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Hydroelectric Power Plants as a Source of Renewable Energy

- legal and ecological aspects -

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1 Introduction

The German Federal Government has set itself the goal of reducing CO_2 emissions by 25% by the year 2005, compared with 1999 as base year, in order to counteract the further warming of the earth's atmosphere. It's a question of setting up a forward-looking sustainable energy supply, and here renewable energy resources are of great importance. The Federal Government is concerned, in the medium and long term, to noticeably increase their contribution to energy supply. The objective is the doubling of the share of renewable energy resources in primary energy consumption by 2010 and, in the long term, increasing their share to at least 50% by 2050 (Federal Environment Ministry [BMU], 1998).

If one examines different options for producing renewable energy, its potential has up to now been variedly developed in Germany. Hydropower has been produced and used on suitable waters in Germany since pre-industrial times. The production of hydropower is effective and of comparatively low cost wherever waters have to be impounded in any case, for other reasons (flood protection, shipping, drinking water extraction); as a result, energy production recommends itself, as it were, as a by-product at negligible additional cost.

The natural potential to produce hydropower depends on water flow and water incline. The larger the water body, the greater water flow and water incline, the greater the potential to produce energy.

About four per cent of electricity from public supplies in Germany comes from the use of hydropower. That might not at first appear to be much, but it is nevertheless about 16 billion kilowatt hours per year, and thus 75% of total renewable energy in Germany. Hydropower is therefore still – despite the strong growth in wind power – the most important renewable energy source (see Table).

Table: Electricity from renewable energy resources in Germany (in million kWh)* (BMU 1999, VDEW 1999)

	1990	1992	1994	1996	1997	1998
Hydropower	15,580	16,153	17,499	16,151	15,792	17,264
Wind power	43	275	909	2,032	2,966	4,500
Biomass	222	295	570	804	879	1,100
Photovoltaics	1	2	4	6	11	20

* excluding waste

Hydropower was already used in pre-industrial times for the operation of sawmills, hammer mills and other mills. The kinetic and potential energy of water current is converted by means of a turbine wheel into mechanical rotational energy, which can be used for driving machines or generators. Hydropower is today used almost exclusively to produce electrical current. Hydropower is a fully developed technology, with which the largest share of renewable energy after biomass is produced worldwide. The greatest potential for the use of hydropower in Germany is to be found in the southern *Länder* [federal states], where the foothills of the Alps ensure a favourable incline. Whereas the use of hydropower potential in large power plants in Germany has been exhausted to a great extent, there is still expansion potential for small hydroelectric power plants, especially for the reactivation and modernization of existing plants. With appropriate state support in the coming years, potential installable capacity is estimated in Germany at about 500 – 800 MW. At the same time, environmental concerns have to be considered in a balanced manner (BMU 1999).

In comparison to air pollution and climate problems brought about by coal and oil, the production of energy with hydropower is environmentally compatible and it also conserves resources. However, this is not without effects on the rivers used. Necessary development and impoundage have a number of adverse effects on rivers, which can only be partly compensated. This conflict between climate benefits and damage to waters is all the more acute, the smaller and more natural the affected river is.

As a result of the demanding climate goals of the last few years, beyond existing hydroelectric power plants on medium-sized and large rivers – often developed for reasons of flood protection and shipping – initiatives have been taken to exploit the remaining potential of waters not yet developed. Regarding small and micro hydroelectric power plants, ecological and economic constraints have to be taken into account in each individual case. Criteria for individual decisions on the circumstances under which the use of hydropower is to be recommended for energy production are absolutely essential, because in Germany

- for a large number of hydroelectric power plants in operation, limited water rights are presently expiring, and the awarding of new concessions is on the agenda,
- there has been an increased reactivation of existing installations in the last few years, encouraged by state support programmes, and
- the construction of small hydroelectric power plants is planned on quite a few sites.

The border area, where the weighing up of benefits and environmental effects is critical, lies with small hydroelectric power plants with a capacity of less than 1 megawatt (MW). More than 90% of all hydroelectric power plants have a capacity of up to 1 MW (VDEW 1998), and it is above all smaller rivers that are developed for this purpose.

The report is based mainly on the findings of three studies carried out within the framework of the Environmental Research Plan of the Federal Ministry for the Environment, Nature Protection and Reactor Safety (BMU),

- "Small hydroelectric power plants – Ecological opportunities and risks of a renewable energy source" (BfG 1996),
- "Environmental compatibility of small hydroelectric power plants – conflict between climate protection and water protection" (IÖW 1998), and
- "Climate protection through the use of renewable energy resources" (Arbeitsgemeinschaft DLR/WI/ZSW/IWR/Forum, 1999),

as well as on a compilation of legal provisions for hydroelectric power plants produced by the Federal Environmental Agency under the participation of the *Länder*.

2 Anthropogenic greenhouse effect and demands on climate policy

2.1 The earth's climate system and the greenhouse effect

The earth's climate is influenced above all by the power of the sun's irradiation and the distance to the sun. At the same time, equilibrium is established between solar radiation on the outer edge of the atmosphere, on the one hand, and the reflection of solar radiation as well as thermal emission from the earth into space, which has an influence on the earth's temperature and climate, on the other hand. A range of variable external influences and a multitude of internal interacting mechanisms contribute to this indispensable equilibrium, shaping the earth's climate system in a most complex way.

Because the earth is more or less a sphere, geographic latitudes are variedly irradiated by the sun (also seasonally, due to the tilt of the earth's own axis of rotation compared with the axis of its orbit around the sun). Maximum radiation density is observed in the tropics, and minimum radiation density at the poles. The resultant drop in temperature towards the poles ensures compensating flows in the atmosphere and in the oceans.

The rotation of the earth and the complex orography (e.g. mountain ranges) of the northern hemisphere in particular, have a long-term influence on the flow patterns of necessary heat transfer towards the poles. The different surface areas of the earth – oceans, land masses with vegetation and continental ice caps – form, together with the atmosphere, the four subsystems of the climate system. Their very different physical characteristics are responsible for the fact that internal and inter-system compensating processes take place on completely different time-scales. A high degree of internal climate variability is the result.

One particular characteristic of our climate system arises from the varying permeability of the earth's atmosphere for short-wave solar radiation (high permeability) and long-wave thermal emission from the earth's surface (low permeability). This results from the physical capacity of certain atmospheric trace gases – so-called greenhouse gases (for example, water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrochlorofluorocarbons (HCFCs)) – to absorb the infrared radiation of certain wavelengths. Through this mechanism a large proportion of thermal emission from the earth's surface is "caught" in the lower layers of the atmosphere.,

Because a similar effect– albeit of a different physical nature – occurs in greenhouses, one talks of the **greenhouse effect**.

Greenhouse gases present in the atmosphere without human contribution give rise in this way – following varied interaction with other components of the climate system – to an increase in the global mean temperature of the earth's surface of about 33 K. Without these gas components in the atmosphere we would therefore have an inhospitable mean temperature of -18° C instead of the current mean value of about 15° C.

The steadily increasing anthropogenic emission of greenhouse gases since the beginning of industrialization has noticeably changed their atmospheric concentration.

Concentrations of CO_2, caused largely by the burning of fossil energy resources (coal, crude oil, natural gas) and fire clearance, increased by about 30% from 275 ppmv (1750) to 364 ppmv (1997). The CO_2 content of the atmosphere is thus higher than at any other time in the past 250,000 years. In the case of methane (CH_4), whose sources are above all agriculture (ruminants, wet cultivation of rice), coal production and landfill dumps, an increase of 145% is to be registered, from a pre-industrial level of 0.7 ppmv to 1.72 ppmv (1994). For nitrous oxide (N_2O), which largely derives from the use of fertilizers and the production of adipic acid, the increase for the same period of time amounts to about 13%, a concentration of 312 ppmv being measured in 1992.

In addition to these natural components increased through anthropogenic emissions, there are a large number of greenhouse gases that are wholly synthetically produced, such as CFCs, PFCs, HFCs and SF_6.

Increasing greenhouse gas concentrations in the atmosphere adversely affect its radiation balance. As a result of increased absorption through greenhouse gas molecules in the infrared spectral band, the atmosphere is become increasingly "opaque" to terrestrial thermal radiation. The natural greenhouse effect is experiencing anthropogenic intensification.

The radiation activity of individual gases is thus determined not only by concentration, but also by their greenhouse potential, as a comparable value of their specific contribution to the "shielding" of thermal emissions from the earth's surface in relation to CO_2, and by their life-span in the atmosphere.

According to the Final Report of the Fact-finding Commission ('Enquete - Kommission') of the German Bundestag on the "Protection of the Earth's Atmosphere" (1995), intensification of the greenhouse effect through the direct impact of anthropogenic emissions of greenhouse gases results from CO_2 to the extent of about 50%, CH_4 13%, HCFCs 24%, N_2O 5% and stratospheric water vapour and tropospheric ozone 8%.

According to the Second Assessment Report of the IPCC (Intergovernmental Panel on Climate Change, 1996), the additional radiation produced by the direct impact of the main greenhouse gases CO_2, CH_4 and N_2O and diverse halogenated hydrocarbons amounts at present to around 2.6 W/m^2, which represents more than one per cent of terrestrial solar constants (approx. 236 W/m^2). Put simply, the synthetic emission of greenhouse gases has boosted the power of the sun's radiation by about 1%.

It must be mentioned at this point, however, that the atmosphere's radiation balance is also affected by sulphate aerosols and stratospheric ozone depletion (reduction of the greenhouse effect) – even if to a lesser extent – as well as through an increase in tropospheric ozone and changes in solar activity (intensifying of the greenhouse effect).

The global average surface temperature has increased by 0.6 $\pm$ 0.2 °C since the late 19th century and the global mean sea level rose by 10-20 cm as a result of the thermal expansion of oceans and the thawing of inland glaciers. According to information on the Third Assessment Report of the 1PCC (2001), a mean increase in global surface temperature of 1.4 C –5.8 ° C in the period to 2100 is probable. So far as sea level is concerned, a global mean increase of between 10 cm and 90 cm is expected for the same period. Furthermore, due to an increase in temperature, more intense precipitation events in the northern hemisphere are expected.

Despite clear advances in climate modelling, there still exist some remaining uncertainties in the projection of future climate changes. Non-linearity in the climate system, in particular, could lead to "surprising" reactions in climate changes, such as a change in oceanic circulation in the North Atlantic, for example.

Although there are a large number of plausible indices for climate-related changes in ecological and social systems that are already taking place, the clear and unambiguous identification of their causes will prove to be difficult in the near future. The reason lies in the complexity of the systems and in their numerous – also non-linear – reactions and sensitivities to a large number of climatic and non-climatic factors.

Model computations and sensitivity analyses for a range of systems affected by climate change lead to the following expectations:

Woodland: Through changes in temperature and water availability, a doubling of atmospheric concentrations of CO_2 would subject around one-third of global woodland to great changes in biological structure. These processes, accompanied by the extinction of whole types of woodland, might lead to the release of large quantities of carbon into the atmosphere (positive feedback).

Deserts and desertification: As a result of additional warming, deserts would present more extreme conditions and thereby threaten the existence of organisms already living at their heat tolerance limits. Desertification due to several factors, including climate fluctuation and human activity, would likely be irreversible in an increasingly drier environment.

Mountainous ecosystems: The altitudinal distribution of vegetation will shift upwards. Certain species that settle on mountaintops for reasons of climate could become extinct because of reduced migration opportunities.

Aquatic and offshore: In lakes and rivers, warming would have the greatest biological impact in high latitudes, where, as a result of higher water temperature, biological production would increase, and in low latitudes, on the habitat borders of species that are to be found in cold or cooler water, where most species would become extinct.

	Changes in temperatures and precipitation patterns would lead to a shift in the geographic distribution of wetlands. Offshore ecosystems would react differently to changes in climate and sea level. Changes in particularly-susceptible salt marshes, mangroves, coastal wetlands, coral reefs and atolls, as well as in river estuaries, would have serious consequences for tourism, fresh water supply, fishing and biodiversity.
Hydrology / water resources:	Glacier retreat will continue and many smaller glaciers may disappear (e.g. half of European alpine glaciers could disappear by the end of the 21st century).The reduced extent of glaciers and the diminished thickness of coverings of snow would likewise affect the seasonal distribution of water in rivers, as well as water supply for hydroelectric power plants and agriculture. Climate changes will lead to an increase in the global hydrological cycle and could have greater effects on regional water resources. Changes in the total volume, frequency and intensity of precipitation have direct effects on the quantity and timing of runoff, as well as on the intensity of floods and droughts. Regional impacts, on the other hand, are presently uncertain. Most models show an increase in precipitation in the future for Europe as a result of increased atmospheric water content. For higher latitudes in Europe an increase in winter precipitation has to be expected. Most models also show decreasing summer precipitation for Southern, Central and Eastern Europe. Therefore summer runoff, water availability and soil moisture are likely to decrease in southern Europe and would widen the gap between the north and the south. Flood hazards will increase across much of Europe. Even if the debate on climate-related changes in the frequency of floods is not yet concluded, intensified precipitation on saturated soils (winter/spring), coupled with earlier thawing, should well increase the frequency and intensity of floods. Heavier widespread precipitation would intensify the risk of winter floods for the large rivers of Western Europe. Increased summer temperatures could lead to more extreme local precipitation coupled with the growing risk of flooding in smaller river basins.
Agriculture/Forestry:	Crop and productivity variations due to climate change will differ widely at a regional level. Models of cereal crops indicate that in some temperate areas yields increase for a temperature rise up to 1°C but decrease with larger temperature changes. In tropical and subtropical regions yields will decrease in general, though they already suffer from poverty and hunger. A considerable deterioration has to be expected. So far as the worldwide supply of timber is concerned, projected demand in the coming century might be satisfied.
Coastal infrastructure:	Climate changes will considerably increase the vulnerability of a number of coastal populations to flooding and loss of land through erosion. Without adaptation measures, the number of people threatened by tidal waves resulting from an increase in sea level of 50 cm . would be double the present worldwide figure of 46 million. Based on the maintenance of current protection systems, the estimated resultant land loss varies from 0.05% for Uruguay, more than 6% in the Netherlands and 17.5% in Bangladesh to 80% for the Mapuro Atoll of the Marshall Islands (migration problem!)
Human health:	Climate changes are likely to have mainly adverse effects on human health, and may lead to a substantial number of deaths.

Direct effects on health include a growth in mortality and disease (mainly heart, vascular and lung diseases), as a result of the projected greater intensity and duration of heat waves.
Indirect effects of climate changes include an increase in the potential transmission of infectious diseases (for example, malaria, dengue, yellow fever, viral meningitis), stemming from the longer life span and extended geographic spread of vector organisms. In addition, flooding may be accompanied by a variety of infection diseases.

2.2 Demands on climate policy

The above summary of a selection of possible effects of global climate change demonstrates the related problems and risks. For the purpose of damage limitation, besides adaptation measures, which certainly will be necessary in the future, there must be a clear restriction and reduction of the causes, and that means, above all, significant limitation on worldwide greenhouse gas emissions. It is the industrialized countries that are primarily responsible for greenhouse gas emissions. Germany occupies fifth place in CO_2 emissions behind the USA, China, Russia and Japan – and therefore bears considerable responsibility for climate protection.

Within the framework of the Climate Protocol[1] adopted at the Third Conference of Parties to the Framework Convention on Climate Change in 1997 in Kyoto, Japan, the following targets for action by industrialized countries were resolved:

Reduction of the greenhouse gases CO_2, CH_4, N_2O, PFC, HFC, SF_6 by a minimum of 5% by the commitment period 2008-2012 (base year 1990; for PFC, HFC, SF_6 1995 can be chosen) on the basis of the following allocation:

- -8% for the EU and certain Central and Eastern European States (the EU intends to jointly fulfil this commitment)
- -7% for the USA
- -6% for Japan, Canada, Poland and Hungary
- 0% (= no increase) for Russia, Ukraine and New Zealand
- +8% for Australia.

The German government had already adopted a much more ambitious national goal in 1990, namely a 25% reduction in CO_2 emissions by 2005, with 1990 as base year, as well as the limitation or reduction of other greenhouse gases (BMU 1998).

In order to achieve its climate protection goal the German government has developed a climate protection strategy and a comprehensive package of measures including, in the meantime, around 150 individual measures. The exploitation of renewable energy potentials is of key importance for the achievement of reduction goals. The government has set the target of doubling the share of renewable energy in electricity production and primary energy input by 2010. The long-term goal of the Federal Environment Ministry is a minimum 50% share of energy supply by 2050 (BMU).

[1] UN Document FCCC/CP/1997/L.7 ADD.1 from March 6, 1998.

3 Energy production with small hydroelectric power plants

3.1 Legal aspects

General legal conditions are always an important factor in the documentation of environment policy issues. By specifying criteria and laying down binding procedures, they determine to a large extent decisions concerning the permissibility of interference with the environment. They are therefore an essential "adjusting screw" for the implementation of environment policy perceptions. If the assessment of scientific facts and findings comes to the conclusion that action is required, it should be investigated whether the objectives can be achieved within the existing legal framework, or whether amendments are required. In both cases, knowledge of existing regulations is indispensable. In the legal assessment of hydroelectric power plants three regulative levels have to be distinguished: European, (German) federal and *Länder* legal provisions.

3.1.1 Provisions under European law

The European Community has enacted a large number of legislation – in particular, directives – in the environmental area, some of which concern the construction and operation of hydroelectric power plants, namely, general legislation (Directive on Environmental Impact Assessments) and legislation concerning nature conservation (Habitat, Fauna and Flora Directive) and water (Water Framework Directive)

3.1.1.1 Directive on Environmental Impact Assessments (EIA) and its amendment

The original Directive on Environmental Impact Assessments[2] was adopted by the Council of the European Community in 1985. This Directive was the subject, in 1997, of an amending Directive. The EIA Directive contains important elements of an EIA system. In addition, Member States are free to enact stricter internal regulations.

The Directive sees the EIA as a procedure by which the environmental impacts of a planned project on all environmental media should be comprehensively identified, described and assessed. It concerns the direct and indirect impacts of a given project on man, fauna, flora, water, air, climate and landscape – including interaction of these factors – as well as on material assets and cultural heritage. Third parties (the public and public authorities) must be given the opportunity to participate in the process of examination.[1]

The Directive principally lays down guidelines on the area of application and on assessment procedure. On the other hand it does not contain substantial criteria, such as limit values, quality objectives, etc. It also relates only to specific projects. Article 4, which is enlarged upon in Annexes I and II, designates the projects that are subject to EIA. For Annex 1 projects, assessment has to be made obligatory in all States, Annex II projects, on the other hand, only to the extent that this is necessary in the view of individual States within the framework of implementation of European guidelines. This does not mean, however, that a State can completely exclude Annex II projects from EIA. The European Court of Justice, in its decisions of 16 and 21 September 1999, specified the discretion available[23,] to Member States regarding decisions as to which Annex II projects should be subject to EIA. "Installations for hydroelectric energy production", to which the hydroelectric power plants dealt with here belong, are mentioned in Annex II (3. Energy industry (j)). This means that they are only subject to EIA when, in the view of individual Member States, their characteristics require it.

In connection with the construction of new, or the major modification of existing hydroelectric power plants, two types of interference with surface waters inevitably arise. Measures of this kind, that is "river canalization and flood relief works" and "dams and other installations designed to hold water or store it on a long-term basis", are listed in Annex II (10. Infrastructure projects (e) and (f)). So far as their EIA obligation is concerned, according to EC law the same applies as for hydroelectric installations.

According to Article 5 of the EIA Directive, project operators have to provide competent authorities with a range of information on the project and its environmental effects. Article 5 (2) and Annex III of

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[1] Council Directive of 27 June 1985 on the environmental impact assessment of certain public and private projects (85/337/EEC) (Official Journal L 175 from 5 July 1985, p.40). Directive amended by Directive 97/11/EC of 3 March 1997 on the Amendment of Directive 85/337/EEC on the environmental impact assessment of certain public and private projects (Official Journal No. L 73/5 of 14 March 1997) (amending Directive).

