Evaluating Economic Policy Instruments for Sustainable Water Management in Europe

WP3 EX-POST Case studies
Subsidies for ecologically friendly hydropower plants through favourable electricity remuneration in Germany

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Executive Summary

1.1 Definition of the analysed EPI and purpose

In Germany, the 2000 Renewable Energy Sources Act (EEG) is the main instrument to promote the use of renewable energy sources. It guarantees for electricity production a defined remuneration per kWh which is above free market prices. The present case study looks at the environmental preconditions for the eligibility of hydropower plants to increased tariffs which form part of the EEG since its amendment in 2004. The environmental measures required aim at substantially improving the ecological status of water bodies next to hydropower plants, if not at reaching good ecological status, as asked by the Water Framework Directive (WFD). However, neither quantitative targets nor a time span for reaching these objectives have been set at the introduction of the instrument.

The case study has been chosen for several reasons. Hydromorphological pressures – including those originating from hydropower use – are an important barrier for reaching the good ecological status (or the good ecological potential) of water bodies in European countries. The favourable EEG remuneration for ecologically friendly hydropower plants in Germany is one of the rare economic policy instruments (EPIs) that have been developed to target those pressures, and not much documentation of this instrument at international level is available so far. The case study provides a good example of how the promotion of renewable energy produced by hydropower can take nature conservation issues into account.

Existing since 2004, the ecological requirements have been further specified in the EEG amendments which enter(ed) into force in 2009 and 2012, following the regular reports of experiences on the implementation of the law. They concern, among others, the biological passability of the weirs and the provision of minimum water flow.

1.2 Introduction

The EEG and its ecological conditions for hydropower plants are applied all over Germany and are in theory relevant for all of the existing 7 500 hydroelectric power stations. Since its introduction in the year 2000, the EEG constitutes an important instrument for maintaining and extending hydropower production. This effect is untouched by the ecological provisions, which do not preclude the plants to be remunerated according to the EEG 2000 conditions. The focus of this case study lies, however, on the increased remuneration proposed after the establishment of ecological improvements on the plants.

Hydromorphological deficits are a major cause for failing to reach good ecological status of river water bodies in Germany. The instrument targets hence an essential water management issue, which is all the more relevant as it represents an area of conflict between water and energy policy targets.

1.3 Legislative setting and economic background

The EPI has been established in the form of an amendment of a law (the EEG), without being compulsory for the hydropower sector. Each hydropower plant operator can decide whether implementing the ecological improvement measures and receiving the higher remuneration is profitable in his case or not. The instrument has been designed to internalise external effects of hydropower use, as the EEG remuneration is apportioned to the electricity consumers, with some exemptions made in the industrial sector. The ecological requirements have been introduced into the existing remuneration framework of the EEG, while considering the demands of the European WFD. They are also a direct result of the prevailing discussions between the supporters of hydropower production as a source of renewable energy and nature conservationists (as well as angling associations) which highlight the negative impacts of hydropower use. The choice of the instrument in its present form was very much facilitated by the already existing EEG remuneration system of hydropower plants. No specific selection process took place.

The practice of concession rights for hydropower plants in Germany and the legal security linked to it has been a major driver for the introduction of the EPI. The approval procedure for new concessions requires compulsory compliance with the new German water law (WHG 2009) – and hence the application of measures foreseen in the WFD river basin management plans to reach good ecological status. Hydropower plants possess, however, concession rights for a period of several decades, or even unlimited user rights. The EPI provides hence incentives to improve the ecological situation earlier in time. In order to ensure investment security, once the ecological measures approved, the remuneration is guaranteed for 20 years (according to the most recent amendment). The EPI, which is a national policy instrument, is in some cases complemented by additional subsidies for ecological improvements, depending on the different German Länder.

In general, the German hydropower sector is well established. This is, however, only partly the case for the small hydropower plants (SHPs), which are particularly dependent on the EEG remuneration to operate in an economically viable way.

At the time of introduction of the instrument, it had been subject to significant data deficits, concerning for example a missing centralised inventory of all existing hydropower plants. Whereas this has changed in the meantime, information lags persist regarding the reporting of the types of measures implemented following the introduction of the EPI as well as regarding their environmental effectiveness.

1.4 Brief description of results and impacts of the proposed EPI

The most important measures which need to be implemented in order to improve the ecological status of water bodies in the area of influence of hydropower plants are the establishment of migration possibilities for fishes upstream, fish protection measures for migration downstream and the provision of minimum water flows (Naumann, 2011). This corresponds basically to the measures applied following the EEG amendment in 2004, as revealed in a recent research project (Anderer et al., 2011 *in print*), indicating a general good steering effect of the EPI. The results of the mentioned project indicate also that a total of about 10 % of the existing hydropower plants dispose of equipment which assists the upstream migration of fishes and / or provide minimum flow conditions. Regarding upstream passability for instance, about half of the measures have been financed by the increased remuneration according to the EEG 2004 and 2009 conditions.

