be sufficient to ensure ecological efficiency?

- Are there accepted methods for ecological fish monitoring related to fish passes?
- How important is fish-stocking as a complementary measure to fish passes?

Downstream migration

- What are the characteristics/design criteria of the most effective installations for downstream fish migration? What are confirmed conclusions? What kind of further knowledge and further tests are needed?
- Are any specific criteria/requirements being used to ensure their efficiency? How binding are these criteria/requirements?
- What species-specific survival rates should downstream fish passage facilities ensure?
- What are the most effective behavioural barriers for downstream migration?
- How can electricity generation losses due to the installation of downstream fish passage facilities be best minimised?
- What alternative measures exist for downstream migration at large hydropower plants?

Minimum flow

- What is the importance of minimum flow to reduce ecological impacts from hydropower?
- Which key conditions and criteria should minimum flow fulfil?
- Does a uniform approach for the determination of minimum flow exist? Should an EU approach be developed?
- How can electricity generation losses be minimised (time of operation, annual adjustment)?

Hydro-peaking

- What are possible mitigation measures for hydro-peaking?
- What kind of regional methods exist to resolve hydro-peaking problems, e.g. in the alpine region? Are there any other regional approaches?

Additional questions

- Are biological continuity, minimum flow and hydro-peaking the most important priority domains for interventions to improve ecological status on the local level at stretches directly affected by hydropower? Which other domains should be considered?
- Are any approaches for the assessment of cost-effectiveness being used on the local level (site-specific)?

6 Strategic approaches & priorities on catchment level (parallel session 3)

This section deals with possible strategic approaches and priorities (in space and in time) to improve hydromorphological conditions in catchments used for hydropower. It is argued that, except for the need to identify site-specific solutions and ecological criteria for HP operation, it is important to define strategic priorities for HP development and for continuity restoration to improve water status in entire catchments or subcatchments.

The first item refers to the planning of “go” and “no-go” areas for HP development. Such strategic pre-planning may be especially relevant for European regions with still relatively high potential for new hydropower development.

Secondly, this section proposes a possible strategy for discussion on the prioritisation of water bodies and measures to improve (upstream & downstream) continuity in hydropower-affected catchments.

Strategic planning of “go” and “no-go” areas for HP development

In section 4 of this issues paper, the definition of “go” and “no-go” areas for HP development was put forward as a possible instrument to promote hydropower and to improve water status. If accepted as a possible instrument, “go” and “no-go” areas could be defined in so-called master plans for hydropower development.

Bearing the non-deterioration clause of the WFD in mind, “go” areas for new HP facilities could be water stretches or basins, which are already used for hydropower or are physically altered due to transverse structures for other uses (e.g. for navigation, drinking water supply or flood protection) or in those cases where the requirements of Art. 4 (7) are met.

“No-go” areas for hydropower schemes could be unregulated rivers in areas of high ecological value or rivers with very limited number of hydropower stations, where the intention is to protect or restore the population of migratory species.

Prioritisation of water bodies for improving continuity on catchment level

The results of the WFD Article 5 characterisation reports showed that, in many river basins, structural deficits and missing biological continuity (partly due to hydropower impacts) are bound to lead to failure of reaching the WFD environmental objectives.

Concerning the WFD biological quality element of fish fauna, which is largely affected by hydropower facilities, hydromorphological measures combined with the restoration of continuity are necessary to reach good ecological status. Management efforts to improve biological continuity for fish should also take account of the cumulative effects of successive HP plants. Populations of long distance migratory fish can only survive if a distinct percentage of the downstream migrating abundance survives (e.g. it was assessed that an eel population will only survive, if 50% of the natural number of eels reaches the sea).[10]

The extended hydromorphological degradation of water systems in Europe requires systematic supraregional analyses of river basins and the development of so-called “continuity strategies”. These strategies aim at restoring the interconnectedness potential of suitable spawning, growth and migration waters for fish on the cathment level. Ultimately, the aim is to support the self-reproduction capacity of migrating fish fauna.

Such “continuity” strategies should be based on the identification of still functional or restorable spawning and growth habitats for target fish species in a catchment, followed by the identification of suitable migration corridors to make these habitats accessible to fish. Such a procedure could allow the temporal and spatial prioritisation of water sections in the

[10] Technical Good Practice Paper, CIS activity on WFD & Hydromorphology, 11/2006.

catchment. Sections identified as “priority waters” would be those where the implementation of measures could be ecologically most efficient.