[2] Decision of the Court of Justice (Sixth Chamber) of 16 September 1999 "Environment Directive 85/337/EEC on the assessment of the effects of certain public or private projects on the environment " – Case C-435/87 (WWF and others v. the Autonomous Province of Bozen and others;

[3] Decision of the Court of Justice (Fifth Chamber) of 21 September 1999 "Environment Directive 85/337/EEC on the assessment of the effects of certain public or private projects on the environment – setting of thresholds", Case C-392/96 (Commission of the European Community v. Ireland).

the Directive specify the information required. The competent authority has to make this information public, and must also involve other authorities. Parties that might be affected by the project, as well as other authorities, must be given the opportunity to comment on the information.

Information from other Member States, whose environment could be affected by the project, is also important. Details are regulated in Article 7.

According to the EIA Directive, the competent authority has to take account of information from those responsible for the project and of statements from other participating parties in the subsequent decision on the permissibility of the project. The Directive contains no substantial criteria on this point. It requires that the decision is made available to the public and conveyed to the States involved.

The amended Directive supplements and revises the original Directive. In particular, Annex I projects, for which EIA is obligatory in all Member States, are extended from 9 to 21 project groups. The amended Directive also modifies the interrelation of protected environmental assets. The interaction to be considered now also relates to material assets and cultural heritage. Regulations on cross-border participation in EIA, which now, among other matters, also covers public participation, have also been extended. Annex I (15) is of importance in connection with the construction of large hydroelectric power plants, "dams and other installations designed to hold water or store it on a long-term basis, where new or an additional amounts of water exceed 10 million cubic metres" now being subject to EIA.

For Annex II projects, the obligation to carry out EIA depends on thresholds and criteria laid down by Member States, or on a case-by-case examination on the basis of the new Annex III. It still applies, that whole project categories may not be excluded from EIA obligation. "Installations for hydroelectric energy production" are mentioned in Annex II of the amending Directive, under 3. "Energy industry" (h). Also included in Annex II measures in the area of surface waters, under point 10. Infrastructure projects, (f), are "construction of inland-waterways (so far as they are not listed in Annex I), canalisation and flood-relief works", and (g) "Dams and other installations designed to hold water or store it on a long-term basis (projects not included in Annex I)".

The amending Directive has been adopted through several specific Acts (among others, Act on the Assessment of Environmental Impacts[4], Federal Water Act, Federal Emission Control Act).

3.1.1.2 Directive on natural habitats, wild fauna and flora (FFH)

The Directive of 21 May 1992 (92/43/EEC) serves the conservation of natural habitats and of wild fauna and flora. According to Article 2 (2), the measures taken in pursuance of this Directive aim at maintaining or restoring a favourable conservation status of natural habitats and species of wild fauna and flora of Community interest.

In addition, according to Article 3 (1), sentence 1, a coherent European ecological network of special areas of conservation will be set up under the title "Natura 2000". This network, comprising sites hosting the natural habitat types listed in Annex 1 and habitats of the species listed in Annex II of the Directive, should enable the natural habitat types and the habitats of species concerned to be maintained or, where appropriate, restored at a favourable conservation status in their natural range. The Natura 2000 network also includes the special protection areas classified by Member States pursuant to Directive 79/409/EEC (conservation of wild birds).

On the basis of criteria and relevant scientific information laid down in Annex III (Stage 1), each Member State should propose, within a period of three years (that is, by June 1995), a list of appropriate sites (Article 4 (1). According to Article 4 (2), the Commission should then establish, within six years of notification of the Directive (that is, by June 1998), on the basis of criteria set out in Annex III (Stage 2) and in agreement with each Member State, a draft list of sites of Community importance, drawn from the lists of Member States. Once sites of Community importance have been adopted, according to Article 4 (4) Member States would designate such sites as special areas of conservation as soon as possible and within six years at most. Germany, however, has not yet fulfilled its commitment to notify all potential Natura 2000 sites to the Commission. As a result, for certain sites direct effect of the Habitats Directive has already been demanded.

According to Article 6 (1), Member States establish necessary conservation measures for special areas of conservation. These principally comprise appropriate statutory, administrative or contractual measures, which correspond to the ecological requirements of the natural habitat types in Annex I and

[4] Gesetz über Umweltverträglichkeitsprüfung UVPG of 12 February 1990 (Federal Law Gazette 1 p. 205) last amended by the Act of 18 June 2002 (Federal Law Gazette I, p. 1941).

the species in Annex II present on site. According to Article 6 (2), Member States take appropriate steps to avoid, in the special areas of conservation, the deterioration of natural habitats and the habitats of species, as well as the disturbance of the species for which the areas have been designated, in so far as such disturbance could be significant in relation to the objectives of the Directive. Projects not directly connected with or necessary for the management of the site, but likely to have a significant effect thereon, are subject, according to Article 6 (3), to appropriate assessment of their implications for the site in view of the site's conservation objectives. These requirements should be fulfilled in the case of small hydroelectric power plants. Their construction can only be approved by individual state authorities when, within the framework of assessment of the implications for the site, it has been determined that the area will not be affected. Because small hydroelectric power plants can in fact bring about considerable adverse effects (cf. remarks in the Federal Nature Protection Act), the assessment of implications for the integrity of the site must, as a rule, prove to be negative. If that is the case, then a small hydroelectric power plant can, however, according to Article 6 (4), be permitted exceptionally if, in the absence of an alternative solution, its construction must be carried out for imperative reasons of overriding public interest. In this case, the Member State has to take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected.

Stricter requirements then apply, where the site concerned hosts a priority natural habitat type and/or a priority that is a threatened species. From that point of view, the construction of small hydroelectric power plants is only permissible, when arguments can be put forward concerning considerations of human health and public safety, largely favourable effects on the environment, or, after the Commission has expressed its opinion, other imperative reasons of overriding public interest.

3.1.1.3 Water Framework Directive

The older EC Directives in the area of water protection are virtually all concerned with the avoidance of and reduction of emissions into water bodies. Water structure (morphology) has not previously been the subject of legislation at the EC level. With the "Directive 2000/62/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy" – in short, Water Framework Directive[5] – a comprehensive, coherent concept for the protection of all Community waters has to be established. All water-relevant factors of influence, that is, not only chemico-physical but also hydromorphological aspects, should be taken into consideration.

A key provision of the Framework Directive is Article 4 (1), according to which, until 2015, at the latest, a good status of water bodies has to be achieved. The basic idea of "good status" is that a water body may be used, but only in so much as its ecological functions are not fundamentally affected. "Good status" is defined, in part, by means of chemical parameters, in the case of surface waters, however, primarily by ecological criteria, which means that the extent to which aquatic communities are adversely affected by human influences has to be examined. Ecological status is "good" when the values for biological, qualitative components of surface waters indicate anthropogenic influences, but deviate to only a negligible extent from values normally recorded in the absence of disturbing influences. The general concept of "good status" is specified for different waters in the extensive Annex V of the Directive. It is above all characteristic biological groups of aquatic flora, invertebrates and fish fauna that are assessed. For the use of hydropower it is important that morphological changes – for example, disruption of water passage, water bed or flow characteristics – also influence the classification of waters, in so far as aquatic communities are affected as a result.

However, the Directive permits timing delays and the toning down of content in achieving this "good status":

Article 4 (4) allows the possibility of extending the deadline for achieving "good status" for individual waters by up to 27 years following the coming into force of the Directive. The reasons for extending the deadline must be included in the management plan.

Toning down the requirements of "good status" offers the possibility of classifying surface waters as "heavily modified". This is permissible, when particular public interests stand in the way of extensive renaturalization of the water body in question. Waters that have been declared to be "heavily modified" for such reasons, are regarded as of "good status", even when water body developments or other structural intervention have not been revoked; it being sufficient, when such improvements have been made as were possible in the heavily modified water body. Such a water body is also classified as "good", although it is still in a completely unnatural condition. In presenting the monitoring results of

[5] OJ 2000 L 327/1. The text of the Water Framework Directive can also be found on the Federal Environmental Agency's Website under http://.www.umweltbundesamt.de/wasser/index.htm

the water body it has therefore to be made clear that it is heavily modified. The exceptional possibility of a "heavily modified water body" has, however, to be applied restrictively. Otherwise the Directive's objective would be endangered, namely that of achieving a uniform, comparable level in European water protection through the specification of "good status".

Moreover, water body status that does not correspond with the specification of good status, or a deterioration in water body status, are compatible with the Directive when the reason for the status is new changes in the physical characteristics of the surface water body, which the respective Member State deems to be absolutely necessary for reasons of overriding public interest (Article 4 (7)). This exceptional possibility has also to be applied restrictively. The Directive indicates this by providing (Article 4 (7)) that less strict environmental objectives have to be specifically explained and their necessity re-examined every six years.

The Water Framework Directive does not limit itself to the definition of "good status", but sets procedural specifications and prescribes certain instruments of water protection, in order that this good status is also achieved in practice.

To ensure that monitoring and measures occur in areas with the highest burden of use, the Directive demands, within the scope of an initial review, the ascertainment of significant anthropogenic pollution of water bodies, including:

- point sources
- diffuse sources
- water extraction
- current regulation
- water body morphology
- land use

On the basis of determined anthropogenic influences it should be assessed whether the attainment of good water quality is endangered; and if a danger exists, an additional detailed description is required. For the use of hydropower, adverse effects in the area of "current regulation" and "water body morphology" are especially relevant. At the present time there are no criteria to distinguish "significant" from "insignificant" water contamination, or to determine when the achievement of "good status" is endangered. A possible approach would be to make use of the charting of structural quality that has been developed by LAWA [*Länder* Working Group on Water-Policy])LAWA 1999); according to which, good status would be endangered through changes in water structure when the water body is allocated water quality class II-III, or worse, in the structural quality chart.

In order to establish a comprehensive, inherently consistent concept for achieving "good status" within a river basin district, a river basin management plan has to be established for each river basin district (Article 13). With these river basin plans, measures are co-ordinated between participating administrative authorities, and the substance of all water management activities communicated externally to the public and the Commission. The public is also to be involved in drawing up the river basin plans (Article 14), which should lead to greater transparency and acceptance.

According to Article 11, Member States are further obliged to establish a programme of measures. The Directive distinguishes between basic and supplementary measures. Basic measures (Article 11(3)) are the minimum requirements to be complied with, even when the waters in question are already of good status. In this way it should be prevented, that the quality of ecologically intact waters deteriorates. This is in accordance with the thoughts behind the precautionary principle , namely, that adverse effects on the environment have in each case to be minimized, even when indications of possible adverse effects are not evident.

Basic measures mainly consist in compliance with prevailing EC environmental law (cf. Annex VI Part A) and in state supervision of certain water body uses. It is important from the viewpoint of hydropower, that the impounding of waters requires approval. At a formal level this will not lead to a change in the legal position in Germany, because impounding, as water body development, already requires official approval under German law (§ 31 Federal Water Act). The material content of the act of approval could however change; for the general specification of "good status" has the effect, that approval for the use of hydropower may basically not be given when, as a consequence of the intended use of hydropower, the specification of good status could no longer be complied with.

In summary, the Water Framework Directive has the following consequences for the (re-) construction of small hydroelectric power plants:

- The use of hydropower is generally only permissible when, despite the use of hydropower, the specifications of "good status" are complied with, that is, when aquatic communities are affected to only a negligible extent.
- Good status has generally to be achieved until the year 2015 . For individual waters, deadline extensions of up to 12 years and more are possible.
- Toning down of the specifications of good status can be achieved through designating the respective water body as "heavily modified"; in addition, for reasons of overriding public interest, less strict environmental objectives can be envisaged than the specifications of "good status". However, these exceptions have to be applied restrictively.
- Significant contamination of water bodies in the areas of “current regulation” and “water body morphology” has to be recorded and subsequently assessed as to whether the achievement of good status is thus endangered.
- River basin plans are to be drawn up for individual river basin districts, in which measures to achieve good status are co-ordinated.
- The impounding of waters requires approval. This approval can – apart from the exceptions described above - only be given when the water body is still of good status following impoundage.

3.1.2 Provisions under German federal law

3.1.2.1 Act on the Assessment of Environmental Impacts (EIA Act) *Umweltverträglichkeitsprüfungsgesetz*[6] *(UVPG)*

In Germany, there is legislation on the Environmental Impact Assessment at both the federal and *Länder* level. They stem essentially from the European Community's original EIA Directive (85/337/EEC) of 27 June 1985. At the federal level, the Act on the Assessment of Environmental Impacts (EIA Act) has been in force since 1 August 1990. There are also special supplementary provisions covering a variety of project categories.

The purpose of the EIA Act is to ensure that for certain project categories

"for effective precautionary environmental protection

1. impacts on the environment are comprehensively investigated, described and assessed in good time, and

2. the findings of an environmental impact assessment are taken into account as early as possible in all decisions on permissibility" (Article 1).

Investigation, description and assessment of the impacts of a project relate in this respect to

1. Man, fauna, flora, soil, water, air, climate and landscape, including respective interaction,

2. Cultural and material assets" (Article 2 (1)).

EIA is generally understood to mean a dependent official procedure for the comprehensive investigation, description and assessment of the environmental impacts of a planned project. The dependence of the UVP procedure finds expression in the fact that the assessment of matters relevant to a decision is always carried out within the framework of another decision procedure, for example, a planning approval procedure.

EIA findings are to be considered as part of the basis for the decision of an administrative body on the permissibility of a project. Above all, the EIA should serve the interests of effective precautionary environmental protection.

The public, other affected authorities and – in the case of possible cross-border environmental impacts – also neighbouring countries have to be involved in an EIA procedure.

There are also a large number of EIA regulations and responsibilities, apart from individual EIA laws, at the federal and *Länder* levels, which cannot be examined here in detail.

Projects subject to EIA are named in the annex I of the EIA Act. Hydroelectric power plants are dealt with under number 13.6 and 13.7 of Annex 1.The *General Regulation on implementation of the Act on the Assessment of Environmental Impacts*[70] of 18 September 1995 contains, in particular, explanations, operational aids and advice on determining the investigative framework at the beginning of the administrative procedure, a summarized presentation and assessment of EIA findings at the end of the procedure, as well as criteria for the investigation, description and assessment of environmental impacts of certain types of projects.

The effectiveness of EIA is shown by the extent to which assessment findings can influence the decision on a project's permissibility. That is dependent, among other things, on the criteria that form the basis of assessment of environmental effects. According to Article 12 of the EIA Act, the assessment and its consideration in the decision-making process must, on the one hand, comply with prevailing laws, and at the same time be potent "regarding effective precautionary environmental protection".

Environmental quality standards, namely, specified or binding threshold, reference and similar values for the quality of soil, air, water etc., which can facilitate both the assessment of environmental impacts and the consideration of EIA findings in the decision-making process of the authorities, are not yet available to the extent required. As a result, material criteria for assessing the environmental effects of small hydroelectric power plants cannot be derived from the EIA Act. The procedure laid down in the Act obliges both operator and authorities to at least weigh up all relevant environmental issues.

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[6] Gesetz über Umweltverträglichkeitsprüfung (UVPG) of 12 February 1990 (Federal Law Gazette I, p. 205) last amended by the Act of 18 June 2002 (Federal Law Gazette I, p. 1941).

[7] Allgemeine Verwaltungsvorschrift zur Ausführung des Gesetzes über die Umweltverträglichkeitsprüfung (UVPVwV) of 18 September 1995 (Federal Law Gazette 1995, No. 32, p. 671

3.1.2.2 Federal Immission Control Act

Bundes-Immissionsschutzgesetz[8] (BImSchG)

The Act on the prevention of harmful effects on the environment caused by air pollution, noise, vibration and similar phenomena (Federal Immission Control Act) concerns itself with installations, technical facilities and other activities, from which harmful effects on the environment can be expected. The area of application of the Act does therefore not cover – if one disregards possible noise - small hydroelectric power plants.

The Federal Immission Control Act also contains no (general) prioritisation of renewable energy resources or immission-free technologies; neither does it claim priority vis-à-vis water law. Article 2 (2), sentence 2 makes clear, that the extension of protected assets in Article 1 to encompass water should not mitigate the material requirements of water law. This means, that the material requirements of water law concerning the protection of water bodies cannot be mitigated by reference to protection of the atmosphere. However, the collision rule takes effect only in the case of deviations of both bodies of regulations. In this case it lays down that, with reference to the protection of waters, the more specific water law has priority. As a logical consequence, the concentration effect of Article 13 does not cover water-related provisions on licenses and permits in accordance with Articles 7 and 8 of the Federal Water Act.

3.1.2.3 Federal Water Act

Wasserhaushaltsgesetz[9] (WHG)

The key Act concerning the assessment of the permissibility of the construction and operation of small hydroelectric power plants is the Act on the Regulation of Matters Pertaining to Water (Federal Water Act) *(Wasserhaushaltsgesetz (WHG))*. This Act draws two basic distinctions: On the one hand, it has to be distinguished whether, in the case of the construction and operation of the installation, it is exclusively a matter of use in the sense of Article 3, or whether development of the water body is involved. According to Article 2 (1), the use of waters basically requires an official permit or licence, whereas for the development of a water body Article 31 stipulates a planning approval procedure. On the other hand, it is of decisive importance for permissibility, whether the reactivation of an installation currently not in operation is involved, which has already been approved, or the construction of a new installation. Certain uses of waters require no approval of any kind whatsoever, including, for instance, such uses as fall within the definition of so-called public use (Article 23) and are thus insignificant uses. Hydroelectric power plants do not fall under this approval-free use. In the construction and operation of hydroelectric power plants the following uses can be pertinent:

- impoundage by a weir (Article 3 (1) No. 2);
- diversions of water (for example, through the turbine) (Article 3 (1), No. 1);
- extraction of solid matter by means of inlet screens (Article 3 (1), No. 3);
- where appropriate, lowering of the water body through the deepening of tailwater (Article 3. (1), No. 2); or
- diversion of water through widening of the water bed (Article 3 (1) No.1).

In the case of an outflow power plant, because of the long inlet channel, the acts of diversion and substance input also fulfil the description of use in Article 3 (1) no. 1 and 4. Impoundage by the weir in the main water body, which is necessary for diversion, also constitutes use (Article 3 (1) No. 2).

According to Article 2 (1) of the Act, the construction and operation of hydroelectric power plants invariably require an official permit (Article 7) or licence (Article 8).

However, according to Article 3 (3) this would not apply if, in the case of the uses mentioned above, measures were involved that served the development of a body of water (legal definition in Article 31 (2), sentence 1: "the establishment, removal or substantial modification of a body of waters or its banks"). In this respect, according to Article 31 a planning approval procedure would have to be carried out that corresponded with the requirements of the EIA Act (see 3.1.2.1)

[8] Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (BImSchG) of 26 September 2002 (Federal Law Gazette I, p. 3830) last amended by the Act of 21 August 2002 (Federal Law Gazette I, p. 3322)

[9] Gesetz zur Ordnung des Wasserhaushaltes (WHG) of 19. August 2002 (Federal Law Gazette I, p. 3245)

It is argued, that measures having the *immediate* objective of water use are not to be treated as development and thus subject to a planning approval procedure, as long as a new water body is not to be created. Only in this latter case do permit and licence requirements exist side-by-side with obligatory planning approval procedures. This argument leads to obligatory planning approval procedures only in the case of an outflow power plant, where impoundage occurs by way of two separate weirs in the main water body and the outflow channel. The creation of the power plant channel would thus be treated as development, whereas the diversion and introduction of water would be treated as water use and subject to permit and licence. On the other hand it is rightly argued, that the question of whether development in fact takes place does not depend on the subjective purpose of the measure, but rather on the objective interpretation of development. The construction of a weir, for instance, would therefore be a development subject to a planning approval procedure according to Article 31 of the Act.

The material criteria to be borne in mind in the case of development are laid down on the hand in Article 31 (5) (added by way of the sixth Amendment to the Federal Water Act in 1996). According to these criteria, natural retention areas have to be maintained, the natural run-off may not be substantially altered, natural habitats have to be preserved and any other considerable detrimental changes to the body of water's natural or be avoided or, where this is not possible, compensated. Planning permission or the granting of a permit have to be refused, where development is deemed likely to impair the public interest, especially if it is likely to considerably and permanently increase the risk of flooding, or the destruction of natural retention areas, particularly in alluvial forests (Article 31 (5) sentence 3). Furthermore the requirements of the Water Framework Directive have to be observed. Therefore any development measures must be based on the management objectives for surface water bodies outlined in Art. 25a to 25d of the Water Act and must not compromise the attainment of these objectives. The development measures must also meet the requirements for water body development as outlined in the programme of measures for each river basin district (Article 31 (1)).