In many cases, ecological improvements through the modernisation of existing plants are technically possible, but face limitations of economic feasibility. While for bigger plants – producing over 150 kW – the financial EEG incentive is often sufficient for the ecological modernisation, a problem persists mainly regarding the existing SHPs with a production capacity up to 100 kW (Knödler and Wotke, 2009). At the same time, SHPs are particularly important from an environmental point of view, as they are often located on small and only little modified rivers. The remuneration level which would be necessary to provide sufficient incentives for SHPs is considered to be not economically reasonable from the policy maker's point of view.

Regarding social effects of the EPI, the EEG apportionment constitutes only a minor part of the electricity bill of households, indicating that the EPI is not linked to a disproportionally high burden for electricity consumers. Other significant distributional or social impacts of the EPI have not been reported.

The relevant transaction costs of the instrument consist mainly in the research processes which accompany its implementation. Monitoring and enforcement costs are negligible, as no controls of the functionality of the measures take place once they have been implemented and accepted by the responsible water authority.

Uncertainty aspects are a major issue in the assessment of the instrument. It is noteworthy regarding the application of measures, their actual ecological effectiveness and the incentive effect of the EPI, compared to other reasons for carrying out ecological improvements. More detailed research is necessary in this regard.

1.5 Conclusions and lessons learnt

The remuneration provided to hydropower plants, which is linked to ecological conditions according to the German EEG after 2004, can generally be considered as a successful instrument, which led to the implementation of ecological improvement measures in several documented cases. The extent to which the measures are applied depends mainly on the amount of remuneration foreseen by the EEG. With the remuneration being proportional to the amount of electricity generated, the potential surplus for SHPs is in most cases not enough to finance the environmental measures. Additional instruments are needed to address their ecologically important impact. A major criticism of the EPI is, that it is designed to promote ecological improvements on hydropower plants where they are economically feasible, and not where they would be ecologically most effective. Furthermore, missing data on the type and number of measures applied and a missing control of their ecological effectiveness constitute a significant source of uncertainty regarding the actual impact of the EPI. With regards to the potential transferability of the instrument, it is facilitated in countries where comparable remuneration systems for hydropower plants exist. In all other cases the introduction of the EPI will be linked to significant transaction costs.

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1 EPI Background

Germany's river water bodies are to a large extent subject to hydromorphological degradation. At present, only 10 % of the watercourses have a high or good ecological status (UBA, 2010b). A first evaluation of the German watercourse structure has been published in 2002. It indicates that only 21 % of the mapped water courses (about 33 000 km) are moderately changed or unchanged (LAWA, 2002). Next to uses like agriculture, navigation and flood protection this is due to hydropower use. Taking into account Germany's ambition to significantly increase the share of renewable energy in the future electricity production (see illustration box below), an important challenge consisted and still consists in reconciling the extension of hydropower use and its impact on nature conservation needs (BGBI, 2004; Naumann and Igel, 2005; BMU, 2010a).

Increasing importance of renewable energy sources in Germany
With regard to climate change considerations, the German government plans to expand its use of renewable energy sources. In 2010, the German Federal Environment Agency (UBA) stated that by "the year 2020, the contribution of renewable energies to electricity supply is to be increased to at least 30 % [...] and continuously increased thereafter" (UBA, 2010a). In addition to these objectives, the recent phasing out of nuclear electricity generation announced in May 30 2011 was accompanied by a plan to accelerate the phasing in of renewable sources of energy.
Hydropower is important for reaching these targets as it is nearly free of emissions, and due to its high level of efficiency as well as the possibility to produce electricity according to the demand while protecting the base load (UBA, 2010a; Naumann and Igel, 2005). However, although some extension in the electricity production by hydropower plants is envisaged and desired, the relative importance of it compared to other renewable energy sources will further decrease in the future, as its sustainable development potential has been already exploited to a considerable extent (BMU, 2008b).

Water management in Germany at the beginning of the 21st century has to be seen against the background of the European Water Framework Directive (WFD). As most river sections which are subject to hydropower use are classified as heavily modified water bodies according to the WFD, the environmental objective is to achieve a "good ecological potential"[1]. This includes both the need for structural changes (installation of fish ladders, smaller grill sizes) and modifications to operation (e.g. guaranteed flow rates during fish migration periods). Those changes are linked to profit losses for the operators of hydropower plants. As hydroelectric power stations

[1] For the sake of convenience, the term "good ecological potential" (GES) will be used in the following.

are provided with very long concession periods of several decades (or even unlimited rights), reaching the good ecological status (GES) soon will depend on the voluntary participation of operators as well as on effective incentives (UBA, 2010a).

In this context, the German Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EEG), which regulates the remuneration of electricity produced from renewable energy sources and fed into the public electricity grid, has been amended in July 2004 in order to provide economic incentives for hydropower plant operators to take ecological considerations into account. In particular, the amendment links the amount of payments for electricity to the amelioration of the ecological status of the water body part which is affected by hydropower use (Naumann and Igel, 2005).