In the same time, this strategic approach supports the identification of measures which meet the requirement of cost-effectiveness. It should be kept in mind that upstream and downstream continuity can probably not be restored in all water bodies, at least not with the resources available in the medium-term. This can only be achieved over several planning cycles (combined with the phased achievement of objectives under WFD Art. 4.4).

The three main steps of the proposed “continuity” strategy are as follows:

1. Identification of priority water bodies in the catchment

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2. Formulation of specific objectives

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3. Selection of a combination of measures

1. Identification of priority water bodies in the catchment

Priority water bodies could be those presenting a relatively low level of alteration in their morphology and/or having favourable spatial characteristics for the restoration of fish communities.

Considering the diversity of migrating fish species, management strategies differentiating between anadromous (migrating from sea water to spawn in fresh water), catadromous (migrating from fresh water to spawn in the sea) and potamodromous (migrating within fresh water streams) species could be probably more effective for the prioritisation of water bodies, objectives and measures.

- Priorities for anadromous & catadromous species: Anadromous species reproduce in freshwater. The mature fish migrate from the sea upstream towards their spawning grounds (e.g. salmon). Juvenile fish migrate later downstream back to the sea. The spawning grounds of the sturgeon (important in the Danube basin) are located in large deep rivers and not in the upper stretches of the river system. As concerns catadromous species, the most well-know is the eel. Eels reproduce in seawater and juvenile eels migrate from the sea upstream. Adult eels migrate back to the sea to reproduce.

  For the restoration of anadromous & catadromous species, it is important to track down their historically used spawning grounds. A suitable information system on transverse physical barriers should give information on the extent to which their spawning grounds can still be reached. Additionally, the habitat quality of spawning grounds should be assessed on the basis of water morphology and water quality information. Using such information, priority and non-priority waters can be selected for the restoration of continuity, oriented to the WFD requirements. Degraded or hardly accessible spawning grounds should not be given priority in the “continuity” strategy.

  The proposed “continuity” strategy should also consider other important issues for setting priorities in terms of actions and measures. For instance, overfishing of the anadromous sturgeon is very important and should be taken into account when discussing priorities for spawning grounds or continuity. In the case of the catadromous eels, the downstream migration of adults is not only hindered by transverse barriers but also by the turbines of hydropower plants (requiring eel-friendly turbine management during their migration period). Finally, in addition to setting priorities for achieving continuity in the context of the WFD, future requirements of the so-called eel management plans (proposed EU regulations currently under preparation) should be considered.

- Priorities for potamodromous species: Potamodromous species such as the brown trout live and migrate within freshwater during their lifecycle (e.g. to small headwater streams to spawn). There are two main strategic issues to consider when setting priorities for restoring their continuity. Efforts to restore habitat interconnectedness should start primarily from those habitats which still host rare or typical populations of potamodromous species. Secondly, priority should be placed on such water systems which host two or more fish regions (e.g. barbel, grayling and trout regions).

Last but not least, migrating fish need areas of adequate size to be able to build up self-reproducing populations. The minimum required size depends on the water type and the spectrum of species. This leads us to an additional issue to be considered in the proposed “continuity” strategy, i.e. the interconnectedness of areas of suitable size.

2. Formulation of specific objectives

Specific environmental objectives should be defined for the water bodies of a catchment, according to the WFD. Two main categories of water bodies can be distinguished in terms of objectives setting in the proposed “continuity” strategy:

- Water bodies whose ecological status can be improved in the short term (e.g. by 2015) and in a cost-effective manner.
- Water bodies which have especially unfavourable characteristics for the fast improvement of their ecological status in terms of continuity. For this category of water bodies, different options of objectives setting may be considered. If the achievement of biological continuity on catchment level does not improve the ecological status, GES or GEP for HMWB do not need the improvement of continuity. Measures for ecological optimisation on the local level (for aspects other than continuity) can be considered. If it is the costs that impede the achievement of continuity, GES or GEP for HMWB should include continuity requirements but exemptions may be considered, e.g. extension of deadlines.

3. Selection of a combination of measures

A cause/effect matrix, which should be developed for each water body or group of water bodies, may be used to assess the primary effect of each restoration/mitigation measure on the WFD ecological indicators. Only the most effective measures should be taken into closer consideration. Combining this information with cost estimations, it should be possible to select a cost-effective combination of measures to restore continuity within a catchment or subcatchment.