The differentiation of permit and licence is a peculiarity of water law, and mainly affects the legal position accorded to the applicant for a licence and the licensing procedure. A permit is the normal outcome according to the concept of the Federal Water Act; with it is coupled revocable authorization to make use of a water body for a specific purpose in a specific way and to a specific extent. A licence may only be granted in exceptional cases under the terms of Article 8 (2) of the Act, but it then confers (with the proviso of revocation according to Article 12 linked to certain circumstances) secure legal status over a long period. According to Article 8 (2), sentence 2, a licence may not be granted for the discharge and introduction of substances into a water body. This does not apply (sentence 3) to the reintroduction of works water from outflow power plants which has not been adversely altered.

Moreover, the material requirements of a permit or licence under water law are basically the same; the range of decisions available for all types of approval of water use is largely independent of the form of the respective approval.

The granting of a licence is largely at the discretion of the licensing authority. However, a permit or licence is only possible where there are no compelling grounds for refusal (which the licensing authority has first to investigate), grounds that cannot be dealt with by way of subsidiary regulations. According to Article 6 (1), both official decisions are subject to the proviso, that there is no effect detrimental to the public interest. This relates to all factors of relevance to water resources management that can be affected by water use, whereby Article 6 (1) particularly emphasizes public water supply. But an adverse effect on other matters of concern not related to water management can also stand in the way of a positive decision. Overriding public interests must be involved, and not merely a negligible effect on these interests. According to Article 6, besides issues of flood protection, compelling grounds for refusal can arise due to ecological effects with regard to the reduction in compensation flow and flow velocity, as well as the restriction of water passage, when, as a result, the present population of water fauna and flora is endangered. For this reason, before a licence is granted it has to be investigated whether these harmful effects can be precluded or limited through conditions for use and other requirements.

Where there are no grounds for refusal, the granting of a permit or licence is at the due discretion of the competent authority, which has also to take particular account of the principles of Article 1a of the Act in weighing up its decision. Waters have to be protected as an integral part of the natural environment and as a habitat for animals and plants. The management of water resources has to be carried out in such a way, that avoidable impairments to their ecological functions are precluded. Conflicting interests of third parties – fisheries, for instance – have also to be considered. If it is technically possible to deal with the mentioned objectives of water ecology and water resources management by means of conditions for use or other requirements, the discretionary decision will

basically favour the project. In this respect, the objective of emission-free and resource-reducing energy production, as well as of possibly related overall economic benefits, have also to be taken into account.

The reactivation of installations currently not in operation is subject to separate regulation in Articles 15 to 17 of the Act. In Article 15 (1) to (3), existing rights and authorities are listed, for which neither a permit nor a licence is required for continuing use. This regulation is only provisional, however, for Article 15 (1) empowers the *Länder* to limit the catalogue of licence-free use on account of existing rights and authorities. At the same time, the *Länder* are empowered to render further use licence-free in their own water laws if they have been formally admitted on the basis of their water law. Because the *Länder* have made extensive use of these rights, reference is made to the relevant regulations of the *Länder* water laws

Basically, vested rights apply to installations existing at a given date, which were lawfully constructed under prior law. It assumes, moreover, that old rights have not in the meantime been extinguished by appropriate entry in the Water Register (Article 16). Under Article 15 (4) sentence 1, revocation of is basically possible only on payment of compensation, and on condition that matters of public interest are adversely affected.

3.1.2.4 Federal Nature Conservation Act

Bundesnaturschutzgesetz[10]

The Federal Nature Conservation Act has recently been amended. In drawing up the Federal Nature Conservation Act, the Federal Government made use of its general powers under Article 75 (1) No. 3 of the Federal Constitution, which means that within the laid down framework the *Länder* are empowered to set their own standards

Article 19 of the Act lays down that interference with nature and landscape must be prohibited when the effects are neither to be avoided nor adequately compensated and the interests of nature protection and landscape conservation have priority in the weighing up of all demands that need to taken into consideration. Furthermore, those responsible for interference are obliged to desist from avoidable interference and to compensate unavoidable interference within a given period through measures of nature protection and landscape conservation. An act of interference is regarded as compensated when, following its termination, no substantial or lasting impairment of the ecological balance remains and the appearance of the landscape has been restored or created anew. In this respect, the *Länder* are empowered to enact more far-reaching regulations .

Article 18 (1) defines interference with nature and landscape as changes in the form or use of a surface area or the corresponding groundwater level, which considerably or lastingly affect the viability of the ecological balance or the landscape. The question, whether the construction, enlargement or conversion of a hydroelectric power plant in the course of modernization satisfies the prerequisites for interference according to the Federal Nature Conservation Act, arises only for projects in the outer zone. If the project lies within the area of applicability of a local development plan, in the unplanned inner zone of a settlement or in a planning area during the drawing up of a local development plan), it is excepted under Article 21 of the Federal Nature Conservation Act from the requirements of Articles 18 to 20 of the same Act. To this extent, interference with nature and landscape, as well as dealing with the consequences of interference, are already taken into account in urban land use planning (cf. Article 1a Building Code (Baugesetzbuch)). Also excluded from the regulation on interference are those projects that can according to the Building Code only be licensed by way of exception or exemption (Article 31 (1), (2), Building Code). For projects in the unplanned inner zone of a settlement according to Article 34 Building Code this does not apply, however, when the objective of conservation, or the protective purpose of the area, is of Community importance and European wild bird conservation areas could be substantially affected (Article 29 (3), Building Code).

In the outer zone according to the Building Code the following applies: The construction or structural alteration of a small hydroelectric power plant results in a change in the form of surface areas, to which surface waters belong. This change is coupled with a considerable and lasting affect on the viability of the ecological balance, that is, of biotic and abiotic components of nature: soil, water, air, climate, fauna and flora, and their respective interaction. The construction of a power plant, or its structural alteration, results in a change in the functional structure of the water bed and banks. At the

[10] Gesetz über Naturschutz und Landschaftspflege (Bundesnaturschutzgesetz – BNatSchG) of 25 March 2002 (Federal Law Gazette I p. 1193).

same time, the operation of the installation, as a result of its influence on water level, flow velocity and flow characteristics, also has an effect on the environmental factors of water quality, fauna and flora.

In addition, the appearance of a water body and the surrounding landscape is optically affected by the power plant building, though a considerable and lasting impairment of the appearance of the landscape only exists when the installation is constructed in a formerly undeveloped area.

Whether this interference in nature and landscape can be compensated, in compliance with Article 19 (2), and can therefore be approved, or whether the building of a small hydroelectric power plant is thwarted by the weighting clause of Article 19 (3), because the adverse effects cannot be compensated, requires the weighing up of circumstances in each individual case.

Protection from adverse effects on valuable habitats and landscape components is regulated in detail in Article 30 of the Nature Conservation Act. Of particular importance for the construction or structural alteration of hydroelectric power plants is the protection of bodies of water in a natural or near-natural state and their banks as well as their natural or near-natural vegetation (No. 1) and humid biotopes (No. 2). Interference within the scope of Article 30 covers all measures likely to have an effect on habitats or landscape components, whereby it is sufficient when there is a serious risk of interference, that is, a certain probability of it occurring. However, the effects must go beyond mere optical disturbance.

Interference with valuable habitats and landscape components in the sense of Article 30, is represented by work on the construction of a hydroelectric power plant, or its enlargement, where additional areas of the water bed or banks are utilized, because the effect on the habitat is direct. The same applies to the operation of the installation, because here, through impoundage and diversion of the water, water level, flow velocity and, possibly, the water bed – and thus the stream or river section – is affected. Because such adverse effects are clearly of a considerable and lasting degree, they are generally inadmissible according to Article 30. The Länder can however permit exceptions only if the interferences can be compensated or the measures are necessary because (other) reasons of public interest take precedence (Article 30 (3).

In addition, Articles 22 ff. of the Act lay down restrictions on the construction or structural alteration of small hydroelectric power plants in especially protected aspects of nature and landscape. Of practical importance, in this respect, is above all the formal designation of nature protection and landscape conservation areas.

Nature protection areas serve, according to Article 23 (1), the special protection of nature and landscape. Article 23(2) prohibits, among other things, the damaging or modification of a nature protection area or its component parts. Modification, in the sense of the provision, is basically every deviation in the physical or aesthetic appearance of the nature protection area, which endangers the objectives of protection. These prerequisites will be regularly fulfilled by the construction or enlargement of small hydroelectric power plants.

Extensive national parks (Article 24) fall under the same protection regime as nature protection areas, on account of their exceptional size and colonization.

In landscape conservation areas, according to Article 26 (2) and on the basis of detailed provisions, all activities are prohibited that change the character of the area or run counter to the particular purpose of protection. It thus becomes clear, that the permissibility of small hydroelectric power plants can only be assessed taking into account the respective terms of designation of a protected area. It can generally be said, however, that the protection of landscape conservation areas is weaker than that of nature protection areas. Changes in the character of an area require, as a rule, massive intervention.

For biosphere reserves (Article 25) the same protection regime applies as for nature protection and landscape conservation areas respectively differentiated between different zones.

The specifications of the Habitat Directive have been incorporated into the Federal Nature Conservation Act mainly through inclusion of Articles 32 to 34. Article 34 (1) provides in the case of projects such as small hydroelectric power plants (cf. Article 8 no 11) in areas of Community importance, or in a European wild bird protection area, for an assessment of compatibility. Because the construction of small hydroelectric power plants generally results in considerable detrimental effects on these areas , and compatibility assessment usually produces a negative result, such construction is basically not permissible (Article 34 (2)). However, paragraphs 3 and 4 allow exceptions, on the same conditions laid out in Article 4 (4) of the Habitat Directive. According to Article 37, Article 34 does not apply for small hydroelectric power plants within the area of a local development plan.

3.1.2.5 Renewable Energy Act

Erneuerbare Energiegesetz[11] (EEG)

The "Act on the priority of renewable energy (Renewable Energy Act)" replaced the Electricity Transmission Act of 1990. The latter guaranteed the transmission of and payment for electricity produced from renewable resources under certain circumstances. On this legal basis, payment for the transmission of hydroelectricity amounted to 7.80 Cent/kWh for installations with a capacity of up to 499 kW, and 6.33 Cent/kWh for installations with a capacity of 500 kW and more (Arbeitsgemeinschaft DLR/WI/ZSW/IWRF/Forum, 1999).

The upper limits contained in the Electricity Transmission Act, which were linked to the share of transmitted renewable energy in the total quantity of electricity transmitted by network operators (the so-called first and second caps) have been dropped. In their place, Article 9 of the Renewable Energy Act lays down an absolute maximum period of support of twenty years, from which only hydropower is excepted, on account of longer amortization periods.

The Renewable Energy Act now sets, in contrast to the former Electricity Transmission Act, fixed minimum rates of payment for the respective energy sources. For hydropower, landfill gas, pit gas, sewer gas, biomass and geothermal energy the level of remuneration is on a sliding scale dependent on the size of the respective installation. According to Article 4 of the Act, payment amounts to a minimum of 7.67 Cent per kilowatt hour for installations with an installed electrical capacity of up to 500 kW, and 6.65 Cent per kilowatt hour for installations with a capacity in excess of 500 kW. However, only those hydroelectric power plants with an installed electrical capacity of under 5 megawatt receive this guaranteed payment. Installations, which produce more power, do not fall within the scope of the Act (Article 2 (2) No. 1). As a result, larger hydroelectric power plants – such as that at *Rheinfelden* – with which, following modernization, not only higher energy output, but also improvements in water ecology have been achieved, do not enjoy the benefit of guaranteed minimum rates of payment. On the contrary, they have to compete without state support with other energy producers under the conditions of the liberalized electricity market, which often has the result that necessary investments are not made, because they don't pay. This must be considered in the drafting of the progress report in compliance with Article 12.

[11] Gesetz für den Vorang Erneuerbarer Energien (EEG) of 29 March 2000 (Federal Law Gazette I, p. 305) last amended by Act of 23 July 2002 (Federal Law Gazette I, p. 2778)

3.1.3 Provisions of the German *Länder* [States]

The following surveys have been prepared on the basis of laws and documents provided by the environment ministries of the respective *Länder*. Relevant publications of the ministries have also been taken into consideration. The surveys are restricted to those provisions that set specific demands on the use of hydropower, and **they reflect the position as at August 1999.**

BADEN-WÜRTTEMBERG

The use of hydropower, one of the most important sources of renewable energy, is a fundamental energy policy objective in Baden-Württemberg. Hydropower's share in annual electricity production amounts to 9%. Of this, 90% is generated in installations > 1 MW, and 10% in installations < 1 MW. Unused potential for energy generation from hydropower exists not only on large waters, but also on small and medium-sized waters. Of particular importance from the energy policy point of view is the potential on the High and Upper Rhine.

In Baden-Württemberg, most licensed hydroelectric power plants – approximately 1,000 in number – have a capacity of < 1 MW. Criteria for the licensing and overall ecological assessment of the use of hydropower with installations of this size were laid down in a joint decree of 25 February 1993 by the Ministries of Environment, Economics and Rural Areas. The weighting procedure has proven its worth: Up to February 1999, 99 installations were licensed and 20 rejected.

In a constructive initiative for water-compatible use of hydropower, and in order to objectivize the debate, positive mapping of potential hydropower sites was carried out on two waters on a pilot basis; potential hydropower sites were designated that, bearing in mind ecological concerns, would be suitable for use in the view of the water management authority and nature protection and fishing authorities. Subordinate water authorities are responsible for decisions concerning the impounding of watercourses as well as the extraction and diversion of water, when available raw-water-based hydropower capacity lies under 1 MW. This is laid down in Article 96 (1) in connection with Article 96 (2), No. 1(c) and Article 95 (2), No.3 of the Baden-Württemberg Water Act (*Baden-Württembergisches Wassergesetz*).

	State Water Act	State Nature Protection Act	State Fisheries Act	Decrees
I. Licensing small hydro-electric power plants	**- Article 17 Specific provisions for the use of hydropower:** Section 1 No. 1: For uses of water including the production and exploitation of the hydropower of public waters, where exploitable hydropower capacity does not exceed 1000 kW, a reasonable fee can be levied on the operator. The amount charged depends on the value of average available raw-water-based hydropower capacity; this is calculated on the basis of the usable water volume and the height of fall. **- Article 35b Hydropower use:** Section 2: …the use of an existing hydroelectric power plant for energy production, up to a maximum exploitable capacity of 1000 kW, is subject to notification to the water authority.	**- Article 24a Specially protected biotopes:** According to Section 1 No. 2, virtually undisturbed and undeveloped stream and river sections are specially protected. According to Section 2, these may not be destroyed or otherwise be substantially or lastingly affected.		**Joint Decree of the Environment and Economics Ministries of 25.02.1993 (GABl. [Law Gazette] of 14.05.1993, No. 12, p. 404)** Section III, IV: "In decisions on the licensing of hydroelectric power plants, not only has the economic side to be examined, but also the effects on the environment, allowing for the following factors: – water management effects, in particular those on flow regime, flow velocity, water bed stability, sediment balance, groundwater and water status; – effects on the habitat of watercourses, in particular on the preservation and development of fauna and flora typical for watercourses, and on the communities of water exchange zones and valley floodplains; – effects on other water body functions, in particular on recreational value, water landscape, other uses; – pollutant reduction and the reduction of waste heat pollution in comparison to fossil-based energy production; – where necessary, examination of measures for diminishing negative effects (installation design adapted to the landscape, features of the water, removal of obstacles to walking, planting of river banks, laying out shallow water zones).
II. Treatment of old rights and authorities	**- Article 122 Old rights and old authorities:** …according to Section 1 No. 1 "a permit or licence is not required for uses in the sense of Article 15 (1) No. 1 Federal Water Act, if, when this Act comes into effect, lawful installations exist for their exercise".			**Decree of 25.02.1993:** Section 1.3: Old rights and authorities, in the sense of Article 15 Federal Water Act in connection with Article 122 State Water Act, granted for hydroelectric power plants, are also obtainable under the conditions contained in Section 1.3.1 when a ground for revocation according to the discretionary provision of Article 15 (4) sentence 2 No. 1-3 Federal Water Act exists. As a rule, old rights and authorities continue to exist, provided there exists no legally effective withdrawal or revocation of the old right. This also applies, when an operator switches from direct machine operation to power

				generation. Section 1.3.1 Requirements for the maintenance of old rights and authorities: The same requirements apply as for the granting of a permit or licence. For a reasonable period of time (about 10 years), no substantial encroachment on matters of public concern may be detectable, which requires the removal of the installation or the rescinding or restriction of its use. No compensation will be provided for retaining minimum flow and a possible resultant reduction in working capacity, or for investment required to create ecological free passage of the water body.
III. Laying down minimum flows in outflow sections	**- Article 35a Minimum flow:** Paragraph 1: In accordance therewith, it must be guaranteed that in the case of every water use "the water volume (minimum water flow) required for ecological functionality is preserved". Paragraph 2 authorizes the superior water authority to issue criteria for the assessment of minimum water flow.			**Decree of 25.02.1993:** Section IV.3.: "Minimum water flow must be explicitly laid down in the water decision. …The requirements to be considered with regard to minimum water flow … are included in the Annex." **Annex to the Decree of 25.02.1993:** Section 2.1: "The determination of minimum flow occurs in a two-stage procedure. In a first step, orientation values for minimum flow are ascertained from hydrological data. These values have to be scrutinized in a second step in the light of local circumstances." Locally ascertained values for the water may only lead, however, to an increase in computed minimum flow of a maximum further 1/6 MLW Section 2.2.1: "For outflow power plants the orientation value for minimum flow amounts in yearly average to 1/3 MLW. Minimum flows are primarily determined on a flow-dependent and dynamic basis. Where this is not possible, seasonally staggered minimum flows can also be laid down. They may not fall short of a sockel value of 1/6 MLW.“ Examples of different methods of assessment of minimum flow are provided. Section 2.3: Orientation values ascertained according to Section 2.2.1 are adapted to local circumstances taking account of the following criteria:

				* Preservation of an inter-related and functional habitat * Functionality of fish ladders * Water quality * Groundwater resources * Temperature balance * Length of outflow and backwater * Aesthetic appeal of the landscape * Water bed stability
IV. Guarantee of ecological free passage			**- Article 39 Measures to protect fish from damage from power-transmission equipment:** Section 1: „Whoever ... sets up power transmission equipment has to attach and maintain at his own cost devices to prevent intrusion." **- Article 40 Construction of fish ladders** Section 1: „Whoever sets up installations in a water body, which hinder or substantially interfere with the passage of fish, has at his own cost to erect, operate and maintain fish ladders."	**Annex to the Decree of 25.02.1993:** Section 1: "Waters in the area of hydroelectric power plants have also to be maintained and developed as far as possible as virtually undisturbed and functional ecosystems. ... The free passage of the watercourse ecosystem is the prerequisite for the development of communities typical for watercourses. ... The free passage of watercourses requires: * A continuous water bed of suitable substrate * Adequate minimum flow in outflow sections * Functional, safe and reliable fish ladders for fish and living organisms * Bypass channel for typical backwaters Examples of the design possibilities for guaranteeing the free passage of watercourses at hydroelectric power plants are described.

BAVARIA

Despite the large number of hydroelectric power plants, a certain potential exists in Bavaria for the further expansion of hydropower; but due to the current situation on the energy market, an increase in the construction of new hydroelectric power plants is not to be expected. The Bavarian government has therefore set its targets on exhausting existing possibilities of developing hydropower, and on carrying out efficiency-improving measures at existing hydroelectric power plants. The state government is anxious, on the one hand, not to make these efforts more difficult through excessive tightening up of compensation flow requirements, or through other restrictions on use required for reasons of water resources management and nature protection, and on the other hand, to extend its efforts towards deregulation and acceleration of licensing procedures to cover the use of hydropower.

According to Article 75 (1), sentence 2 of the Bavarian Water Act (*Bayerisches Wassergesetz*), local district authorities are responsible for carrying out licensing procedures. The state water resources management authority and water resources management offices are expert bodies, which, according to Article 75 (5) of the Bavarian Water Act, participate in and represent the specialized interests of water resources management.

So far as minimum flow in outflow sections is concerned, a "guide to compensation flow", applicable for installations of up to 500 kW, was drawn up and published in July 1996 by the Bavarian Ministry for State Development and Environmental Issues.