More precisely, in its § 6, the EEG (2004) defines the conditions for remuneration which are either linked to reaching the GES or to substantially improving it compared to the previous status. The requirements depend on the capacity of the hydropower plants as well as on the year in which the permission to construct or to operate the plant has been obtained (see Annex I for more details). The conditions which have to be fulfilled are twofold. Hydropower plants up to and including 500 kW for example, which were licensed since 2008, have to be in accordance with some location bound requirements; in particular they have to (EEG, 2004):

- be "constructed in the spatial context of an existing barrage weir or dam which wholly or partially existed before or was newly built primarily for purposes other than the generation of electricity from hydropower" or

- operate without a complete weir coverage.

The second criterion is the improvement of the GES, in which the evaluation considers in particular the following aspects: biological continuity, minimum water flows, management of solids and reservoir management. For existing hydropower plants, these requirements can be met through a modernisation of the plant, whereas the decisive aspect lies in the improvement of the state of the water ecology and of the accompanying floodplain. This means that measures which are only targeting the ecology can be seen as a modernisation in the sense of the EEG (Naumann and Igel, 2005). This second criterion has been further specified in the EEG amendment of 2009 (see box below).

Specifications of the EEG amendment of EEG 2009
In the EEG amendment of 2009, the terms 'substantial improvement of the ecological status' are further defined by indicating that they need to refer to the following criteria (EEG, 2009):

- storage capacity and management,
- biological passability,
- minimum water flow,
- solids management, or
- bank structure,

or shallow water zones have to be established or abandoned channels or branches have to be connected, in so far as the measures in question are necessary individually or in combination, taking into account the relevant management goals, in order to achieve good ecological status.

In the case of hydropower plants up to 500 kW – the category which encompasses the highest number of plants operating in Germany – remuneration could increase of 2 cents/kWh to 9.67 cents/kWh according to the EEG 2004 (see Chapter 3.2 on tariff details). The EEG amendment has been accompanied with an operational guideline, in order to guarantee a nationwide consistent and transparent implementation (Naumann and Igel, 2005).

The evaluation of whether a substantial improvement in the ecological status has been reached is in the hand of the responsible water agency and has to be decided case by case. It has been recognized from the outset that this decision cannot be judicially controlled to the full extent. The evaluation takes place in the context of the mandatory approval procedure according to German water law. It has also been admitted in the beginning that the additional gain due to the EEG will often not be enough to finance all ecological improvement measures on existing hydropower plants. Therefore, the local conditions, the cost-benefit-ratio of a measure from an ecological and an economic point of view as well as the depreciation period of the plant have to be considered during the identification and determination of adequate ecological measures (Naumann and Igel, 2005).

As a mechanism of revision of the instrument, the German ministry of the environment (BMU) has to report regularly on the experiences made with the EEG. This includes in particular the ecological significance and the operational capability of the measures (Naumann and Igel, 2005). In addition to those reports on experiences, research projects have been launched recently to evaluate the impact of the instrument (e.g. Anderer et al., 2011 *in print*).

2 Characterisation of the case study area – Germany

The Federal Republic of Germany is located in the centre of Europe and has a size of about 357 100 km². More than four-fifths of its area is covered by forests or under agricultural use (30.1 % and 52.5 %, respectively). Settlements and traffic infrastructure occupy 13.2 % of the territory; whereas water accounts only for a small proportion of 2.4 % (see also Figure 2.1) (UBA, 2010a). Only 3.3% of the total agricultural area is equipped for irrigation (UBA, 2011a). In the last 20 years, in particular the surface of urban areas increased considerably, whereas the agricultural surface diminished (UBA, 2007a).

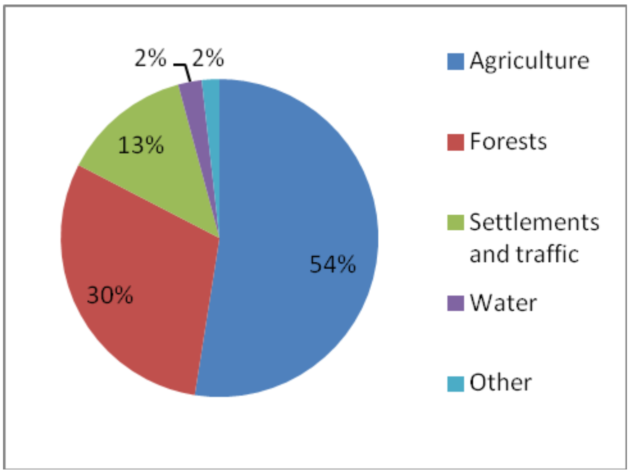

Figure 2.1 – Land use in Germany

Source: UBA, 2010a

In Germany, precipitation occurs at all times of the year, with an annual average of 789 mm. Most of the surface water bodies are fed by inflows from groundwater. Overall, the country has abundant groundwater supplies, although they are subject to varying availability and quality due to regional geographic characteristics (UBA, 2010a). Available water resources are being estimated at 188 billion m³ (UBA, 2011b).