In general, to support decisions in the context of the proposed “continuity” strategy, systematic information is needed on transverse physical barriers, on their impacts on continuity and on functional habitats in the catchment in question. The access to necessary information will depend on the kind of databases available in each country. For instance, in

Germany, a data system on transverse barriers is being used, which provides information on the construction type and passage of individual barriers. This data system is combined with an index system which enables the evaluation of transverse barriers at single sites but also in the wider water system or catchment. In combination with ecological and economic data (e.g. "expense" indexes), it is possible to gain information important for the selection of the most important and effective measures to restore continuity. Additionally, future monitoring for the WFD should be developed in such a way to enable continuity-related assessment of biological impacts on the catchment level.

Main questions
- What should be considered in the planning of "go" and "no-go" areas for hydropower?
- Do we need a common approach for setting ecological priorities in Europe, river basins or in specific regions, e.g. in the alpine region?
- Is a strategic prioritisation of water bodies to achieve continuity compliant with the WFD as regards the chronological implementation of measures and the determination of different objectives?
- Which criteria are reasonable for the prioritisation of water bodies? Where (at which water bodies, water types, catchments) is restoration most appropriate from an ecological point of view?
- How can we identify subcatchments and water bodies which need to be prioritised for mitigation/restoration in order to maintain typical fish populations in whole catchments?
- Which survival or „return“ rates should be ensured for specific fish species, in order to enable population self-reproduction?
- What kind of information and criteria are needed to prioritise water bodies in terms of continuity restoration? Do the Article 5 reports include enough information (e.g. on numbers, height of weirs etc.)? If not, what other sources of information can be used?
- How should we deal with water bodies and subcatchments which cannot be improved in terms of continuity and fish migration? (distinguish between HMWB and non-HMWB?)
- Are there already any concrete examples of new locations for hydropower planned under WFD Article 7 from the Member States? Do new hydropower schemes endanger the achievement of the WFD objectives in the catchment?

7 Outlook

This paper has outlined key issues and problems at hand to be discussed at the Berlin WFD & Hydropower workshop. Some possible solutions and alternatives have also been proposed for discussion, in the direction of balancing hydropower generation and the WFD objectives. Emphasis was placed on the use of instruments to promote hydropower and to improve water status, on good practice in hydropower use and on the definition of possible strategies and priorities on catchment level.

Information exchange and discussions on further steps between different interest groups at the Berlin workshop should contribute to the current debate on the use of hydropower for sustainable energy generation under consideration of ecological water protection.

8 Literature

Common Implementation Strategy for the Water Framework Directive 2006: WFD and Hydromorphological pressures - Policy Paper. Version 8.0. 3 November 2006.

Common Implementation Strategy for the Water Framework Directive 2006: Good Practice in managing the ecological impacts of hydropower schemes; Flood protection works; and works designed to facilitate navigation under the Water Framework Directive. 30 November 2006. Final Version.

Deutsche Umwelthilfe (Ed.) 2006: Lebendige Flüsse & Kleine Wasserkraft – Konflikt ohne Lösung? [Living Rivers and Small Hydropower – Conflict Without Solution? In Geman] Berlin.

European Commission, Directorate-General Energy and Transport: http://ec.europa.eu/dgs/energy_transport/index_en.html

German Federal Environmental Agency (Ed.) 2003: Hydroelectric Power Plants as a Source of Renewable Energy. Legal and ecological aspects. Berlin. Available at www.umweltbundesamt.de

German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Ed.) 2007: Conclusions from the International Symposium. Time to adapt. Climate change and the European Water Dimension. Vulnerability – Impacts – Adaptation. 12-14 February 2007, Berlin. Available at http://www.climate-water-adaptation-berlin2007.org/documents/conclusions.pdf

Geman Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Ed.) 2005: Guidelines for hydropower tarifes. Charged by new and modernized hydropower plants under Germany's Renewable Energy Sources Act. Berlin.

Kampa, E. & N. Kranz 2005: WFD and Hydromorphology. European Workshop. 17-19 October 2005, Prague. Workshop Summary Report. Available at http://www.ecologic-events.de/hydromorphology/documents/967_summary.pdf

Larinier, M. & G. Marmulla 2003: Fish Passes: Types, Principles and Geographical Distribution – An Overview. In: Proceedings of the Large Rivers Symposium 2. Phnom Pen, 11-14 February 2003. Volume II. 183-206. Available at http://www.lars2.org/