The " guide to compensation flow " is intended to provide responsible water resources management offices with basic information for the preparation of their expert opinions, and thereby serve the uniform treatment of these technical issues throughout the State. The guide deals initially only with the appraisal of outflow power plants that already exist and are to be newly licensed, and does not apply for hydroelectric power plants with a capacity in excess of 500 kW, for which investigations commonly employ a special methodology, mainly involving the state water resources management authority.

	State Water Act	Decrees, principles and other provisions
I. Treatment of old rights and authorities	**Article 96 Old rights and old authorities:** Paragraph 1, sentences 3, 4: "If the exercise of old rights and old authorities (Article 15 (1) Federal Water Act) for outflow power plants with a capacity of at least 1,000 kW procures substantial widespread disturbance of water management or water ecology functions due to insufficient water flow in the water bed, the district authority can require the carrying out of a permit or licensing procedure. The requirement may not be made if it would be unreasonable, bearing in mind those interests of the operator worthy of protection"	
II. Support of hydroelectric power plants		**Principles for the support of small hydroelectric power plants in Bavaria as laid down by the Bavarian State Ministry for Economics, Transport and Technology in January 1990:** The Free State of Bavaria supports small hydroelectric power plants with a capacity of up to 1,000 kW, measured at the generator terminals. The reactivation, maintenance, improvement and construction of small hydroelectric power plants are supported. The construction of small hydroelectric power plants is only supported in exceptional cases, so far as is ecologically justifiable. Only those projects are supported, whose eligible costs exceed 30,000 DM. Non-repayable grants are given by way of project support covering a fixed proportion of total project costs. Eligible costs comprise all capital expenditure necessary to increase and secure energy production (for example, machine technology and electrical engineering, structural and civil engineering, hydraulic engineering and steel construction for hydraulic engineering). Costs for architectural and engineering services are allowed for by way of a flat rate surcharge amounting to 10% of eligible capital expenditure. The grant amounts to up to 30 % of eligible costs and is limited to eligible specific capital expenditure of a maximum of 8000 DM/kW capacity.

III. Laying down minimum flows in outflow sections		According to compensation flow guidelines, the determination of minimum flow in outflow sections occurs in five steps: 1. Compilation of basic data Basic data, such as general information on the water body, description of the catchment area, hydrological conditions, balance of nature, power plant data, technical description of buildings etc., are generally obtained from the application documents of project developers. Where appropriate, supplementary information on the qualitative status of the water body (chemistry, biology, fishing etc.) – so far as is available – is to be obtained from the Water Management Office. At the same time it is to be examined, whether uses and functions are relevant to the decision, and, if necessary, further information is to be gathered. 2. Estimation of the so-called water-ecology threshold value ($Q_{GÖ}$) For estimating $Q_{GÖ}$ the following criteria are important: – Determination of flow characteristics near the water bottom in a natural test (simulating four different flow levels and establishing flow characteristics in each case using the hemisphere method – Water quality – Fish – Appearance of the water landscape – Where appropriate, location of the outflow section in legally-protected nature conservation areas (obtain the opinion of the nature conservation authority) – Where appropriate, incidence of „Red List species“ (obtain the opinion of the nature conservation authority) – Where appropriate, water stretches of particular ecological value (obtain the opinion of the nature conservation authority) – Where appropriate, existence of valuable biotopes (obtain the opinion of the nature conservation authority) – Existing waste water discharge into outflow sections or the power-transmission channel – Adequate wetting of the water bottom $Q_{GÖ}$ obtained in this way forms the basis for the required weighing up of interests with energy-related economic issues. 3. Estimation of the so-called economic threshold value (Q_{EN}) The effects of obligatory minimum flows in outflow sections according to $Q_{GÖ}$ on the profitability of small and micro hydroelectric power plants are roughly estimated according to a system. The estimation of Q_{EN} occurs with reference to the obligatory minimum flow, and where it falls short of it, the utilization of hydropower potential is adversely affected and possibly uneconomic. 4. Recommended compensation flow (Q_{RE}) In consent procedures for existing installations according to water law (for example, new licences due to expiration of the period of consent), recommended compensation flow Q_{RE} should not challenge the existence of the installation. This means, that Q_{RE} is generally equated with Q_{EN}, unless $Q_{GÖ}$ turns out to be lower than Q_{EN}. This priority does not apply for outflow stretches in water body sections of particular ecological value.

		If Q_{EN} or Q_{RE} turn out to be much lower than $Q_{GÖ}$, laying down compensation flow can be abandoned if it does not appear to be ecologically useful. In licensing procedures for installations with a capacity of up to 25 kW, the laying down of minimum flow can likewise be dropped, because, from the viewpoint of water resources management, these small installations generally do not lead to serious adverse effects of a water-ecology nature. Only where there are doubts should it be decided, in early consultation with the nature conservancy authority, whether in-depth economic and ecological investigations are necessary. 5. Where appropriate, dynamization of the constant value Q_{RE} A basis for the dynamization of compensation flow is provided by the relationship of the average flows of summer and winter months.

BERLIN

Compared with other *Länder*, hydropower potential in Berlin is negligible. For this reason no specific provisions have been created under state law regarding its use.

In Berlin, the Water Authority – that is, the Minister (*Senator*) responsible for water resources – is responsible according to Article 20 in connection with Article 85 of the Berlin Water Act (*Berliner Wassergesetz*), for the granting, restriction and withdrawal of water licenses.

BRANDENBURG

In Brandenburg, with the exception of certain provisions in the State Fisheries Act on the ecological free passage of watercourses, there are no provisions of a statutory or subordinate legal nature governing the use of hydroelectric power plants as a renewable energy source.

According to Article 126 (1) in connection with Article 124 (1), No. 3 of the Brandenburg Water Act (*Brandenburgisches Wassergesetz*), the authorities responsible for decisions in procedures under water law are district authorities and self-governing – that is, not subject to district administration – towns and cities, in their function as subordinate water authorities. The State Environmental Agency is responsible as superior water authority (Article 126 (2), No. 1 in connection with Article 124 (1) No. 2, Brandenburg Water Act) for the granting of permits and licenses for the extraction of surface water in excess of 5000 cubic metres per day.

The treatment of old rights and authorities is provided for in Articles 147 (old rights and authorities), 148 (registration of old rights and authorities) and 149 (measures concerning the extinguishing of an old right or authority).

	State Fisheries Act / State Ordinance on Fisheries
I. Guarantee of ecological free passage	**- Article 27 State Fisheries Act – Measures for the prevention of damage and compensation:** Paragraph 1: "Whoever constructs or operates installations in or on waters, which ... can adversely affect biodiversity in waters or the migration of fish, fish fauna as a whole or individual species, has to take preventative measures at his own cost. " Paragraph 2: "Should such measures not be possible, or be economically unreasonable, then, in place of the obligation under Paragraph 1, compensation is to be paid." **- Article 30 Fish ladders:** Paragraph 1: "Whoever erects barrages and other structures in a water body, or substantially modifies existing installations, which prevent or severely impair the passage of fish, must install and maintain appropriate fish ladders at his own cost. ..." Paragraph 6: "With structures or installations, which already existed at the coming into force of this Act, and which prevent or seriously impede the passage of fish, the fisheries authority can subsequently order the erection of fish ladders …" **- Article 23 State Ordinance on Fisheries – Fishery requirements for licensing procedures for hydraulic engineering installations** Paragraph 1: "The Fisheries Authority is to be involved during licensing procedures for hydraulic engineering installations." **- Article 24 State Ordinance on Fisheries – Protection of fish from intrusion into installations for water extraction** Paragraph. 1: "The inlets of hydroelectric power plants ... in and on waters are to be secured, in line with generally recognized engineering principles, against intrusion by fish. With screens and similar appliances the gap between bars may not exceed 18 millimetres."

BREMEN

Hydropower potential in Bremen is negligible in comparison with other *Länder*. There are therefore no specific provisions under state law concerning its use.

According to Article 21 in connection with Article 152 (1) of the Bremen Water Act (*Bremisches Wassergesetz*), the Water Authority (Article 151 (1)) is responsible for conducting licensing procedures.

HAMBURG

Hydropower potential in Hamburg is also comparatively low. For this reason there are no specific provisions under state law governing its use.

The influence of a hydroelectric power plant on water ecology is taken into account in individual cases within the framework of existing laws and regulations.

Responsibilities in the area of water law and water resources management, in particular for the conduct of legal procedures, derive in Hamburg from the "Order on responsibilities in the area of water law and water resources management", according to which the Environment Authority, as water authority, is basically responsible (Section I.1 and I.2 of the Order in connection with Articles 92, 93, 86 (1) sentence 1, Hamburg Water Act (*Hamburgisches Wassergesetz*).

HESSE

Concerning hydropower use in general, and on the issue of minimum flow in outflow sections in particular, the Hessian Environment Ministry enacted on 13 February 1996 a "provision laying down minimum water quantity in watercourses for the extraction and reintroduction of water" together with implementation provisions, which were published in the State Gazette of 25 March 1995, No. 13, p. 1003.

According to the Responsibility Order of August 21, 1997, the environment offices of regional authorities are responsible for granting licenses (permits and superior permits) for the use of surface waters for hydropower.

	Decrees
I. Licensing of small hydroelectric power plants	**Environment Ministry Decree of 13.02.1996:** "In the case of new installations or the extension of existing installations, before laying down the volume and minimum volume of water extraction, the entire effects of existing and planned new water uses on the watercourse are to be recorded and assessed." ... "Approval under water law is to be granted to hydroelectric power plants in the form of a licence for a limited (30 years) period."
II. Treatment of old rights and authorities	**Environment Ministry Decree of 13.02.1996:** "Where in the case of existing installations application for further use is made during the life or following the expiration of a permit or licence, application documents, as is the case with a new application, are to be examined in the light of the aforementioned ecological factors and also considering economic justification. Should an existing installation be unable to fulfil the above-mentioned requirements at the time of renewed granting of approval, the period for adaptation is five years. Adaptation can be required under extensive utilization of existing installation components. If such adaptation cannot take place, it is to be examined whether further approval is ecologically justifiable."
III. Laying down minimum flows in outflow sections	**- Environment Ministry Decree of 13.02.1996:** "Minimum flow is derived from MLW, because it is assumed that water body biocoenoses are adapted to low-water conditions. ... For the maintenance of ecological water functions and the preservation of the typical appearance of the water, and taking into account concerns of possible uses for the extraction and re-introduction of water from flowing waters", the following minimum flow is provisionally laid down: - with a catchment area < 20 km² an orientation value of 0.9 MLW - with a catchment area of 20-50 km² an orientation value of 0.5 MLW - with a catchment area > 50 km² an orientation value of 0.33 MLW in the outflow section, which is to be increased or reduced according to specific local conditions for the preservation of ecological functionality." **- Implementation regulations for the Decree of 13.02.1996:** Minimum flow is established in the following operational steps: 1. Establishing the orientation value (MW and MLW from "*Deutschen Gewässerkundlichen Jahrbüchern*" [German Hydrological Yearbooks], or determined according to a procedure described in the Annex). 2. Establishing the flow duration curve pattern, that is, establishing the connection between the potential natural status of the water system and the chronological distribution of the flow (duration curve): An equable duration curve MW/MLW </= 5,5 (pattern I) tends more towards winding types of flowing waters; a less equable duration curve MW/MLW > 5,5 (pattern II) always presupposes a ramified system. 3. Laying down increases and reductions on account of local circumstances (criteria: watercourse type, mean value of MLW, flow characteristics in the course of a year; increases in the case of strongly varying flow characteristics, reductions in the case of consistent flow characteristics)

IV. Guarantee of ecological free passage	**Implementation regulations for the Decree of 13.02.1996:** "Concerning the diversion of water, inlet and outlet channels, together with the outflow section, can take on useful ecological functions. Watercourse biocoenoses and linear passage for fish must be preserved."

MECKLENBURG-WESTERN POMERANIA

With the watershed running through Mecklenburg-Western Pomerania from the North Sea to the Baltic Sea, the topological and hydrological situation offers few sites with water resources providing for effective use of hydropower. Moreover, the continuous ecological passage of waters is of increasing importance. The State will continue to prioritize the creation and safeguarding of the ecological passage of waters compared with the use of hydropower.

On account of this situation, no provisions are contained in the Mecklenburg-Western Pomerania Water Act (*Wassergesetz des Landes Mecklenburg-Vorpommern*), and up to now no administrative regulations or decrees are planned on this issue. The State Offices for Environment and Nature, rural district administrators and the mayors of self-governing towns and cities are basically responsible, in their function as subordinate water authorities (Article 108 in connection with Article 106 of the Mecklenburg-Western Pomerania Water Act), for decisions in procedures under water law. As expert bodies, the State Environment and Nature Authority and the State Geological Authority conduct conceptual and specialized work in the preparation and conduct of water authority procedures (Article 110 (1).

Regarding the use of renewable energy sources, the State of Mecklenburg-Western Pomerania relies on wind power.

LOWER SAXONY

The State Government in Lower Saxony has set itself the goal of increased use of hydropower. The government's "Programme for nuclear-free electricity supply in Lower Saxony", assumes a growth of 50 MW in installed electrical capacity of hydropower by the year 2006. In 1996, installed electrical capacity of hydropower amounted to about 60 MW.

At present, "Technical regulations for hydroelectric power plants" are being drawn up and discussed. These regulations should lay down basic ecological requirements for an area affected by the use of hydropower, make recommendations on the design of hydroelectric power plants, and also provide information on the determining of minimum flow.

As subordinate water authorities, the rural districts and self-governing towns and cities are responsible for carrying out water procedures. This is regulated in Articles 170 (1), 169 and 168 (3) of the Lower Saxony Water Act (*Niedersächsisches Wassergesetz*). By contrast, district administrations, as superior water authorities, are only responsible in special cases (Article 1 No. 1 of the Ordinance on responsibilities in the area of water law of March 9, 1999 in connection with Articles 170 (1), sentence 2, and 168 (2), Lower Saxony Water Act).

	State Water Act	Decrees
I. Licensing of small hydroelectric power plants		**Environment Ministry Decree of 15.07.1996 (Lower Saxony Ministerial Gazette of 31.10.1996, No. 41, p. 1620):** - Section 2.1: "In procedures under water law (permits, approvals, planning approval procedures and plan consent procedures), aspects of the use of hydropower are to be weighed up with other matters of public interest, as well as with the interests and rights of third-parties." - Section 2.1.1: "Approval (according to Article 13 Lower Saxony Water Act) is to be limited to an appropriate period. Among other matters, the issue of water supply is at first to be considered, followed by the economic importance of use for the operator (for example, with regard to the probable amortization period for tax purposes)." - Section 2.2.1: "In the examination of the permissibility of projects (new buildings, extensions or modernization of existing installations, reactivation of installations currently not in operation), the provisions of nature conservation law are also to be taken into consideration. The competent water authority should involve the responsible nature conservation authority as early as possible. The State Ecology Agency (*Niedersächsisches Landesamt für Ökologie, NLÖ*) should be consulted, when the assessment of individual cases requires special expert knowledge. "
II. Treatment of old rights and authorities	**- Article 32 Exceptions from the licence obligation (for uses on the grounds of old rights and authorities)** **- Article 33 Revocation of old rights and authorities** **- Article 36 Content and scope of old rights and authorities** **- Article 37 Other old uses**	**Environment Ministry Decree of 15.07.1996:** Section 2.1: "Origin, content, scope and continued existence of an old right and an old authority, are subject to prior law (Article 36, Lower Saxony Water Act (*Niedersächsisches Wassergesetz*). Old rights and authorities continue in force, in so far as they have not already expired, provided there exists no legally effective withdrawal or revocation of the old right (in accordance with Article 33). The renovation of parts of the installation, or other technical modifications of the installation, do not require a new permit or approval when the water uses deriving from the modified installation do not go beyond previously permitted uses (cf. Article 32). A procedure under water law is required, however, when the use is to be extended beyond an existing old right or an existing old authority or another existing permit under water law. The new permit or consent for extended use replaces existing old rights or authorities (Article 37).“
III. Laying down minimum flows in outflow sections	**Article 120 (2) Sentence 1:** "In the development (of waters) natural flow characteristics are not to be substantially changed ... and other major adverse changes in the natural or virtually undisturbed state of waters are to be avoided or, where this is not possible, compensated.“	**Environment Ministry Decree of 15.07.1996:** - Section 2.2: In the building, operation and removal also of small hydroelectric power plants (up to 1 MW) the effects on ∗ flow and current conditions, flow velocity ∗ substance balance of a water body ∗ temperature and oxygen regimes ∗ free passage ∗ habitat for fauna and flora ∗ groundwater are to be separately assessed.

		- Section 2.2.2: Laying down an adequate volume of compensation flow in the case of outflow power plants, in order to avoid or diminish damage to waters.
IV. Guarantee of ecological free passage		**Environment Ministry Decree of 15.07.1996:** - Section 2.2: In the erection, operation and removal of small hydroelectric power plants (up to 1 MW), the effects …on free passage …are to be assessed separately. - Section 2.3.1 Ascent of fish: "If the passage of fish will be interrupted through the construction of a hydroelectric power plant, adequate fish ladders are to be laid out and maintained." - Section 2.3.2 Descent of fish: "The passage of fish into lower lying water stretches is to be secured through an adequately proportioned bye-channel or other facility." - Section 2.3.3 Animal protection: "Inlet and outlet of a hydroelectric power plant are to protected against intrusion by fish. In so much as technical facilities are inadequate for extensive eel migration, the hydroelectric power plant is to be disconnected during the main eel migration period. The competent water authority should consult as early as possible the authority responsible for animal protection and the inland fisheries department at the NLÖ."

NORTH RHINE-WESTFALIA (NRW)

Water authorities in North Rhine-Westfalia are expected to weigh up, on an equal basis, the two environment policy goals of "avoidance of carbon dioxide emissions" and "maintenance of watercourse ecology " in the licensing of hydroelectric power stations.

Because hydropower potential in North Rhine-Westfalia – mainly on the economically viable large rivers – is already exhausted to the extent of 75-80%, an increase is only possible on existing unused weirs or on small, ecologically very sensitive streams. Here weighing up by water authorities very often comes down on the side of watercourse ecology, against the use of hydropower, or conditions have to be demanded for the prevention of ecological damage that make the operation of the installation unprofitable.

On account of this situation, the State Ministry for Environment, Regional Planning and Agriculture has commissioned a study to highlight potential hydropower sites on which small hydroelectric power plants could be profitably operated, taking account of all environmental issues. With this study, the attention of potential operators of hydroelectric power plants should be drawn to those sites for which, from the very beginning, there is a strong probability of licences being granted. The study will be prepared section by section for individual water systems and require, for the whole of North Rhine-Westfalia, a period of about three years to prepare.

The responsibility of regional administrations (regional councils), as superior water authorities, for the licensing of hydroelectric power plants where more than a total of 200 m^3 of water is extracted from surface waters within a period of two hours, is provided for in the "Ordinance on the regulation of responsibilities in the area of technical environmental protection" in connection with Article 136 of the State Water Act (*Landeswassergesetz Nordrhein-Westfalen*). Districts and self-governing towns and cities are responsible as subordinate water authorities (Article 136).