Central water uses in Germany are drinking water supply, wastewater disposal, shipping, hydropower and flood protection (UBA, 2010a). The amount of water abstracted per source is shown in

Table 2.1 for three different years, being about 32 billion m³ in total in 2007. Abstraction both from groundwater and surface water decreased substantially in all sectors. Compared to 1991, reductions in water abstraction amount to more than 30 % in the past 20 years. Altogether, only less than 20 % of Germany's available water resources have been used in 2007 (UBA, 2010a and 2011b). The share of water used by the different sectors is shown in Figure 2.2. Public water supply is using only less than 3 % of the total available water resources.

Table 2.1 – Groundwater and surface water abstraction in Germany (in million m³)

Source of abstraction / Year	1998	2001	2007
Groundwater	6 710	6 204	5 825
Surface water	33 880	31 802	26 476

Source: Eurostat, 2010

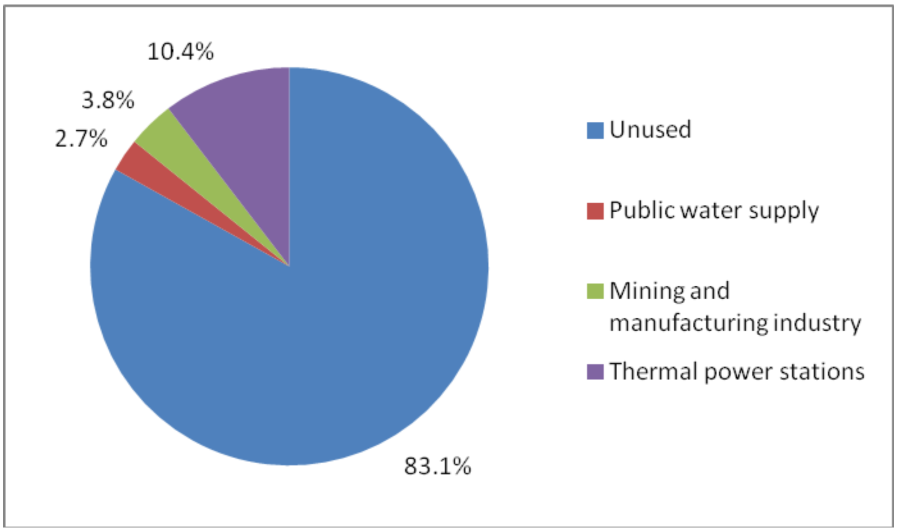

Figure 2.2 – Use of available water resources in Germany in 2007

Source: UBA, 2010a, adapted

Main pressures on water

The water management priorities for all German river basins are the following (UBA, 2010a):

- Reduction of discharges of nutrients and selected pollutants from diffuse and remaining point sources into surface waters and groundwater.
- Improvement of hydromorphological characteristics (e.g. the quality of the waterbed, bank reinforcement, water balance) in surface waters and recreation of biological continuity (for fish fauna in particular).

Structural degradations – which are amongst others linked to hydropower use – are – coupled with pollution through nutrients and pesticides – the principal reason why 90 % of the surface water bodies fail to meet the objective set by the European Water Framework Directive (WFD) in terms of species composition and frequency of occurrence of organisms (UBA, 2010a).

Currently, about 7 500 hydropower plants are operating in Germany. Of these, 402 are considered to be large plants – having a capacity higher than 1 MW. They generate together 93 % of Germany's electricity from hydropower (UBA, 2010a). Depending on the hydrological conditions in the different years, the share of hydropower in the total electricity generation in Germany varied between 3 and 5 %, being just under 21 000 GWh in the year 2008. More than 80 % of it is generated in the Central German Uplands in Bavaria and Baden-Wuerttemberg, being areas with high levels of precipitation. Among renewable energy sources, hydropower is at present the third most important (22 %) after wind power (44 %) and biomass (24 %) (UBA, 2010a). In 2010, 7 600 persons have been working in the hydropower sector (BMU, 2011a). Investments in hydropower in Germany amounted to 70 million EUR in 2009 whereas the economic turnover was 1 350 million EUR (BMU, 2011b).

Economic characterisation

In 2010, Germany accounted for about 81.8 million inhabitants (Eurostat, 2011), with 89 % of the population living in cities and urban agglomerations. Population density has been 230 inhabitants per km² in 2009, and is hence well above the European average of 116 people per km² (UBA, 2010a). With the biggest population and the highest GDP, Germany is the most important market of Europe and the fourth biggest economy in the world. In 2009, the total GDP was 2 397 million Euros, the GDP per capita 116 PPS[2] (EU-27 = 100; Eurostat, 2011). The share of the most important sectors in the total GDP is illustrated in Figure 2.3.