	State Water Act	Decrees
I. Licensing of small hydro-electric power plants	- the approval of hydroelectric power plants takes the form of a **"superior permit" according to Article 25a:** In so far as water body development is not involved, for the approval of hydroelectric power plants a "superior permit" according to Article 25a State Water Act is aimed at. Such permits may only be granted in a formal procedure, and only subject to the examination of objections raised on the basis of the rights and interests of third parties. A superior permit is therefore largely on an equal footing with a licence. However, the water authority retains the possibility to revoke a superior permit for well-founded reasons.	**Environment Ministry Decree of 30.08.1991 and Economics Ministry Circular of 07.02.1994 (Ministerial Gazette of the State of North Rhine-Westfalia of 08.03.1994, No. 17, p. 332):** - Section 5: Regional councils report every two years – on 1 September – on the number of adaptation orders and new permits they have issued for hydroelectric power plants under water law. New installations and improvements of existing installations are to be shown separately.
II. Treatment of old rights and authorities	**- Article 164 Old rights and authorities:** According to Article 164, old rights and authorities for hydroelectric power plants continue to be valid until their withdrawal. This also applies when use goes beyond the old right and authority, or when the purpose of use has been changed or switched according to Article 15 (4), sentence 2, no. 3, Federal Water Act. They can retain their validity, if they have been adapted to present-day demands.	**Environment Ministry Decree of 30.08.1991** Section 3 ff.: Revocable old rights and old authorities can only retain their validity when the following prerequisites are fulfilled (adaptation to present-day demands): • Laying down an ecologically established minimum water flow • Compliance with the interference regulation under nature conservation law (Articles 4 to 6 Landscape Act NRW) • Constructional measures for water outflow and reintroduction must take account of vegetation attendant to the water. • For a reasonable period of time (about 10 years) no serious adverse effects on matters of public concern may be perceivable.
III. Support of hydroelectric power plants		**Environment Ministry Decree of 30.08.1991 and Economics Ministry Circular of 07.02.1994 (Ministerial Gazette of the State of North Rhine-Westfalia of 08.03.1994, No. 17, p. 332):** - Section 2.17, 5.5: Investment in the construction, reactivation and improvement of hydroelectric power plants linked to the supply network with an installed capacity of up to 500 kW can be supported with a state grant of up to 25%. Expenditure on the reactivation or extension of installations is supported by up to 5,000 DM/kW installed capacity, for the construction of new installations up to 8,000 DM/kW installed capacity.
IV. Laying down		**- Environment Ministry Decree of 30.08.1991:**

minimum flows in outflow sections		Section 3.1: "The water body must have an individually laid down, ecologically-determinable minimum water flow. Redress for the compensation flow required to be maintained, is not provided." In a draft report from 06.12.1991 an orientation value of 1/6 MLW is mentioned, which can be increased in exceptional circumstances, seasonally staggered, up to 1/3 MLW. Local conditions are also to be taken into account. The state government is hopeful of a uniform regulation for all *Länder* through the LAWA. In this case the decree should be up-dated. In consent procedures, water authorities increasingly demand ecologically orientated water flow, for instance, according to the FST hemisphere method according to STATZNER, which, in the case of highland streams, lies between 47% and 136% of MLW.

RHINE PALATINATE

In Rhine Palatinate, there are no specific provisions or decrees under state law dealing with the licensing of small hydroelectric power plants.

The water authority responsible for the granting, restriction, withdrawal, revocation or extension of licenses for all uses of waters of Grades 1 and 2, as well for the extraction and diversion of water from Grade 3 waters in excess of 400 cbm/day, is the regional authority, as superior water authority (from January 1, 2000, the Structure and Licensing Directorate). This is provided for in Article 34 (1) n. 2 (a) and (b) in connection with Article 105 (2) of the Rhine Palatinate Water Act (*Landeswassergesetz Rheinland-Pfalz*). The subordinate water authority (district authorities, self-governing towns and cities) is responsible, according to Article 34 (1), no. 3 (d), for approving the extraction and diversion of Grade 2 waters up to 400 cbm/day. The allocation of responsibility (Article 34 (1)) for decisions on the restriction and revocation of old rights and authorities is governed by Article 34 (2).

The "Guide for the determination of ecologically-established minimum flow", which laid down minimum flow in the outflow sections of hydroelectric power plants, was presented on 17 June 1999.

The introduction to the Guide emphasized the special social and energy policy significance of hydropower as the most important source of renewable energy in Germany. It also referred, however, to the conflicts of ecological objectives, which can arise between the use of hydropower and the goal of preserving and restoring virtually undisturbed water systems.

The Guide finds spatial application in the low mountain ranges with a stony and gravely substrate that are most common in Rhine Palatinate.

Ecologically established minimum flow in outflow stretches and river sections diminished by extraction should counteract a barrier effect and enable in future the preservation of

- natural, reproducible and site-typical watercourse communities,
- the functions of the ecological balance,
- an appropriate water quality, and
- the aesthetic importance of the landscape

of affected waters.

One can only do justice to this concept, orientated, as it is, towards waters as biotopes, in highland watercourses with interstitial as spawning ground and habitat, when minimum flow demonstrates the following essential characteristics:

- a mean flow velocity of $v \geq 0.3$ m/s at least over half the width of the natural low water bed,
- adequate water depth in the thalweg,
- adequate width of wetted areas as habitat for water biocoenosis.

Flow velocity is therefore of decisive importance, for it effects not only the preservation of species typical for running waters, but also the forming of the corresponding substrate.

Water depth and surface width determine a water body potentially colonizable by water organisms, which has to provide a habitat of a minimum size (for example for fish, as the largest species under consideration).

So far as concerns the quantitative regulation of minimum flow, it has to be examined whether a seasonally dependent dynamic part of each water body – due to fish spawning seasons, for example – can lead to adjustment of required minimum flow. The minimum water depth required for ichthyological reasons can be limited to fish spawning seasons, if the remaining minimum flow criteria are met.

On account of the varied hydrological and ecological status of waters, minimum flow is regulated on a case-by-case basis in Rhine Palatinate, for only in this way is a proper and appropriate assessment of affected stretches of water possible. Hydrological evaluations show that on many waters flows of < 0.5 MLW have never been observed, or have been achieved or undercut on only a few days in a given year. In addition, the variation limits of waters in Rhine Palatinate – especially of the River Nahe – are very important. Comparison shows that mean low water flow in the Nahe catchment area is equivalent to about just one-third of low water flow in comparable river basin areas in other *Länder*. The laying down of statistical values can therefore serve no useful purpose. The legal basis for guaranteeing the ecological free passage of weir bodies is provided by Article 50 of the State Fisheries Act (*Landesfischereigesetz*) and the provisions on costs contained therein.

There are no support programmes in Rhine Palatinate for the subsidization of hydropower installations.

SAARLAND

There are no provisions under Saarland state law regarding the use of hydropower. Any applications are duly examined and necessary decisions taken on a case-by-case basis.

The use of renewable energy plays a very important political role in Saarland. In recent times, the construction of hydropower installations has been supported by way of the market introduction programme for renewable energy resources.

The Saarland Minister for the Environment commissioned a study on the use of hydropower, to record all possible instances of profitable use.

All decisions relating to water permits for the use of surface waters are taken by the Minister for the Environment, as superior water authority, in accordance with Article 103 (1) and (2) No. 1 in connection with Article 102 (1) of the Saarland Water Act (*Saarländisches Wassergesetz*). For all other waters, district authorities, urban community chairmen and town mayors are responsible in their function as subordinate water authorities (Article 103 (1) and (2) No. 2 in connection with Article 102 (2) of the Saarland Water Act.

In their decisions concerning the licensing of weirs, water authorities have to observe the principles contained in the decree on surface waters (Decree of the Minister for the Environment – the superior water authority – on surface waters of 16 June 1975, State Law Gazette, p. 439). According to Section 7 of the Decree, weirs may not be approved if damage to matters of public interest is to be expected. The construction of a weir generally represents such damage if a detrimental change in water resources management is to be expected from the planned water on the proposed site (Section 7.1.1.). In order to prevent detrimental changes in water resources management from weirs, the following provisions must be complied with:

Section 7.1.1.1: Weirs may be planned only on those sites where, determined by the size of the catchment area and an indicator value for specific flow (low water specific flow), the flow to the weir is at least large enough to operate the installation and to maintain sufficient compensation flow in the water body.

Section 7.1.1.2: The indicator value for specific flow is set for the time being – reflecting natural circumstances in Saarland – at 0.7 l/skm^2 for areas with a negligible retention capacity (for example, in lacustrine limestone, carboniferous systems), and at 1.2 l/skm^2 for areas with a great retention capacity (for example, mottled sandstone). A higher estimated specific flow in the hydraulic documentation must be verifiable.

Section 7.1.1.3: Compensation flow in the water body, or running off the weir, must amount to at least 60% of the cumulative inflow from the catchment area (see Section 7.1.1.2.), as determined according to indicator values for specific flow. Losses from evaporation and infiltration through existing weirs higher in the catchment area have to be deducted from the remaining 40% of total water cumulative flows. In the absence of evidence, evaporation losses have to be estimated at 8 mm/day and infiltration losses at 10 mm/day.

SAXONY

The use of hydropower as a source of renewable energy already makes a large contribution to environment-compatible energy production in Saxony, and thus also to climate protection. In 1998, electricity from installed capacity of around 67 MW achieved a 1.3% share in total electricity consumption in Saxony. At present, about 250 hydroelectric power plants are in operation, mostly installations of < 1 MW capacity, of which 203 supply the public network. Due to statutory provisions and ecological demands, exploitable hydropower potential is regarded, however, as largely exhausted. From the water ecology point of view, there are implementation problems at many existing installations. Only 60% of installations ensure the required minimum water flow. Fish ladders exist at only one-fifth of hydroelectric power plants.

To protect watercourses in Saxony, the Environment Ministry – with the agreement of the Economics Ministry – has produced guidelines for the use of hydropower with small hydroelectric power plants (< 1 MW capacity). The guidelines are not directed at hydropower as such, however, which is still recognized in accordance with the Saxony Water Act (*Sächsisches Wassergesetz*) as an important source for the production of renewable energy (Article 91a (1)), but rather serve the protection of river landscapes from ecological damage. Their area of application is limited to installations with a capacity

of less than 1,000 kW, because here the conflict between relatively low electricity production and serious ecological damage to waters is particularly great. According to the guidelines, the river habitat therefore enjoys basic priority. Installations at new sites, or installations of only low capacity, should no longer be licensed. Where required under nature conservation law, the reactivation of small hydroelectric power plants currently not in operation may not take place in protected areas such as the "*Sächsische Schweiz*" National Park, in biosphere reserves, nature protection areas as well as on natural land listed and protected as a monument, and should also not be permitted in other sensitive landscapes, such as natural parks and landscape conservation areas.

The guidelines should be considered when taking advantage of legally sanctioned latitude in the making of assessments. To guarantee proper administrative action, it is explicitly emphasized, however, that the principles laid down do not replace the exercise of discretion in individual cases and decisions on the basis of established facts and circumstances. Questions of proportionality, vested rights and claims to old rights have to be taken into account by the competent authorities.

Minimum ecological requirements for hydroelectric power plants have to be complied with. Saxony therefore invariably stipulates the legal requirement of ecologically established minimum flow for all hydroelectric power plants, the construction of fish ladders, and preventing fish from intruding into turbines.

The level of support for hydropower is orientated towards additional costs of construction, reactivation or modernization required for ecological reasons.

In accordance with Articles 38, 39, 40 and 41of the Saxony Fisheries Act (*Sächsisches Fischereigesetz*), fishery authorities, because of their special responsibilities, have to be involved in the licensing of hydroelectric power plants under water law. Fishery authorities should also be involved, or informed, in the case of reactivation of installations currently not in operation within the framework of existing legal consents, because, according to Article 41 (2) Saxony Fisheries Act, in the case of existing installations the construction of fish ladders can be subsequently required (Decree of the Environment Ministry of 21 September 1995).

	State Water Act	State Fisheries Act	Decrees
I. Licensing of small hydro-electric power plants	**- Article 91: Approval of the installation under water law, where appropriate Article 31 Federal Water Act for extensions or permit/licence according to Articles 2,7 and 8 Federal Water Act for uses (impounding, extraction, diversion).** **- Article 91a: Hydroelectric power plants:** Paragraph 2: "In the construction and operation of a hydroelectric power plant, particular account is to be taken of the interests of fish, nature and soil protection, landscape conservation and precautionary regeneration." **- Article 22: Temporary restrictions on uses:** Possibility of a temporary restriction (without compensation) or prohibition of uses in the public interest in extreme natural circumstances, or in the case of disturbances that can lead to an adverse effect on waters. **- Article 23: Levy for water extraction:** Paragraph 1 No. 1: For the use by extraction or diversion of water from surface waters, a levy is imposed by the Free State of Saxony. However: Paragraph 4 No. 3: The extraction and diversion of water from surface waters for direct hydro-power use and heat production are exempted from the levy.		**Guidelines for hydropower use with hydroelectric power plants < 1 MW (small hydroelectric power plants) of 26.02.1999:** – absolutely no small hydroelectric power plants on new sites; – absolutely no consent for hydroelectric power plants = 100 kW; – exceptional inspection required for sites in sensitive areas; – invariably, requirements regarding ecologically established minimum water flow, fish ladders and inlet screens (in detail, see IV and V). Decree of 21.05.99: Approval and notification (repair and commissioning) of hydroelectric power plants according to §§ 91, 91a Saxony Water Act (*Sächsisches Wassergesetz*)

II. Treatment of old rights and authorities	**- Article 21: Measures on expiration of a permit or licence:** Paragraph 1: "If a permit or licence has expired or partially expired, and if new consent is not possible, the competent water authority can oblige the previous holder of the right to wholly or partly remove installations for the use of the water and to restore the water to its former status within the framework of water regulations or prevent detrimental effects, at his own cost." **- Article 41: Discontinuing operation of a weir:** "A weir may only be permanently put out of action or removed with approval according to water law. Article 18 (licence revocation) and Article 21 apply accordingly." **- Article 91a: Hydroelectric power plants:** Paragraph 3: "The commencement of repairs or starting up hydroelectric power plants that have been out of action for longer than six months is to be notified to the competent water authority."		**Environment Ministry Decree of 25.03.1996:** - Section II.1.: "If the old right no longer exists (due to changes in use, for instance), the water authority can lay down regulations within the framework of the new consent procedure on the guaranteeing of minimum flow/ compensation flow." - Section II.2.: If the old right still exists, the authority can revoke it at its due discretion (Article 15 (4), Federal Water Act). - Section II.3: If the water authority does not want to revoke the old right, it has the possibility under Article 5, Federal Water Act to issue a subsequent order (Article 15 (4) sentence 3 Federal Water Act), that is, to subsequently lay down regulations on minimum flow and compensation flow.
III. Support of hydroelectric power plants			**Administrative Regulation of the Environment Ministry of 01.01.1997 on "Immission Protection" (State Gazette No. 29 of 17.07.1997, p. 731):** - Section 2.2.6: "(The Free State of Saxony supports ...the construction, reactivation and modernization of hydroelectric power plants with an installed capacity of up to 500 kW..." - Section 5.1: "Support takes the form of project support, provided in the form of non-repayable grants based on a fixed proportion of total project costs. Support is limited to a maximum amount." - Section 5.3.6: "(The level of support) ...for hydroelectric power plants amounts to up to 70 per cent of substantiated additional expenditure resulting from ecological requirements, to a maximum, however, of 200.000 DM per hydroelectric power plant or site" **Guidelines for hydropower use with hydroelectric power plants < 1 MW (small**

			hydroelectric power plants) of 26.02.1999 Rate and amount of subsidy relate to additional expenditure on ecological measures.
IV Laying down minimum flows in outflow sections	**- Article 42: Draining of water** Sentence 1: "Provided that the competent water authority has not determined otherwise, impounded water may only be drained in such a way that the ...ecological functions of the water body are impaired no more than is unavoidable, and maintenance of the water is not impeded." - **Article 42a: Minimum water flow** "Uses of surface waters that involve the impounding, extraction or diversion of water may only be permitted when it is guaranteed, that the flow volume (minimum water flow) required for the ecological functionality of the water is maintained. Taking account of local conditions, minimum water flow is laid down by the competent water authority in its notice of approval, bearing in mind matters of public interest, in particular the importance of the water body and its banks as habitat for plants and animals, as well as its importance for the appearance of the landscape; the interests of the water user are to be adequately considered.“	**- Article 39: Draining of waters** Paragraph 3: "A fishpond may not be drained of so much water that as a result the water suffers lasting damages habitat."	**Environment Ministry Statutory Note of 05.02.1996:** - Section 3.1: "Indicator values for the assessment of ecological minimum flow are established on the basis of hydrological statistics. The basis of reference is the natural, long-standing mean low water flow (MLW) of the last 20 years at least." - Section 3.1.1: "Ecological minimum flow should not be less than 1/3 MLW to 1/2 MLW if the concomitant specific flow is > 1 l/skm².“ - Section 3.1.2: "At least 1 l/skm² is laid down as specific flow (q) of ecological minimum flow, if 1/3 MLW to 1/2 MLW is small than 1 l/skm².“ - Section 3.1.3: "In the "*Sächsische Schweiz*" and "*Erzgebirge/ Vogtland*" National Parks, as well as in other protected regions, the indicator value should be orientated more towards MLW.“ - Section 3.1.4: "Seasonal staggering of ecological minimum flow should be set between 1/3 MLW and MLW.“ - Section 3.2: Explicit reference is made to the necessity of case-by-case decisions, as well as to the obligation on the part of the applicant/operator to prove that free passage of the water ecosystem, and the outflow section as habitat, are maintained (Recommendation of the LAWA-Report, "The determination of ecologically-established minimum flows", of February 1995, as a methodical basis). - Section 3.3: "In long-lasting, extremely dry periods, competent water authorities can order the temporary interruption of operation of the installation for the protection of water ecology - Section 3.5: "The owner/operator has to ensure that measuring points / measuring equipment are provided for the constant control of minimum flow." **Environment Ministry Decree of 25.03.1996:** **(With the Amendment of the Saxony Water Act, this decree should be read in connection with Article 42a of the Saxony Water Act)** - Section I.1: "Where a hydroelectric power plant is operated on the basis of provisions of the Federal Water Act, the competent water authority can subsequently order measures for the improvement of the physical, chemical or biological quality of the water (Article 5 (1) No. 1a in connection with Article 4 (2) no. 2a, Federal Water Act). This also covers the

			maintenance of minimum flow as well as the subsequent increase in compensation flow."
V. Guarantee of ecological free passage		**- Article 38: Damage prevention measures at water extraction installations and power-transmission equipment:** Paragraph 1: "Whoever erects or operates installations for water extraction or power-transmission equipment has, at his own cost, to prevent the intrusion of fish through appropriate devices." **- Article 13 of the 4th Ordinance on implementation of the Fisheries Act:** "The gap between the bars of screens and other devices to prevent the intrusion of fish into installations for water extraction or power-transmission equipment may not exceed 20 mm." - **Article 40: Guaranteeing fish passage:** Paragraph 1: "In waters according to Article 2 (1) no devices may be installed, which prevent the passage of fish." **- Article 41 Fish ladders:** Paragraph 1: "Whoever erects a weir in a water has to guarantee the passage of fish through appropriate fish ladders." Paragraph 2: "In the case of existing	

		installations, which prevent the passage of fish, the erection of fish ladders can be subsequently required.“	

SAXONY-ANHALT

No recommendations have been made in Saxony-Anhalt regarding the creation of ecological free passage and the establishing of minimum flow for hydroelectric power plants with an installed capacity of up to 1,000 kW, because investigations have not yet been concluded. However, the State basically supports the drawing up of general guidelines for the use of hydropower, in order to do equal justice to the demands of environmental protection and nature conservation.

The district authorities and self-governing towns and cities are basically responsible, as subordinate water authorities, for the conduct of licensing procedures under water law, in accordance with Articles 171, 172 (1) in connection with Article 170 (3) of the Saxony-Anhalt Water *Act* (*Wassergesetz für das Land Sachsen-Anhalt*). The areas of responsibility of superior and subordinate water authorities are demarcated in the "Ordinance on divergent responsibilities in the area of water law of September 16, 1997 (State Law Gazette, p. 847). The State Environment Protection Authority and the State Environment Protection Offices, as expert bodies, advise and support the water authorities in the enforcement of water law (Article 170 (4)).

	State Water Act	Decrees
I. Treatment of old rights and authorities	**- Articles 32 ff.** contain basic provisions on old rights and authorities. **- Article 83a: Existing installations:** Paragraph 1: "For weirs erected before 08.09.1993, whose licensing under water law cannot be verified, the owners or beneficiaries have until 31.12.1999 to apply to the water authority for the necessary consent (licence, permit). Weirs, for which application (sentence 1) is made within the set time limit, may continue in operation pending the decision of the water authority." Paragraph 2: "Should the owner or beneficiary no longer want to use the weir, application has to be made to the water authority, before the deadline laid down in Paragraph 1, for permission to remove or discontinue operation of the weir according to Article 84.“ Paragraph 3: "On expiry of the deadline laid down in Paragraph 2, the water authority goes ahead officially with the procedure according to Article 84." **- Article 84 Discontinuance of operation and removal of weirs:** Paragraph 1: "Weirs may only be kept continually out of operation with the approval of the water authority."	
II. Support of hydroelectric power plants		**Guideline of 19.09.1991 on the granting of aid for the use of hydropower (State Gazette No. 39/1991, p. 1051):** - Section 2: "The object of support is small hydroelectric power plants with a capacity of up to 300 kW, measured at generator terminals. Support is provided for the reactivation, extension and construction of small hydroelectric power plants." - Section 3: "Owners of small hydroelectric power plants and the holders of rights of use are entitled to apply." - Section 5: "Support takes the form of project funding. Funds are granted on the basis of a fixed proportion of total project costs. Funding occurs in the form of a non-repayable grant. The grant amounts to a maximum of 30 per cent of eligible expenditure. The grant is limited to eligible specific capital expenditure of a maximum of 6000 DM per kW installed capacity.“ Investment and planning expenditure in particular is eligible, including: • machine technology and electrical engineering (turbine, drive, generator, control,

		switch-gear cabinet, electrical circuits for connection to the energy supply network), • structural and civil engineering (site organization, excavation), powerhouse with inlet and outlet, weir, hydraulic engineering and steel construction for hydraulic engineering, such as embankments, cut-off walls/trenches, inlet screens, screen cleaning machines, inlet gate, fish ladders and other devices) The granting of funds for the use of hydropower lies within the sphere of responsibility of the Ministry of Economics and Technology. It is intended to amend the Guideline.
III. Laying down minimum flows in outflow sections	**Article 85: Draining of impounded water:** Paragraph 2: "Weirs have to guarantee a minimum flow."	
IV. Guarantee of ecological free passage	**Article 80a: Ecological free passage:** "In the erection or substantial modification of a weir, the ecological free passage of the water is to be guaranteed. In agreement with the competent nature conservation authority the water authority can allow exceptions." **Articles 94 ff. Fisheries Act** also contain provisions on fish ladders.	

SCHLESWIG-HOLSTEIN

There are no special provisions on the use of hydropower under state law in Schleswig-Holstein. The State Water Act (*Wassergesetz des Landes Schleswig-Holstein*) contains only general provisions on the operation of weirs, independent of the question of the extent of hydropower use with these installations.

The consequence is, that from an economic point of view the use of hydropower in Schleswig-Holstein is of minor importance, because only a negligible output can be achieved on account of the terrain (low inclines and little water flow).

Under Article 107 (1) No. 4 in connection with Article 105 No. 2 of the State Water Act, the State Nature and Environment Authority is responsible, as superior water authority, for the granting, alteration, restriction or withdrawal of a licence or old rights. In addition, according to Article 108 in connection with Article 105 No. 3 of the Water Act in connection with the Act on the Structural Adjustment of Public Authorities (*Behördenstrukturanpassungsgesetz*) of 12 December 1997, the State Environment Offices as well as the rural districts and self-governing towns and cities are responsible as subordinate water authorities.

	State Water Act
I. Treatment of old rights and authorities	**- Article 26 Discontinuing operation of weirs:** "A weir may only be continually put out of operation or removed with the approval of the water authority. Article 13 applies accordingly.“ **- Article 13 Measures on expiration of a permit or licence:** Paragraph 1: "Where a permit or license has wholly or partly expired, the water authority can, for reasons of public interest, require the operator to leave installations for the use of the water wholly or partly in their present condition, or to remove them at his own cost and restore the water to its former state.“

THURINGIA

In the case of outflow power plants in Thuringia, the compensation flow to be left in the original water bed is laid down by the licensing authority within the framework of licensing procedures under water law. In this case, the regulation contained in Works Standard No. 5 of February 2, 1973, "Graphic methods for drawing up a water balance for longitudinal profiles for river basins", of the Water Resources Management Office (*Wasserwirtschaftsdirection Saale-Weiße Elster*) is applied, assessment always being on a case-by-case basis.

In addition, the general recommendation can be initially applied, that minimum water flow be based on 0.1 x MW or a specific flow of 1.0 l/skm^2. This rule applies to the use of hydropower at Thuringia dams, published in the Thuringia Dam Guideline of 29 April 1997 (State Gazette No. 23, p. 1223).

In so much as nature conservation concerns are affected by the use, or project for the use of hydropower, restrictions can arise in individual cases, in particular in nature protection areas. A generalizing assessment based on specific regulations or provisions does not take place.

The district authorities and self-governing towns and cities, as subordinate water authorities, are basically responsible under Article 105 (1) of the Thuringia Water Act (*Thüringer Wassergesetz*) for conducting licensing procedures under water law, where not otherwise provided. In so far as Grade 1 waters are concerned, the State Administrative Authority is responsible as superior water authority, according to Article 105 (2) No. 3, for procedures on the granting of licenses and superior permits as well as for planning and approval procedures according to Article 31 of the Federal Water Act.

The State Environment Offices are expert bodies for all matters concerning water resources management and water ecology. They support subordinate water authorities, the superior water authority and the State Environment Agency in the exercise of their duties. Matters on which State Environment Offices are to be consulted by subordinate water authorities are regulated by the Administrative Regulation of 29 April 1999 (State Gazette No. 21, p. 1193).

	State Water Act	State Fisheries Act	
I. Treatment of old rights and authorities	**- Article 129** (Old rights and old authorities)		
II Support of hydroelectric power plants			**Guideline of the Thuringia Ministry of Economics and Infrastructure of 21.12.1995 on the support of rational and environmentally sound energy use as well as of the use of renewable energy sources, amended on 11.04.1997**
III. Guarantee of ecological free passage		**- Articles 41 and 42** provide for the guarantee of fish passage, and lay down how the burden arising from the subsequent requirement for fish ladders at existing installations is to be borne. **- Article 36** regulates preventive measures against the intrusion of fish and lays down replacement measures for damage to the fish population.	

DRAFT REPORT OF THE PANEL OF EXPERTS INVESTIGATING "MINIMUM FLOW AT HYDROELECTRIC POWER PLANTS" FOR THE *LAWA*[12] WORKING GROUP "MANAGEMENT OF SURFACE WATERS, HYDRAULIC ENGINEERING" (Status 23.11.2000):

"Recommendations for establishing minimum flows (Q_{min}) in outflow sections of hydroelectric power plants and their regulation in the enforcement of water law"

Often insurmountable weirs and outflow sections with inadequate flow are seen as the main problems concerning the operation of small hydroelectric power plants.

For a solution to the problem of "weirs as structural barriers" reference is made to the erection or re-erection of fish ladders, for which the leaflet (232/1996) "Fish ladders – dimensioning, structural design, functional control", published by the German Association for Water, Wastewater and Waste (*Deutsche Vereinigung für Wasserwirtschaft, DVWK)*, provides an adequate planning basis.

Recommendations for minimum flows should ensure, that the impediment of species passing through outflow sections, as well as the desolation of these water sections are reduced, and as a result, that the use of hydropower makes good its claim to environmental compatibility. In 1999, some eighteen months after being given the task, the LAWA panel of experts investigating "Minimum Flow in Hydroelectric Power Plants", presented the LAWA Working Group "Management of Surface Waters, Hydraulic Engineering" with draft "recommendations for establishing minimum flows (Q_{min}) in outflow sections of hydroelectric power plants and their regulation in the enforcement of water law". Two procedural possibilities were proposed, reflecting the varying experiences and dealings of the federal *Länder*: The "biotope outflow approach", and the "eco-hydrological approach". Both methods take as their starting point the demands on waters made by fish as the chief link in the aquatic food chain. The biotope outflow approach combines – related to fish fauna of the respective biotic environment – minimum demands on habitat with water quality. The eco-hydrological approach combines hydrological parameters with water quality, through which the minimum demands of particular fish fauna on habitat are approximately ensured. Both approaches provide for dynamization during the spawning and development phases of the respective indicator fish species.

Every investigation of Q_{min} requires individual observation encompassing, among other things, data on the structural quality of the water. With regard to enforcement under water law, existing and new hydroelectric power plants are considered, as well as installations about to be reactivated.

In-depth investigations are currently being carried out on different waters for the purpose of testing the proposed methods. On conclusion of the investigations it is intended to publish "recommendations".

[12] *Länderarbeitsgemeinschaft Wasser* – Joint Water Commission of the Federal States

Summary of *Länder* provisions

Under *Länder* law, individual provisions on the use of hydropower as a source of renewable energy vary, in part very considerably, so far as regulatory density and depth are concerned. This is to be explained by the fact, that in individual *Länder*, due to differing geographic, hydrographic and energy policy situations, the need for action and regulation varies widely, and, on the other hand, existing provisions have been independently enacted without agreement within the framework of the *Länder* Working Group on Water (LAWA).

The provisions are summarized below with regard to the positive mapping of all potential hydropower sites (I.), the promotion of hydroelectric power plants (II.), the treatment of existing installations (III.), the assessment of minimum flow in outflow sections (IV.) and measures for ecological free passage (V.).

I. Positive mapping of potential hydropower sites

In Baden-Würrtemberg, all potential sites where small hydroelectric power plants with a capacity of up to 1,000 kW could be profitably operated – bearing in mind all environmental concerns – have been recorded in positive mapping. North Rhine-Westfalia and Saarland also aim at positive mapping.

II. Promotion of hydroelectric power plants

Hydroelectric power plants are promoted in Bavaria, North Rhine-Westfalia, Saxony, Saxony-Anhalt and Thuringia with the help of support programmes for immission and climate protection projects, and for the use of renewable energy sources. The construction, reactivation and modernization of installations with a capacity of up to 300, 500 or 1,000 kW are eligible for support, which takes the form of non-repayable grants and fluctuates between 25, 30 and 70% of eligible expenditure. There are also differences concerning the expenditure eligible for support. In some cases, only planning costs and capital expenditure on increasing or securing energy production are eligible, in certain cases, only expenditure resulting from ecology-related demands, and in other cases, both types of expenditure are eligible. In Lower Saxony, pilot and demonstration projects in the area of "new and renewable energy resources" can be supported through low-interest loans of up to 70% of expenditure eligible for grants.

In other *Länder*, there are no provisions concerning criteria for the promotion of hydroelectric power plants: that is, none existed at the time of preparing the review.

III. Treatment of existing hydroelectric power plants on the basis of old rights and authorities

There are provisions in Baden-Würrtemberg, Bavaria, Hesse, Lower Saxony, North Rhine-Westfalia, Saxony, Saxony-Anhalt, Schleswig-Holstein and Thuringia on the treatment of existing hydroelectric power plants and weirs on the basis of old rights and authorities.

There are no comparable provisions in other *Länder*.

In most of the *Länder* that have enacted provisions, old rights and authorities continue in force as long as there has been no legally effective withdrawal or revocation and the old right has not expired. To maintain the old right it is necessary to examine the installation both from an ecological point of view and with respect to profitability, and if necessary, to adapt it to current requirements with particular regards to minimum flow and ecological free passage (in part under provision of a five-year period of adaptation). Compensation is generally not provided for investments required for these purposes; however, in almost all *Länder* with appropriate programmes they are included in expenditure eligible for support. If the right can or should no longer be exercised, water authorities in most *Länder* are able to order the demolition of the installation, in part or as a whole.

IV. Provisions on minimum flow

Provisions on minimum flow in the outflow sections of small hydroelectric power plants and other weirs exist in Baden-Würrtemberg, Bavaria, Hesse, Saarland, Saxony and Thuringia. In Lower Saxony, North Rhine-Westfalia, Rhine Palatinate and Saxony-Anhalt, appropriate regulations are currently being prepared or have yet to be specified. In part, the *Länder* are waiting for and setting their hopes on the findings of the LAWA Panel of Experts investigating "Minimum Flow at Hydroelectric Power Plants", before themselves undertaking new or additional steps regarding provisions on minimum flow.

The provisions enacted up to now differ in many ways. Minimum flow is established in a single-, two- or five-stage procedure. In each case, the basis for assessment is provided by an orientation value derived from hydrological data. These orientation values are also established on the basis of different methods, and fluctuate as a static value on yearly average between 0.33 and 1.36 MLW, and between 0.7 and 1.2 l/skm^2 as specific flow (the orientation values can at present also be laid down on a seasonal or flow-dependent and dynamic basis). Economic aspects are only considered in assessments in Bavaria. All other *Länder* - in as much as they have provisions on minimum flow – (and the LAWA Draft Report) take exclusive account of hydrological and ecological aspects. The length of outflow sections plays no role in any of the existing provisions.

V. Provisions on ecological free passage

Provisions on the ecological free passage of hydroelectric power plants and weirs – above all through protective measures against damage to fish from power-transmission equipment, and through the erection of fish ladders – have been enacted in Baden-Würrtemberg, Brandenburg, Hesse, Lower Saxony, Saxony, Saxony-Anhalt and Thuringia. In this respect, too, great differences exist regarding the degree of specification and the binding nature of the provisions. In Fisheries Acts, on the one hand, binding legal obligations are placed on operators of hydroelectric power plants and weirs, and detailed advice and instructions issued to water authorities in appropriate decrees; on the other hand, in some *Länder* no, or merely very general and non-binding statements regarding the ecological free passage of installations are to be found.

3.1.4 Support Programmes

Apart from the Renewable Energy Act (see 3.1.2.5), the most significant instrument for the promotion of renewable energy resources, there is a range of other support programmes at the EU, (German) federal and *Länder* level. Besides these governmental instruments, there are also voluntary undertakings on the part of utility companies as well as private mechanisms. From available information on the cost framework and duration of the programmes, total development aid for renewable energy resources can be estimated for the year 1997 at 859 million DM (including payments under the Electricity Transmission Act – predecessor of the Renewable Energy Act). Of this sum, 69.2 million DM is attributable to the use of hydropower (Arbeitsgemeinschaft DLR/WI/ZSW/IWR/Forum, 1999)

3.1.4.1 Support Programmes at the EU level

ALTENER II Programme

The ALTENER II Programme[13] runs from 1998 to 2002. The main aims of this programme are to support the creation of general conditions required to carry out a Community action plan for renewable energy – in particular the creation of legal, socio-economic and administrative conditions - and to encourage capital investment of both a private and public nature in the production and use of energy from renewable sources. One aspect of the programme is the promotion of hydroelectric power plants with a capacity of less than 10 MW.

The following activities are being financed through ALTENER II:

- Reports and actions that implement and complete Community measures for exploiting the potential of renewable energy sources.
- Pilot projects for creating and renewing infrastructures and instruments for the development of renewable energy resources.
- Improved exchange of experience and know-how concerning co-ordination between international, Community, national, regional and local activities, and the establishment of a central system for this purpose.
- targeted action for facilitated market penetration of renewable energy resources and the promotion of investment.
- Actions for the implementation, monitoring and assessment of Community actions and measures.

Following approval of an increase in funding for ALTENER II by the European Parliament in early February 2000, the European Union will provide a further three million Euros for research in the energy sector, as a result of which the total budget of the Programme increases to 77 million Euros.

Proposal for a Directive on the promotion of renewable energy sources

At the suggestion of the Commission, a "Directive on the promotion of electricity from renewable energy sources in the internal electricity market"[14] should be enacted. According to the Draft, "renewable energy sources" include non-fossil energy resources and thus hydroelectric power plants. According to Article 2, No. 1 of the Draft, only those hydroelectric power plants count as renewable energy sources, which have a capacity of less than 10 MW. The Draft makes no minimum ecological demands relating to the eligibility for support of the construction and operation of these hydroelectric power plants (under 10 MW).

3.1.4.2 Support programmes at the German federal level

In connection with ecological tax reform, the Federal Government published a support programme for "measures for the use of renewable energy resources"[15], coming into force on 1 September 1999 and valid up to the year 2003. This programme provides, among other things, for the promotion of the

[13] Official Journal L159 of 03.06.1998, p. 1 ff.

[14] Draft of a Proposal of the Commission of 12.05.2000 (EC/279/2000)

[15] Details are regulated in "Guidelines on the promotion of measures for the use of renewable energy resources" of 20.08.1999 of the Federal Ministry for Economics and Technology (*Bundesministerium für Wirtschaft und Technologie – BMWi*) – Federal Gazette No. 162 of 31.08.1999, p. 15137.

construction, modernization and reactivation of small hydroelectric power plants with an installed capacity of up 500 kW. The total volume amounted in 1999 to 200 million DM. Hydroelectric power plants are supported with loans of up to 100% of the cost of capital investment, and through debt relief for such loans amounting to 1,500 DM per kW for construction and 600 DM per kW for enlargement or reactivation. The obligation to operate a supported installation is restricted to a period of five years. Loans are provided by the *Kreditanstalt für Wiederaufbau (KfW)*. In contrast to the conditions for the provision of grants, so far as the granting of loans is concerned the guideline does not require that the project to be supported has to be officially approved. Consideration of environmental concerns is also not required.

Since 1994, installations for the use of renewable energy in private households, industrial and commercial enterprises, as well as in agriculture, have been supported with investment grants by the Federal Ministry for Economics and Technology ("100 Million DM Programme"), The objective of this programme is an increase in the demand for technologies using renewable energy, as well as a reduction in production and installation costs. The grants made available in the period up to and including 1997 amounted to 65.3 million DM, of which 4.2 million DM were for 98 hydropower projects (Arbeitsgemeinschaft DLR/WI/ZSW/IWR/Forum, 1999).

The Federal Ministry for Education, Science and Research has promoted renewable energy within the framework of various energy research programmes, but there are no special programmes promoting the use of hydropower.

Besides support programmes, low-interest financial aid can be applied for by way of different programmes at the federal level. For instance, within the framework of the ERP environment and energy saving programme, low-interest loans for energy-saving measures can be provided. The maximum sum available amounts to 1 million DM in the "old" *Länder* [formerly West Germany] and 2 million DM in the "new" *Länder* [formerly East Germany]. From 1990 to 1997, within the scope of this programme, loans amounting to 2,949.9 million DM were granted, of which 222.5 million DM were for hydroelectric power plants. The environment programme of the *Deutsche Ausgleichsbank (DtA*) provides loans for investment in installations for the use of renewable energy. The maximum loan available amounts, as a rule, to 10 million DM. From 1990 to 1997, loans amounting to 1,225.6 million DM were provided by DtA, of which 82.5 million DM were for hydroelectric power plants (Arbeitsgemeinschaft DLR/WI/ZSW/IWR/Forum, 1999).

3.1.4.3 Support programmes of the German *Länder*

Apart from programmes at the federal level, there are also widely varying support programmes at the *Länder* level (see also 3.1.3). An exhaustive compilation of expenditure under *Länder* support programmes for the period 1991 to 1997 shows total support amounting to 1,725.3 million DM, of which 71.3 million DM were attributable to the use of hydropower, whereby in 1993 the highest level was recorded, since when the annual amount has more than halved (see Table).

Table: Support [in million DM] for the use of renewable energy in the Federal *Länder* (Arbeitsgemeinschaft DLR/WI/ZSW/IWR/Forum, 1999)

	1991	1992	1993	1994	1995	1996	1997
Total	132.3	194.8	272.6	283.4	288.9	266.5	286.8
Of which hydropower	7.3	11.4	16.1	11.4	10.5	7.2	7.4

In comparison with other renewable energy resources, a relatively low proportion of support is attributable to the use of hydropower.

3.2 Estimation of the potential of small hydroelectric power plants

In view of predominant natural geographic conditions in Germany, the use of hydropower is not possible everywhere. More than three-quarters of technically feasible potential is to be found in the States of Bavaria and Baden-Würrtemberg, whereas in the north of Germany there are hardly any possibilities for energy production with hydropower (see Illustration). 70% of potential utilizable with present-day technology is already exploited.

From the technological point of view, for quite a long time the use of hydropower has been developed as far as possible. Operating efficiency, level of utilization, technical reliability and technical life of installations are all considerable.

A total of 5,299 hydroelectric power plants (owned by power supply companies and others) were in operation in Germany in 1996, feeding 17.2 terawatt hours (TWh) into the supply network. Of these plants, 4,881 with a capacity of under 1MW accounted for a net production (supply) of 1.49 TWh. 85% of hydroelectric power plants thus supplied 9.2% of electricity produced from hydropower. Related to total electricity consumption in Germany, around 0.33% was covered by small hydroelectric power plants (IÖW 1998, VDEW 1998).

Assuming that with the production of 1 kWh of electricity in Germany there arises an average of 0.57 kg of CO_2, this means that in 1996, with regard to the anthropogenic greenhouse effect, as a result of electricity production with small hydroelectric power plants approximately 850,000 tonnes of CO_2, emission were avoided. Related to total CO_2 emissions in Germany amounting to around 910 million tonnes in 1996, this is a share of 0.09%. Were the total electricity produced by small hydroelectric power plants to be produced by an average generation system, total CO_2 emissions in Germany would be 0.1% higher (IÖW 1998, BMU 1998).