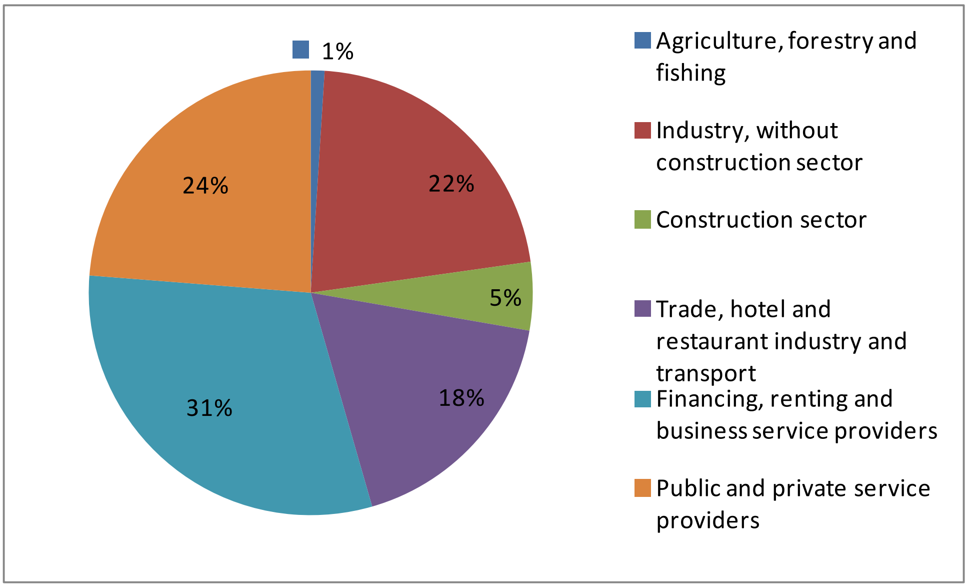

Figure 2.3 – Share of the economic sectors in the German GDP in 2009

Source: Statistisches Bundesamt, 2010, adapted

[2] PPS : Purchasing power standard

Water relevant developments in the past

After the Second World War, water conservation all over Germany was unable to manage all the challenges entailed by the rapidly growing industrial activity. Until the late 1960s and the early 1970s, water pollution had increased to a critical level. West-Germany, which was economically more dynamic, introduced quite early effective measures (e.g. construction of numerous sewage plants), which in particular improved pollution caused by the industrial sector. After the German reunification in 1990, one major task was to raise the Eastern German Länder to the same level of environmental protection. An integrative approach to inland water management constitutes nowadays a fundamental policy in Germany, and predating the implementation of the EPI. This relies basically on two pieces of legislation: the European Water Framework Directive, and the German Federal Water Act (UBA, 2010a).

3 Assessment Criteria

3.1 Environmental outcomes

When looking at the environmental impact of the EEG favouring ecologically friendly hydropower plants, two different aspects are worth considering. In the first place, with a remuneration paid per kWh, the EEG provides incentives for investments in an extended production capacity or the construction of new hydropower plants. Thereby, the EPI has an effect in terms of reducing the emission of greenhouse gases by promoting the use of renewable energy sources. In the year 2010, for example, electricity generated by hydropower was responsible for about a quarter of all CO_2 emissions avoided through the use of renewable energy sources in Germany (BMU, 2011b; see Figure 3.1), by replacing in particular brown coal (BMU, 2007)[3]. At the same time – and this will be the focus of the following considerations – the conditions defined by the EEG aim at improving the hydromorphological situation of water bodies next to existing hydropower plants by providing incentives for voluntary or early adaptation of the plant structure and/or operation. The main environmental impacts of hydropower plants are described in the illustration box below.

[3] It is estimated that about half of the emission reductions of CO_2 can be attributed to the EEG. The other half stems from renewable energy sources remunerated independently of the EEG (BMU, 2007).

Main impacts of hydropower plants
Hydropower plants impact the structure and function of water-dependent ecosystems associated to them principally by interrupting the biological passability of watercourses, and by causing direct damage to organisms as a result of turbine operation, as well as at power plant grills in the case of downstream migration (UBA, 2010a). Also the abstraction of water disturbs the river ecosystems significantly (Knödler and Wotke, 2009). UBA (2010a) specifies furthermore that "where several plants exist in sequence, this damage has a cumulative effect, placing fish populations at risk. Atypically low flow speeds occur in the weirs used for hydropower (...), leading to sludge accumulation, a lack of oxygen, and the conversion of typical watercourse biocoenoses to degraded lake biocoenoses. Dyke construction and uniformly high or unnaturally fluctuating water levels lead to a loss of contact with watermeadows, and the water balance is disturbed. Sedimentation leads to the reabsorption of bed material as a result of erosion and deepening below the

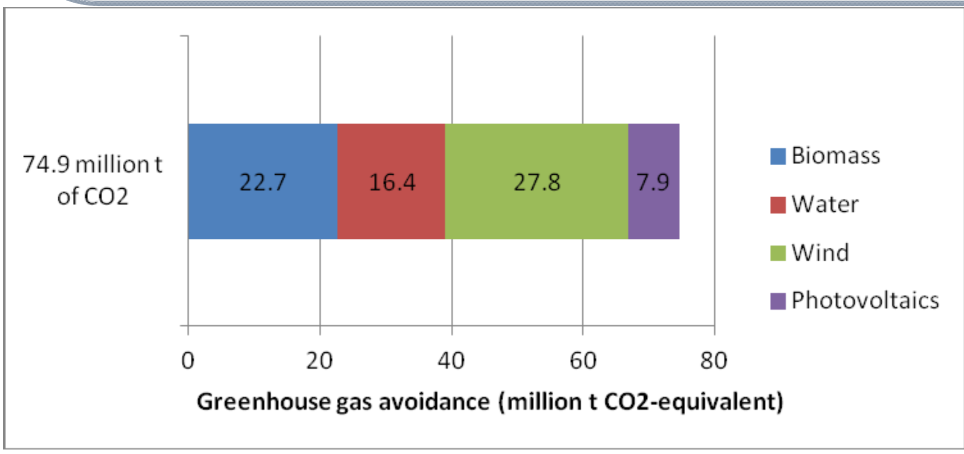

Figure 3.1 – Avoided CO_2 emissions due to electricity production through renewable energy sources in 2010

Source: BMU, 2011b, adapted

Note: Difference of sums due to roundings.

Naumann (2011) emphasises, that the following criteria are the most relevant for the removal of ecological deficits: establishing the biological passability upstream, ensuring a sufficient fish protection downstream, and providing the ecological minimum flow. Those measures form therefore rightly part of the EEG conditions foreseen for hydropower plants (see Chapter 1).

Changes in hydropower use
The legislation on the sale of electricity to the grid (StrEG) from 1990, which has been replaced by the EEG in the year 2000, stimulated the operation of small hydropower plants (SHPs) and has prevented its impending decline (BMU, 2010a). In the year 2007, the predominant part of the electricity generated stemmed from big plants which were not remunerated according to the EEG (BMU, 2008a). In terms of num-

bers of plants, from the 7 500 existing ones 6 925 have been remunerated according to the EEG in 2009[4] (Table 3.1).

Table 3.1 – Number of hydropower plants remunerated according to the EEG (2007-2009)

Year	2007	2008	2009
Hydropower plants remunerated according to the EEG	6594	6 645	6 925

Source: Anderer et al., 2011 *in print*

The amendments of the EEG in 2004 and 2009 which introduced the ecologically bound fees for hydropower plants have also successfully provided incentives for the construction or extension of plants with a capacity above 5 MW (see box below).

Induced developments regarding big hydropower plants
According to the BMU (2010a), the EEG 2004 and 2009 pushed in particular the development of the following four big hydropower projects, complying with the ecological requirements:

- The extension of the hydropower station Albbruck-Dogern in 2009 by 24 MW (107.4 MW),
- the new construction of the power station Rheinfelden (100 MW, official start of operation in September 2011) (Energie-Chronik, 2011),
- the new construction of a hydropower plant on the Weser (10 MW, start of operation 2011-2012),
- the extension of the French-German power station Iffezheim on the Rhine by 38 MW (146 MW, start of operation in 2012).

[4] It is important to emphasise that this number alone does not allow any conclusion on the degree of ecological adaptation of the plants, as this includes also plants which have been remunerated according to the EEG before the amendment in 2004 or which have a production capacity of less than 500 MW and which have been approved or started operation between 01/08/2004 and the 31/12/2007 and which therefore receive the EEG 2004 remuneration without fulfilling the ecological requirements (see Annex I).