Forecasts assume, that by the year 2005 there could be an additional 1,000 small hydroelectric power plants in operation, with an average capacity of 70 kW. Were these additional installations to achieve on average the same net production as existing small hydroelectric power plants, total net production of small hydroelectric power plants would increase to 1,729 TWh. This additional capacity would correspond to avoided emissions amounting to around 149,000 tonnes of CO_2, that is, almost 0.02% of total emissions (IÖW 1998, Grawe/Wagner 1996).

Against this background, reference has to be made to the optimization potential of large hydroelectric power plants, which, due to general economic and legal conditions (see Section 3.1.2.5 – Renewable Energy Act), is not everywhere exploited.

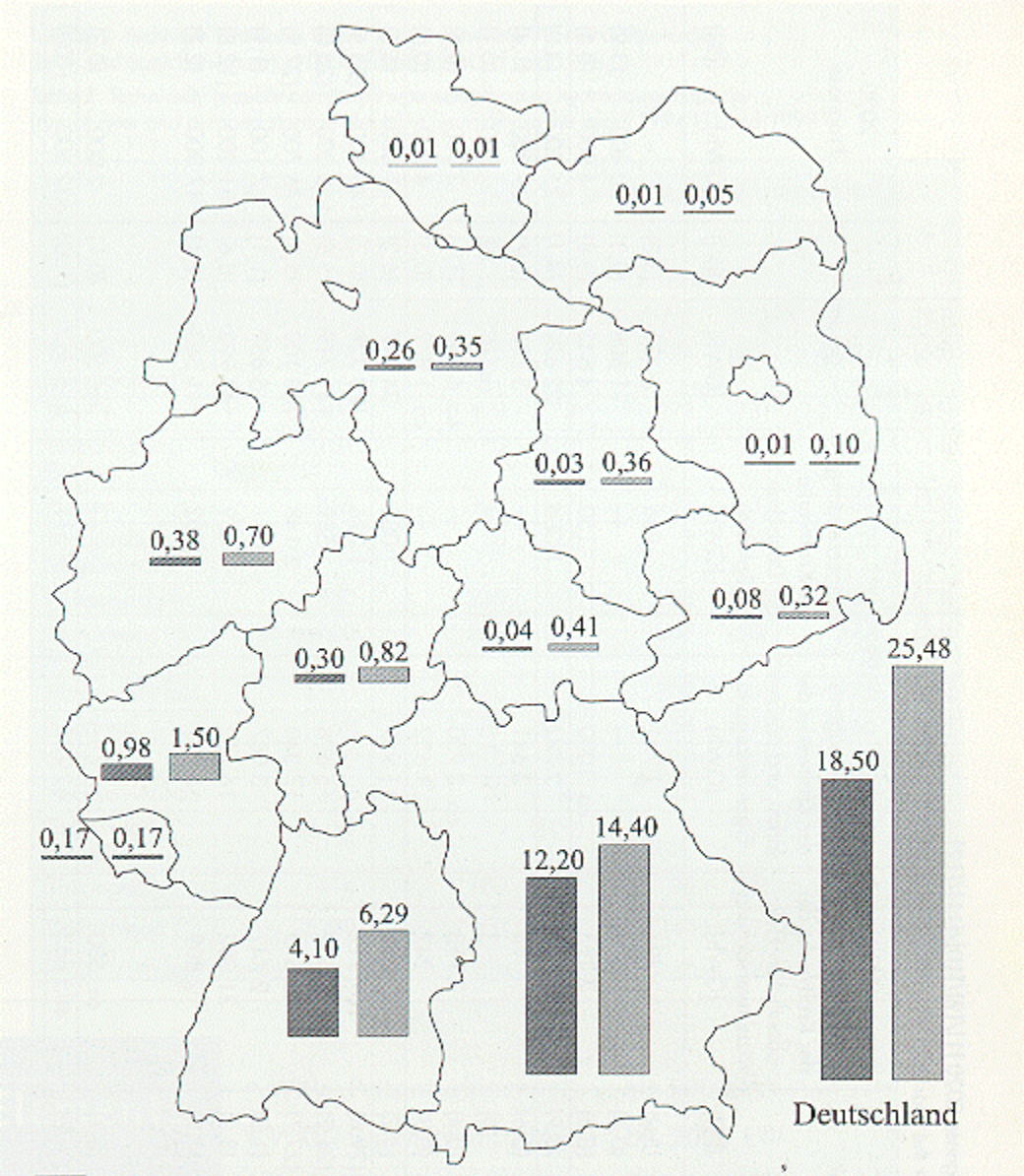

Bild 1: Technisch nutzbares sowie derzeit genutztes Wasserkraftpotential in Deutschland 1998 in TWh/a

Fig. 1: Technically feasible compared with actually used hydropower capacity in Germany in 1998 (TWh/a)

(Giesecke, Heimerl 1999)

Table: Compilation of data on electricity production by small hydroelectric power plants (capacity < 1 MW) (different sources, see text)

	Status 1996	Additional potential up to the year 2005
Number	4,881	1,000
Fed into the supply network (TWh)	1.49	0.27
Share of renewable energy production (%)	9.2	

To achieve the national climate protection goal, in the short and medium term additional exploitable potential is assumed above all for wind energy, biomass as well as passive and active solar-thermal production. In the medium and long term, photovoltaics, geothermal energy as well as secondary energy resources such as hydrogen and fuel cells on the basis of renewable energy can also make an important contribution to energy supply (BMU 1998).

On the other hand, the additional potential for hydropower use is lower, due to the extensive exploitation that has already taken place, and particularly since ecological damage to the affected waters is relatively higher in the case of small and micro hydroelectric power plants.

4 Effects of hydroelectric power plants on the watercourse ecosystem

The impounding and development of waters (for the production of hydropower) have ecological consequences for flood plains, water morphology and biocoenoses.

4.1 Function of natural watercourses and their floodplains in the balance of nature

An important characteristic of natural and virtually undisturbed watercourses is their dynamism. All watercourse habitats are affected and modified by seasonally occurring high and low waters. As a result of flow dynamics, semiaquatic habitats such as gravel, sand and mud banks are also created. Animals and plants, more or less specially adapted to local conditions, are to be found in waters, which are particularly dependent on water current conditions, sedimentary substrate, water depth and food supply. Fish have a particularly noticeable dependence on water current conditions and water depth. The dwelling areas of young and old fish differ according to water depth; they also differ in summer and winter months.

A floodplain – the area flanking rivers that at times of high water flow is regularly flooded, subsequently dries out again, and is also affected by changing groundwater levels – is typical for a natural watercourse in lowlands, in mountain foreland and in large mountain valleys. Areas close to rivers are often flooded, higher-lying areas only in the case of major floods. The constant alternation in area and timing between erosion and alluviation, that is typical for floodplains, as well as fluctuations in groundwater level, are directly dependent on the dynamics of the watercourse. A great diversity of interconnected aquatic, amphibious and terrestrial biotopes thus emerge in the floodplain, with highly varied fauna and flora specially adapted to changing conditions. Dependent on the type of floodplain, different waters are found, fed directly from the river but mostly through groundwater or tributary streams and springs.

Watercourses and their floodplains play an important role in the water and substance balance of an area. Apart from changing conditions of precipitation and the size of the catchment area, it is above all geological conditions and vegetation that have a considerable influence on flow process in waters, on flow duration and fluctuation. With high water, when water overflows banks and seeps away over a wide area, large quantities of water quickly infiltrate in flooded riverine wetlands. When the high water recedes, the infiltrated water seeps back into the watercourse. Riverine floodplains thus represent a substantial water reservoir and a natural high- and low-water buffer. Vegetation and surface relief in natural floodplains favour sedimentation at times of high water, and thereby contribute to substance retention in the area. As a result of high rates of evaporation of floodplain vegetation in summer months, the microclimate is strongly affected.

Through hydraulic engineering operations, in particular through watercourse correction, impounding, water body maintenance and intensive land use, the natural configurations of watercourses and their floodplains are generally greatly modified. Virtually undisturbed water sections are largely limited to the upper course of small watercourses outside areas of agricultural uses. Comprehensive representative investigations have shown for individual *Länder* that, compared with the status unaffected or negligibly affected by human intervention, around two-thirds of waters have distinct to extremely heavy structural deficits (UBA 1999). A simplified overview map of the structural quality of German rivers which was published by the Joint Water Commission of the Federal States (LAWA) in 2002 showed that only 10 % of the rivers were unchanged or only slightly changed. The functionality of a water body ecosystem can only be guaranteed, when diffused effects and modifications of water structure are kept at a level low enough to ensure that communities typical of the natural environment are preserved. In the last few decades, effects of polluting substances have for the most part been decisive for water quality. This has essentially changed, among other things through the construction of sewage treatment plants and improved sewage treatment technology. Deficits in water body structure are thus increasingly becoming a limiting factor in the improvement of the ecological functionality of waters. As far as can be established with the present state of knowledge, it has to be assumed that interference with water body structure can bring about substantially more far-reaching – in part, irreversible – changes than anthropogenic substance inputs.

4.2 Effects of hydroelectric power plants on the hydrology, morphology and biology of watercourses.

The construction, operation and reactivation of hydroelectric power plants on small waters involve far-reaching interference with the structure of the watercourse, which can lead to a change in or

irreversible loss of valuable types of habitat, to a loss of species of fauna and flora typical for watercourses and floodplains, as well as to a deterioration in the quality of waters. Hydroelectric power plants on small waters do not therefore correspond with the concept of sustainable water resources management.

Among manifold negative effects are the following:

Effects of the construction of a hydroelectric power plant with a weir

Because small hydroelectric power plants are generally conceived as run-of-the-river plants, watercourse **impoundment** is generally to be found, but no reservoir. In the impounded area, flow velocity is reduced from the end of backwater up to the weir. With decreasing flow velocity the transportation power of a watercourse is weaker and sedimentation stronger. The settling suspended matter creates a subsurface with fine substrate. The original mosaic-like distribution of the most different microhabitats within a small area disappears. Coarse river bed structures, such as scours, fords and crossflow areas are covered. The increase in groundwater level, combined with lower flow velocity, has a negative effect on the variability of bank configurations such as undercut and convex banks. The diversity of site conditions, with important partial habitats for many types of fish, is lost. Not only gravel banks for gravel spawners, but also flat well-vegetated bank zones for plant spawners and hatching fish disappear. The number and respective population of fish species correlate directly with the decrease in structural diversity of waters (BfG 1996, Bezirksfischereiverband Oberfranken 1998). (Attention is drawn to the fact, that a large proportion of typical fish fauna of watercourses in Germany is categorised as critically endangered in Red Lists.) There is also a considerable adverse effect on benthic invertebrates (macrozoobenthos), which is reflected in a reduction in the number of species, and also in the predominance of just a few insensitive (euryoecic) species. Because macrozoobenthos play an important role in fish food, this also has an effect on the composition of fish fauna.

Moreover, increased sedimentation seals the water bed (colmatage) and thus diminishes not only groundwater infiltration, but also the accessibility of the hyporheic interstitial for organisms (interstitial below the water bed, which serves as an area of retreat at times of high and low water, and of extreme temperatures, as well as a development area for the fry of different rheophile fish species).

The long-term accumulation at high water of non-degraded fine organic matter in backwater can further result in substantial oxygen depletion in flowing waves.

Zoobenthos species and fish adapted to water current find no suitable living conditions in areas of diminished flow velocity, which can lead to disruption of upstream migration. In backwater a community develops similar to that found in still waters. In the tail-bay a community dominated by filterers is found, similar to sea outlet biocoenoses. Only following longer stretches of water is a typical river population with a large share of shredders again to be found.

Algae find better living conditions in still waters, so that mass algae development can occur in nutrient-polluted waters, and oxygen deficiency can be the result when algal bloom dies off, particularly as atmospheric oxygenation is diminished through reduced turbulence in the backwater (partly connected with the release of nutrients from sediment and the emergence of biogases relevant to the climate). Smaller impounded areas show changes typical for river bays, when on a smaller scale (flow velocity at mean low water (MLW) < 20 cm/s, water residence time < 1/2 day, mean water depth 1.5 – 2.0 m) (BfG 1996).

Backwaters have a multiple and at the same time regulative function, in so much as they prevent flooding of the surrounding countryside. Constant water and groundwater levels result in the disappearance of pioneer sites, water exchange zones and waters typical for floodplains. Permanently wet areas arise in former floodplains. The result is a change in the composition of species and in vegetation zoning.

As a result of sedimentation in the backwater, suspended sediment load below the weir decreases. The increased occurrence of extreme flows often results in heavy erosion of the water bed. Scours in the water bed create so-called "hanging valleys"; that is, steps form at the confluence of tributaries, as a result of which the passage of fish and small organisms into tributaries is impeded. This affects not only typical migratory fish, but also fish species, for example, that migrate in winter from tributaries into deeper river sections.

Water bed erosion also leads to a drop in groundwater level, and thus to a reduction in groundwater resources in the area of floodplains. Alluvial forests gradually dry out, marshland and wetlands, which are dependent on groundwater, disappear. The result is a change in floodplain vegetation (for instance, the displacement of pasture-land by grey alder and ash trees), or the dying off of the

floodplain. With the disappearance of tessellated floodplain vegetation, numerous assimilated terrestrial and amphibious animals are displaced. Drying-out soil is better aerated. This facilitates accelerated re-mineraliation and can lead to increased nutrient input into the watercourse.

The sediment balance of a water body includes not only bed load and fine sediment, but also deadwood. Impounding results also in the interruption of the transport of deadwood. Deadwood is removed at inlet screens. Coupled with the regular clearing of waters and the extensive prevention of deadwood input from embankment areas, a deadwood deficit arises in watercourses, which additionally contributes to habitat impoverishment.

Impounding also leads to a monotonization of the aquatic habitat and current characteristics, a restructuring of aquatic communities, a loss of water level and groundwater dynamics, a deterioration in oxygen conditions and the self-purification power of the water body, a change in the bed load balance, a change in the local water regime, and ultimately to the disconnection of tributaries and riverine floodplains.

The **weir** of a hydroelectric power plant brings about an interruption in the free passage of a watercourse (loss of longitudinal interdependence) and thus to the division and diminution of the water habitat as well as to the impediment and prevention of migration for the purposes of spawning, feeding, propagation and compensation. It is above all long-distance migrants that are affected, but also fish that migrate over smaller stretches of a water, as well as small organisms that live in the soil. Investigations in the area of the River Main disclosed, for instance, that of 146 inspected weirs – 80% of them at small hydroelectric power plants – 64 were passable for fish downstream and only 11 were passable upstream (Bezirksfischereiverband Oberfranken 1998).

There are also, of course, natural water systems, which – because of waterfalls, for instance – are not completely passable. But generally, many fish species and invertebrates are dependent on rivers that are passable. At different ages and seasons, fish visit different configurations in waters. With many species of river fish, feeding places, winter habitat and spawning grounds are spatially separated. Besides migration for the purpose of spawning, migration to partial habitats for propagation is therefore also important. Through migration, over- and under-population are also compensated. The erection of a single obstacle to migration can lead to the extinction of a species, when spawning grounds can no longer be reached. Longer river sections with a high flow velocity and without calm areas after weirs represent migration barriers.

Also of importance is the free passage of waters for the propagation of fresh-water mussels, at whose larva stage fish act as carrier organisms.

In the long term, the disruption of water passage leads to a genetic isolation of populations. A lack of genetic exchange can result in a decrease in genetic variability, which can mean diminished adaptability to natural and anthropogenic modifications.

Outflow power plants are predominant among small hydroelectric power plants. **Diversions** from the original watercourse bed help form favourable water inclines for electricity production. Here the following additional effects occur:

- diminished flow in the original water bed (in the absence of minimum flow requirements to complete drying out at seasonal low-flow periods;
- loss of natural periodic flow fluctuations;
- prolongation of low water periods;
- change in water regime in floodplains, loss of floodplain vegetation dependent on periodic flooding;
- modification of the temperature balance in outflow sections (as a rule, higher summer temperatures and greater ice formation in winter);
- surge and recede effects with flooding;
- increased sedimentation in the original water bed due to lower flow.

The result is a further loss of aquatic habitat and a still greater influence on groundwater levels in floodplains.

Requirements for a reduction in negative effects

In order to reduce the above-mentioned negative effects, from the ecological point of view the following criteria have to be adhered to:

Impounding for the purpose of water diversion should be avoided. Constructions should be chosen that divert water in such a way that the character of the watercourse is preserved (for example, lateral water intake with a diversion structure in the water body).

In addition, new hydroelectric power plants should be designed to allow water to be diverted in such a way, that passage in the water bed itself is not restricted (for example, lateral water intake with a diversion structure in the water.). In order to reduce the considerable ecological damage from existing obstructions, fish ladders are required to guarantee free passage. These include block ramps, which allow the ascent and descent of fish and macrozoobenthos (DVWK 1996). Older technical fish ladders have often not functioned.

Previously enacted *Länder* provisions on minimum water flow in outflow sections are primarily directed at hydrological factors. From the water ecology point of view, the growing consideration of ecological aspects in the laying down of minimum flows is to be supported (see also 3.1.3). The laid down compensation flow volume should not be constant, but vary according to natural water level fluctuations (dynamic compensation flow volume). A sockel volume should however be laid down, which may not be undercut. Installations should be designed in such a way, that laid down compensation flow volume is structurally guaranteed.

Effects of operation of a hydroelectric power plant

In general operation (river power plants), damage to fish – particularly long-distance migrants – can be caused by turbines. The degree of damage can lie between 0% and 100%, depending on the type of turbine, the space between vanes, the number of revolutions per unit of time, utilization of turbine capacity, as well as size and species of fish (BfG 1996). Damage to fish is often avoided by placing screens in front of turbines. Originally designed with a gap of 80 – 100 mm between bars and used to protect turbines from floating debris, a space of 20 mm is now common for the protection of fish. This 20 mm gap does not offer complete protection, however, because flat fish and young fish can still intrude into turbines. Moreover, only properly positioned screens minimize damage to fish, and in the case of most power plants this is not the case. The result is, that the screens themselves and screen cleaning equipment cause fish losses (Verband der Deutschen Fischereiverwaltungsbeamten and Fischerwissenschaftler) 1995).

Adverse effects on aquatic communities can further arise due to disturbances, repair work (partial or total impoundage) or reservoir flushing. Sudden mobilization of solid matter that has accumulated in the impounded area over a longer period of time, leads to shock loading in downstream river sections. As a result of the rapid increase in flow and sudden movements of bed load, organisms living on the water bed (macrozoobenthos, fish) are washed away. High loads of suspended matter can further directly damage the respiratory organs of these organisms. Where there is a high proportion of an organic material in the sediment load, oxygen depletion can result from degrading processes, with the consequences already mentioned. The river bed of downstream water sections, as well as organisms living there, is covered with mobilised sediment. The deposits can also lead to a loss of washed-over detritus and gravel banks, and thus to a restriction of the reproduction of fish species that spawn on gravel.

Intense interference with fauna and flora occurs with surging and receding. Whereas natural high waters generally recede slowly, with a sudden and heavy surge of water, fauna are taken by surprise and drift. Through the erosion of attached algae and macrophytes and the washing away of particular organic materials as a result of surging, the number of benthic invertebrates diminishes. Due to the reduced food supply there is also a quantitative and qualitative change in the fish population. If the released water is driven back, flooded areas again fall dry, and the organisms left in the dried out areas are no longer able to find their way back to the water bed flow. In cases of regular drying-out, fish fauna are destroyed. Only very few macrozoobenthos species can survive these periods in the hyporheic interstitial. Through the release of warm surface water, or cold deep water in the case of large reservoirs, abrupt changes in the temperature regime arise, whereby the tolerance zones of aquatic organisms can be exceeded. Daily observed surging and receding, common with intermittent working of reservoirs, are highly unnatural. The consequence is a continuous harmful effect on terrestrial and aquatic communities (continuous loss of fish and invertebrates, decline in water plants, marsh plants and reeds).

Effects of the reactivation of hydroelectric power plants

The effects of reactivation of a small hydroelectric power plant depend on the condition of the plant. In extreme cases, the same effects can occur as with the construction of a new installation. On the other hand, an improvement in the ecological situation at the site can result from the imposition of requirements for use – such as the restoring of free passage, for instance.