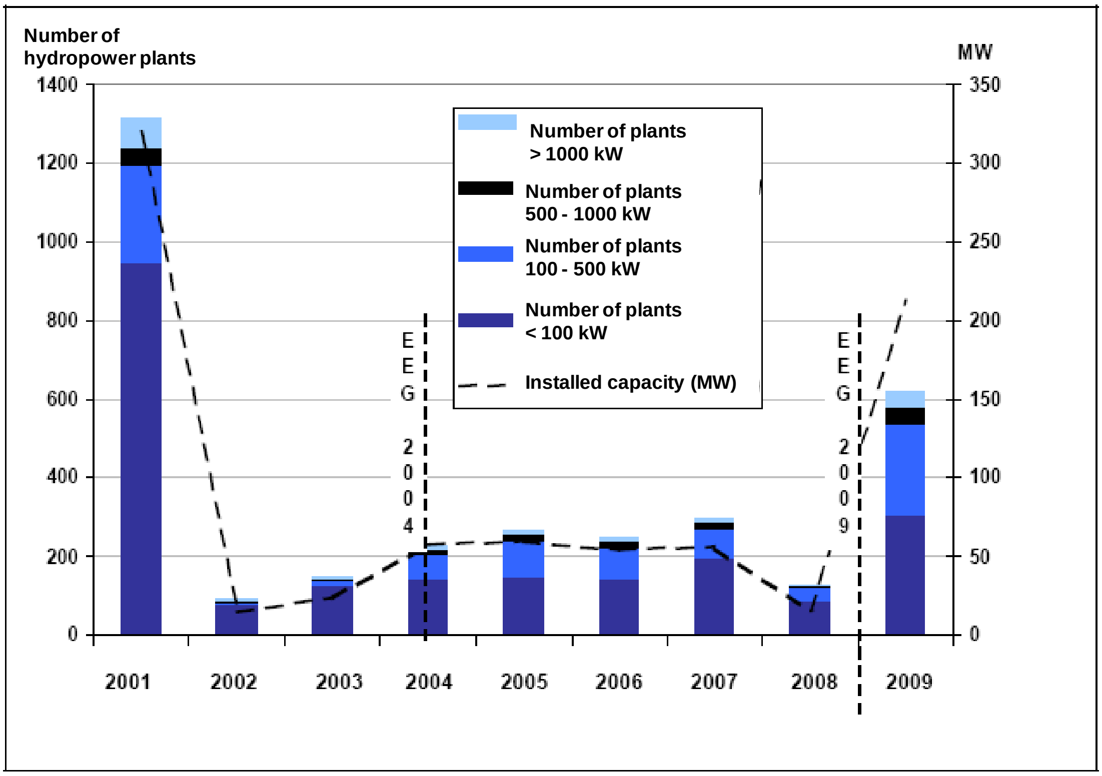

Figure 3.2 – Development of hydropower plants, number of plants differentiated according to installed capacity and starting year of operation

Source: Dumont and Keuneke, 2011, adapted and translated by the author

In the year 2009, a relatively high number of plants has been modernised or new constructed (see Figure 3.2 and Figure 3.3, Dumont and Keuneke, 2011). This can be explained by the fact that operators waited for the more attractive remuneration conditions of the EEG 2009 to come into effect. It can furthermore be expected that the predominant majority of the 78 new constructions of hydropower plants in 2009 took place on already existing hydropower sites. According to Dumont and Keuneke (2011), most of those works are probably modernisations, which have been classified as new constructions due to the high investments. In those cases, the EPI gave an incentive to accelerate the adaptation of the plants to recent regulations – which ask to comply with the WFD requirements – by making new approvals necessary[5].

[5] Please note that a difference can be made regarding the incentive effect of the EPI. In cases where new hydropower plants are built to replace stations which were at the end of their concession period or at the end of their economic lifetime, the incentive effect of the EPI is primarily leading to increased electricity production, with environmental standards being fulfilled according to regulation. The same applies to the rare case of constructions on new sites.

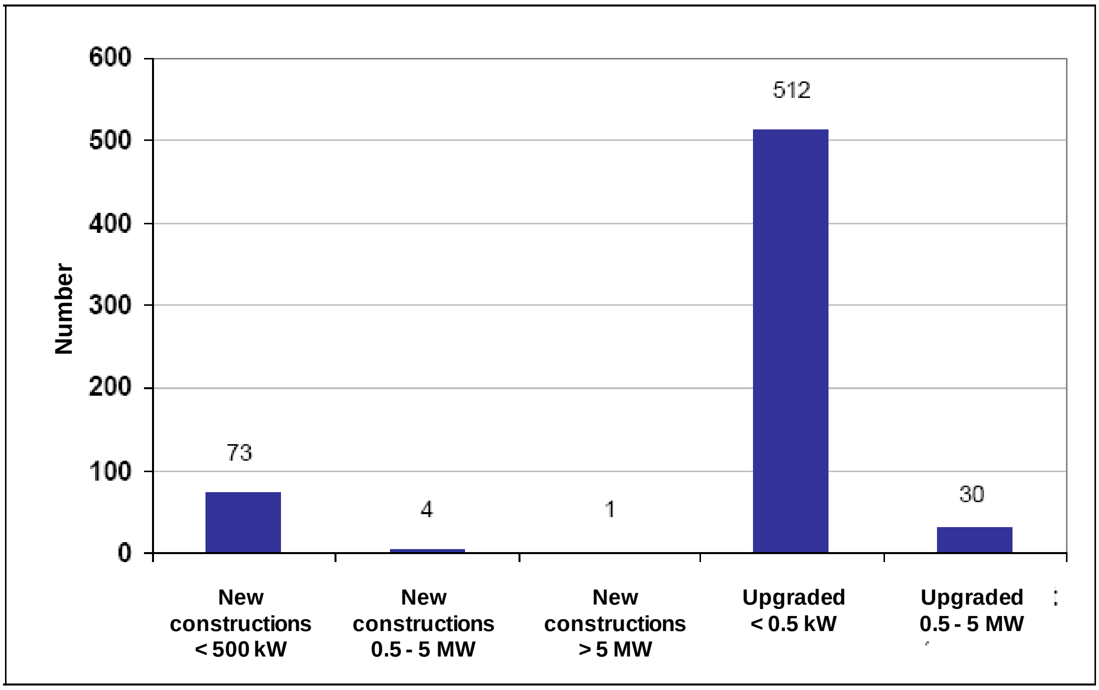

Figure 3.3 – Number of new constructions or upgraded plants in 2009 according to production capacity classes

Source: Dumont and Keuneke, 2011, translated by the author

Changes in pressures and impacts

The main pressure exerted by hydropower use is linked to its dam constructions (see for example Dumont, 2005). In Germany, about 55 000 transverse structures are documented, and it can be expected that all hydropower plants are installed next to one of them (BMU, 2008b). Improvements of their biological passability are possible and have taken place on part of the plants for example in the form of fish ladders, in particular for the upstream migration process (BMU, 2008b). Anderer et al. (2011 *in print*) try to provide a comprehensive indication on the number and type of ecological measures applied to hydropower plants which have been induced by the EEG amendments. They indicate that about 10 % of the existing hydropower plants possess an equipment which assists the upstream migration of fishes and / or provide minimum water flow conditions. Figure 3.4 shows the relative importance of the different measures applied, and illustrates that a great part of them have been applied in order to benefit from increased remuneration of the EEG.