Apart from the adverse effects on watercourses and their floodplains that have been described, positive effects are also often mentioned (Dahlmann, Rasper 1996):

- raising groundwater level,
- storage of water and groundwater,
- oxygenation,
- possibilities of regulation and intervention with high water,
- prevention of erosion,
- improved sedimentation of pollutants and nutrients,
- removal of waste from waters,
- creation of new habitats in waters, and
- creation of new valuable biotopes.

The raising and stabilization of groundwater level represent a positive effect only on waters with heavy groundwater drawdown due to water correction and sinking. Areas with naturally and strongly fluctuating, or naturally deep-lying groundwater levels are affected by impoundment, however, as has already been described.

Oxygen enrichment through the power plant weir is advantageous only in isolated cases, in which, due to considerable waste water load, oxygen deficiency symptoms in the water below the impounded area occur. It has however to be mentioned, that in the impounded area of a hydroelectric power plant a deterioration in the oxygen balance generally occurs.

The regulation of high water flow can be beneficial in waters where, on account of water corrections and the loss of natural flood-control areas as a result of dyking and drainage in the catchment area, instances of high water increasingly occur. As a rule, however, the regulation of high-water flow represents interference with the flow dynamics of a watercourse, and should therefore only take place where it is absolutely necessary for the purpose of use.

In waters with increased vertical erosion, as a result of correction and deepening or substrate extraction from the water bed, the raising of the water bed in the impounded area using bed load can be advantageous. But then increased erosion can be observed below the backwater area. Both processes compensate each other, in so much as an overall reduction in erosion does not take place. In virtually undisturbed waters, the prevention of natural erosion (in particular lateral erosion) and the typical watercourse biotope that is thus created is to be regarded as a severe encroachment.

Improved sedimentation of pollutants and nutrients in the backwater can be desirable with increased input through discharges, run-offs etc. Sedimentation in the reservoir does not represent an improvement in the situation, however, because substances can still be mobilised. A reduction in the pollutant and nutrient load of the water body could only occur through regular removal of polluted sediment from backwater areas and their transfer to land.

The removal of waste, which accumulates at weirs and the screens in front of turbines, is only necessary in those cases where the deposit of waste occurs in and on the water body. In this case the clearing of waters has a positive effect in so much as rubbish is involved and not natural debris (for example, deadwood, foliage).

The positive effects mentioned, such as the "creation of new habitats" and "new valuable biotopes" are not general objectives of water protection. These are rather concerned with the preservation and further development of communities typical for the natural environment and dependent on regional characteristics. This is contradicted by the creation of artificial reservoirs and wetlands, because this way the spectrum of species typical for the natural environment is changed.

In summary it can be said, that in the case of severe prior damage to a water body (for instance, through development, maintenance, impoundment or waste water load), the use of hydropower can have a quite positive effect in isolated cases. The construction of hydroelectric power plants on such waters thus offers the opportunity to lay down requirements for accompanying measures to improve water quality. However, irrespective of hydropower use, with waters that have suffered severe prior damage the causes of water pollution have to be diminished.

5 Economic viability of small hydroelectric power plants

5.1 Business economic assessment

Economic analysis from the perspective of the business enterprise considers the flow of costs and revenues associated with capital investment. In considering revenues from small hydroelectric power plants, it has to be borne in mind that the electricity produced in small hydroelectric power plants can be utilized in three ways:

- complete feeding into the network of power supply companies; that means, calculating proceeds on the basis of the guaranteed price laid down in the Renewable Energy Act (formerly Electricity Transmission Act; see 3.1.2.5);
- entire internal consumption; that means, calculating on the basis of charges levied on end users; or
- partial feeding into the supply network; that means, calculating on a mixed basis comprising payments for network supply and end-user prices.

With capital expenditure there are considerable variations (see Table), depending on whether the construction of a new installation or the modernization or reactivation of an existing installation is involved. Furthermore, the respective site circumstances can have a considerable effect on costs.

Table: Capital expenditure per kW of capacity (different sources)

Source		Capital expenditure (DM/kW)		
		Construction	Modernization	New machinery / Reactivation
Giesecke (1990)	< 100 kW 100 kW - 1 MW > 10 MW	10,000 7,000 5,000	4,000 4,000 4,000	1,500 1,500 1,500
DBU (1994)		Ab 6,000	2,500 – 6,000	2,500 – 3,500
BINE (1995)*		15,000 – 25,000	11,000 – 19,000	4,000 – 7,000
BMWi (1994)		8,000 – 9,000**	3,000 – 8,000	1,000 – 4,000
BEE (1996)	< 100 kW 100 kW - 500 kW 500 kW - 5 MW	17,000 – 35,000 15,000 – 25,000 13,000 – 20,000	13,000 – 26,000 11,000 – 19,000 10,000 – 15,000	5,000 – 10,000 4,000 – 7,000 4,000 – 6,000
Arbeitsgemein-schaft DLR/WI/ ZSW/IWR/Forum (1999)	70 kW 300 kW 1 MW	17,000 15,000 10,500		8,000 6,000 5,000

* Data according to Bundesverband Deutscher Wasserkraftwerke
** With small hydroelectric power plants costs can be higher (between 10,000 and 16,000 DM)

Operating costs of hydroelectric power plants are generally expressed as a percentage of capital expenditure on the entire plant or of individual expenditure categories, fluctuating between 0.8% and 5% (IÖW 1998, Arbeitsgemeinschaft DLR/WI/ZSW/IWR/Forum (1999). A further important factor concerning the profitability of small hydroelectric power plants is those costs that derive from the fulfilment of water protection requirements, including additional expenditure for replacement measures, fish ladders etc., on the one hand, and production losses due to compensation flow requirements, on the other hand. With micro-installations, water protection requirements generally result in non-viability.

Model computations of the economic viability of small hydroelectric power plants compiled for favourable sites by different institutions result in costs per kWh produced amounting to 0.156 – 0.422 DM for newly-constructed installations, 0.210 for modernized installations and 0.076 – 0.334 for reactivated installations (see Table).

Table: Energy production costs of small hydroelectric power plants (different sources)

Source		Energy production costs (DM/kWh)		
		Construction	Modernization	Reactivation
BEE (1995)	100 kW	0.422	0.210	0.334
Arbeitsgemein-schaft DLR/WI/ ZSW/IWR/Forum (1999)	70 kW 300 kW 1 MW	0.329 0.248 0.156		0.186 0.109 0.076

The computations show that, especially in the case of small hydroelectric power plants of up to 100kW capacity, in all three cases – construction, modernization and reactivation – the costs of producing electricity are higher than payments under the Renewable Energy Act (7.80 Cent/kWh (0,15 DM/kWh) for installations with a capacity of up to 499 kW, and 6.33 Cent/kWh (0,13 DM/kWh) for installations with a capacity of 500 kW and more) (see 3.1.2.5). Electricity can therefore hardly be produced economically in these installations under present conditions, even in favourable circumstances, without further state support (see 3.1.4).

For small hydroelectric power plants the question therefore arises as to the real motives of investors. Small businesses often operate hydroelectric power plants, themselves using the electricity produced. Investment in a hydroelectric power plant is often regarded as a provision for retirement. There are also investors who construct and operate a hydroelectric power plant through their own investment companies, setting off expenditure incurred during the course of capital investment at times of heavy tax burdens, and postponing receipts for a later period. In such cases, investment in a hydroelectric power plant resembles less a commercial investment and more a retirement or insurance plan, and must therefore also be compared with these forms of investment.

5.2 Overall economic assessment

The following comments solely comprise a comparison of hydroelectric power plants of different sizes, whose efficiency and environment-compatibility are compared on the basis of economic and ecological criteria. An overall economic comparison with other energy resources, such as nuclear power or the fossil energy resources coal, oil and gas, cannot be carried out at present, because appropriate methods have not yet been developed.

From the overall economic point of view, the support of a particular sector is only useful when positive external effects are to be expected from the provision of these goods, which do not benefit the provider of the goods. Here the situation can arise that, due to the lack of incentive, the goods in question are supplied in a smaller quantity than appears to be rational from the economic point of view. In the opinion of proponents of hydroelectric power plants, such positive external effects are generated by these installations, because they produce electricity without carbon dioxide emissions. In comparison to electricity production with calorific power plants, benefits thus accrue to society as a result of avoided external costs, which society should reimburse to the owners and operators of hydroelectric power plants. In an overall economic assessment, however, negative external effects have also to be taken into consideration.

In a report commissioned by the Federal Environmental Agency, the Institute for Ecological Economic Research - *Institut für Ökologische Wirtschaftsforschung IÖW* surveyed different approaches to the evaluation of positive and negative effects of small hydroelectric power plants, and undertook an overall economic assessment (IÖW 1998). To start with, positive external effects – that is, advantages due to electricity production without carbon dioxide emissions – were estimated on the basis of different costing methods. These were then compared with negative effects on watercourses (negative external effects).

In Germany in 1994, the base year, there were 4,633 hydroelectric power plants (owned by power supply companies and others) with a capacity of under 1 MW and a net production of 1.46 TWh. In relation to total electricity consumption in Germany amounting to 447 TWh from public supply, 0.33% was covered by small hydroelectric power plants. Assuming that the production of 1 kWh of electricity in Germany gives rise to 0.57 kg of CO_2, electricity production by small hydroelectric power plants

resulted in 826,500 tonnes of CO_2 being avoided. According to the method of assessment (GEMIS 3.0 1997), Fankhauser 1995, INFRAS et al 1996, Hohmeyer, Gärtner 1992), positive external effects of between 42 million and 601 million DM were achieved.

As a method of assessing negative external effects, the monetary valuation of biotopes was included in the investigation. The method was developed within the framework of the regulation on intervention contained in the Federal Nature Conservation Act, in order to be able to determine the level of compensation payments. According to the model used (fund model, investment model, compensation claims for specific biotopes), different values arise for compensation payments per square metre of biotope. For the assessment of small hydroelectric power plants on the basis of these values, it was estimated to what extent – in terms of surface area – CO_2-free energy production would "offset" intervention in a watercourse. In the "most unfavourable" assessment for hydropower (higher value for the biotope affected, lower costs for CO_2 emissions), with small installations only intervention in an area of about 70 square metres is "compensated". In the "most favourable" assessment for hydropower (low compensation claim for the biotope, high costs for CO_2 emissions), the area is about 30,000 square metres. This would represent, for example, a river valley strip 50 metres wide and 600 metres long – an area that could in most cases be affected by the head-bay and the erosion section (tail-bay) (see Table).

Table: Cost-benefit analysis of small hydroelectric power plants – intervention area (in m^2) compensated by positive external effects (IÖW 1998)

Biotope assessment	**Fund model**		**Investment model**		**Model for compensation claims for specific biotopes**	
CO_2 costs	**798 DM/m^2**		**448 DM/m^2**		**28 DM/m^2**	
Hydroelectric power plant capacity	<50kW	50-100kW	<50kW	50-100kW	<50kW	50-100kW
Square metres of compensatable intervention						
GEMIS 3.0	71	252	127	450	2.038	7,208
Fankhauser	165	581	293	1,036	4,688	16,580
INFRAS	193	682	343	1,216	5,503	19,463
Hohmeyer/Gärtner	1,041	3,682	1,855	6,559	29,677	104,958

Even when the overall economic assessment of small hydroelectric power plants is fraught with uncertainties and problems, it nevertheless shows, that intervention in nature and landscape connected with small hydroelectric power plants results in external costs that are not to be ignored, also considering climate protection. The smaller the installation the less favourable the values.

6 Summary

Already in 1990 the German Government decided, as its contribution to the limitation of worldwide greenhouse gas emissions, to reduce CO_2 emissions by 25% by 2005 – base year 1990 – and to limit or reduce other greenhouse gases. In order to achieve its national climate protection goal, the Government developed a national climate protection strategy and a comprehensive package of measures that meanwhile includes around 150 individual measures. To achieve the reduction goal, the potential of CO_2-free renewable energy sources is also being discussed. The objective is the doubling of the share of renewable energy in primary energy consumption by 2010, as well as a long-term increase to a share of at least 50% by 2050.

Among possible options, hydropower is the furthest developed in Germany. However, predominant geographic conditions only partially favour the use of hydropower. More than three-quarters of technically exploitable potential is found in Bavaria and Baden-Würrtemberg, whereas in the north of Germany possibilities for electricity generation through hydropower hardly exist. Around 70% of the potential utilizable with current technology has already been exploited. The technological potential is also largely exhausted. This is reflected in the relatively low rates of support available for hydropower use in support programmes.

The remaining exploitable potential therefore mainly concerns small, previously undeveloped, virtually undisturbed waters. Because of this, a considerable conflict arises between the objectives of climate protection, on the one side, and water and nature protection on the other, particularly as possible growth in small and micro hydroelectric power plants could contribute only very little to a reduction in CO_2 reductions in Germany. Possible harmful ecological effects, particularly on the few remaining virtually undisturbed watercourses in Germany, could be considerable. This conflict, between positive effects in relation to climate protection and negative effects in relation to species and biotope conservation, becomes all the more intense the smaller – and therefore less effective – the hydropower installation and the more natural the affected watercourse. Macro-economic cost-benefit analysis shows that the economic costs can be considerable, compared with the benefit. The smaller the installation's capacity and the more natural the watercourse, the less favourable the cost-benefit analysis.

Economic evaluations show that, especially with small hydroelectric power plants with a capacity of up to 100 kW, in all three cases of new construction, modernization and reactivation, the cost of producing energy is higher than the rates of payment under the Renewable Energy Act, and therefore in many cases, even in favourable circumstances, electricity can hardly be produced economically.

Economic considerations show, that a subsidy that covers the operating costs of small hydroelectric power plants – in particular plants with a capacity of under 100 kW – leads to high macro-economic costs for the avoidance of CO_2 emissions. Against the background of negative ecological effects, further exploitation of the potential of small hydroelectric power plants is not a priority for climate protection.

Considering prevailing legal provisions and the requirements of the EC Water Framework Directive the following recommendations are put forward:

- On account of their higher efficiency, large hydroelectric power plants are generally to be given preference to small and micro-installations for secondary use on waters already developed and impounded. In the development of hydropower capacity attention should be focused on their optimization.
- With virtually undisturbed waters, or those where renaturalization is planned, the use of hydropower should be renounced.
- The construction and reactivation of small hydroelectric power plants is unproblematic at existing weirs that cannot be demolished, in particular when, at the same time, ecological improvements – for instance, restoring free passage – can be achieved.
- With the reactivation of installations currently not in operation, and the renewal of water rights, concerns of water protection should be more strongly considered and conditions laid down (for example, functional fish ladders, structurally-guaranteed dynamic minimum water flow, exclusion of flash floods downstream dams).
- In the case of new installations, impounding of a water body for diversion is to be avoided. Constructional methods should be chosen, which divert the water used in such a way that the free passage and character of the watercourse is maintained (for example, lateral water intake with a

diversion structure in the water body). Requirements are to be issued on minimum flow and on measures for the avoidance of damage to fish from turbines. Flash floods downstream dams are to be prohibited.

- Positive mapping of all potential sites is recommended, where, taking account of environmental concerns, small hydroelectric power plants with a capacity of up to 1,000 kW can be economically operated, such as has already taken place in Baden-Würrtemberg.

Bibliography

Arbeitsgemeinschaft DLR/WI/ZSW/IWR/Forum: Klimaschutz durch Nutzung erneuerbarer Energien, UBA-Berichte 2/00, 2000

BEE (Bundesverband Erneuerbare Energien): Erneuerbare Energie: 50 Fragen & 50 Antworten. Beantwortung der Fragen zur Anhörung des Ausschusses für Wirtschaft des Deutschen Bundestages zum Thema Stromeinspeisungsgesetz (StrEG), 1996

Bezirksfischereiverband Oberfranken e.V.: Analyse der biologischen Durchgängigkeit des oberfränkischen Mains und seiner wichtigsten Nebenflüsse. 1998

BfG (Bundesanstalt für Gewässerkunde): Kleine Wasserkraftanlagen - Ökologische Chancen und Risiken einer regenerativen Energiequelle, 1996

BINE: Wasserkraftnutzung. Potentiale in den fünf neuen Bundesländern. Herausgegeben vom Fachinformationszentrum Karlsruhe, 1995

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit): Nachhaltige Entwicklung in Deutschland - Entwurf eines umweltpolitischen Schwerpunktprogramms, 1998

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit): Energiegewinnung durch kleine Wasserkraftanlagen, Umwelt 2/98, 1998

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit): Umweltverträglichkeit kleiner Wasserkraftwerke, Umwelt 3/98, 1998

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit): Erneuerbare Energien und nachhaltige Entwicklung, 1999

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit): Kleine Wasserkraftanlagen als nachhaltige erneuerbare Energiequelle, Umwelt 7-8/99, 1999

BMWi (Bundesministerium für Wirtschaft): Energieeinsparung und erneuerbare Energien. Berichte aus den energiepolitischen Gesprächszirkeln beim Bundesministerium für Wirtschaft, 1994

Dahlmann, I.; Rasper, M.: Auswirkungen von kleinen Wasserkraftanlagen auf Fließgewässer und ihre Auen. Inform. d. Naturschutz Niedersachs. 5/96, 1996

DBU (Deutsche Bundesstiftung Umwelt): Demonstrationsvorhaben zur umweltgerechten Wasserkraftnutzung in den neuen Bundesländern, 1994

DVWK: Fischaufstiegsanlagen - Bemessung, Gestaltung, Funktionskontrolle, Merkblatt 232/1996, 1996

Giesecke, J.: Perspektiven der Wasserkraftnutzung in Baden-Württemberg. In: Wasserwirtschaft Bd. 80 (6), S. 285-294, 1990

Giesecke, J.; Heimerl, St.; Wasserkraftanteil an der elektrischen Stromerzeugung in Deutschland . In: Wasserwirtschaft Bd. 89 (7/8), S. 336-344, 1999

Grawe, J., Wagner, E.: Nutzung erneuerbarer Energien durch die Elektrizitätswirtschaft. In: Informationszentrale der Elektrizitätswirtschaft (Hg.): Erneuerbare Energien. Ihre Nutzung durch die Elektrizitätswirtschaft, S. 6-17, 1996

IÖW (Institut für Ökologische Wirtschaftsforschung): Umweltverträglichkeit kleiner Wasserkraftwerke - Zielkonflikte zwischen Klima- und Gewässerschutz, UBA-Texte 13/98, 1998

IPCC (Intergovernmental Panel on Climate Change): Climate Change 1994 - Radiative Forcing of Climate Change, IPCC, 1995

IPCC: Zusammenfassung für politische Entscheidungsträger und Synthesebericht, Zweiter umfassenden IPCC-Bericht, 1996

IPCC: Climate Change 1995 . Impact, Adaptions and Mitigation of Climate Change: Scientific-Technical Analyses, IPCC-WG II, 1996

IPCC: The Regional Impacts of Climate Change, A Special Report of IPCC - WG II, 1998

LAWA (Länderarbeitsgemeinschaft Wasser): Gewässerstrukturgütekartierung in der Bundesrepublik Deutschland - Verfahren für kleine und mittelgroße Fließgewässer, Entwurf Januar 1999

LAWA (Länderarbeitsgemeinschaft Wasser): Gewässerstruktur in der Bundesrepublik Deutschland 2001, Hannover November 2002

LAWA-Arbeitskreis „Bewirtschaftung oberirdischer Gewässer, Wasserbau“: Empfehlungen zur Ermittlung von Mindestabflüssen (Qmin) in Ausleitungsstrecken von Wasserkraftanlagen und Festsetzung im wasserrechtlichen Vollzug", Stand: 23.11.2000

UBA (Umweltbundesamt): Umweltqualitäts- und Umwelthandlungsziele im Gewässerschutz, UBA-Texte 63/96, 1996

UBA (Umweltbundesamt): Maßnahmenplan Nachhaltige Wasserwirtschaft, UBA-Texte 25/99, 1999

VDEW: Stromzahlen 1996, zitiert in: Umwelt 3/98, 1998

VDEW: Stromzahlen 1998, pers. Mitteilung, 1999

Verband der deutschen Fischereiverwaltungsbeamten und Fischereiwissenschaftler e.V.: Kleinwasserkraftanlagen und Gewässerökologie - Probleme und Lösungsansätze aus fischereilicher Sicht. Schriftenreihe Heft 9, 1995