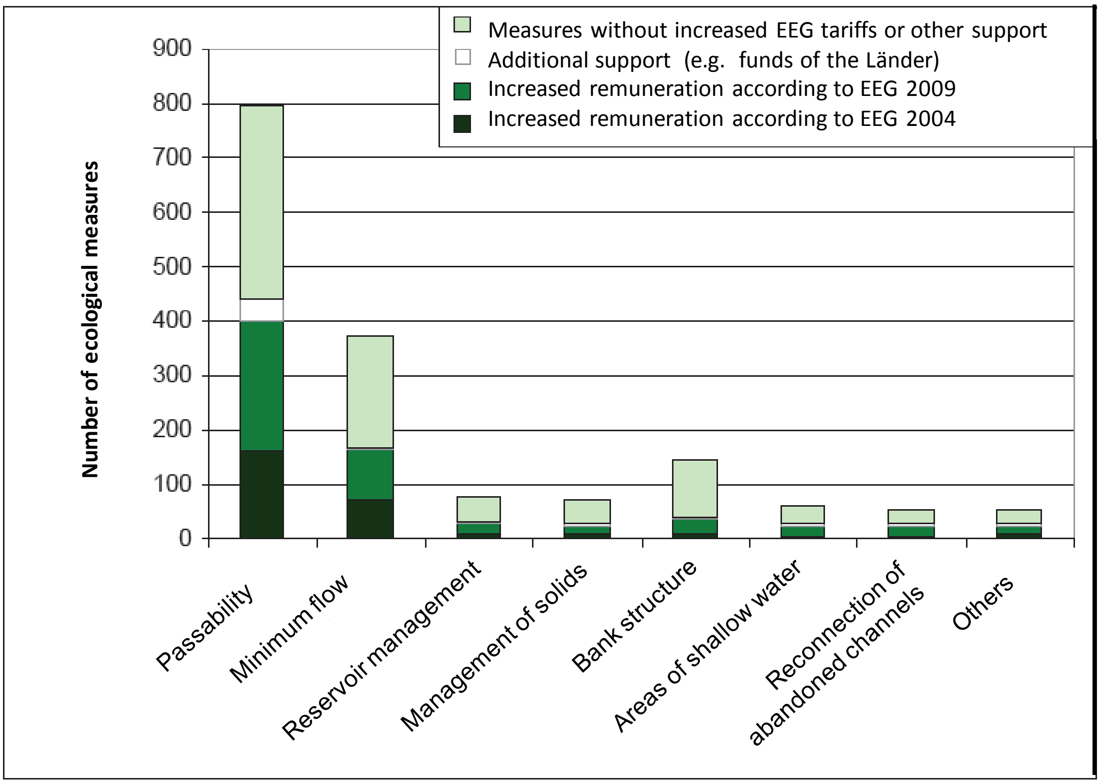

Figure 3.4 – Support to ecological measures on hydropower plants according to the seven measures of the EEG 2009

Source: Anderer et al., 2011 *in print*, translated by the author

Note: The data is coming from a survey targeted to all German hydropower plant operators. The figures summarise the returned answers of 859 plants (15 % of the total).

The concrete improvements of two of the big hydropower plants mentioned above (Albbruck-Dogern and Rheinfelden, both on the river Rhine) are illustrated in UBA (2008). The situation before and after the implementation of the measures is presented in Table 3.2.

Table 3.2 Changes in impacts due to the implementation of ecological measures on two big hydropower plants

Characterisation element	Hydropower plant Albbruck-Dogern	Hydropower plant Rheinfelden
	Situation before (re)construction of the plant	
Impact / ecological deficiency	- Insufficient residual water flow (3-8 m³/s) due to the diversion section for the existing power plant "Albbruck Dogern" - Interrupted continuum by river weir - Interrupted fish migration	- Impaired continuity - Loss of a part of specific riverine habitats

Characterisation element	Hydropower plant Albbruck-Dogern	Hydropower plant Rheinfelden
	- Low fish population - Low population of aquatic fauna	
	Actions taken	
Ecological measures applied	- Immediate increase of the residual water flow: 3.8 m^3/s to 40 m^3/s; from the 1st January 2008 up to 70-100 m^3/s - Creation of a nature like fish ladder with collection gallery, renaturing of former gravel islands, upvaluation of a bird-island - New weir-power plant extension uses in operation a water flow of min. 200 m^3/s - Implementation of the ecological measures until 2012	- Natural-like bypass channel with spawning possibilities and comprehensive gravel structures over a length of about 900 m - Construction of a pool fish pass with rough bottom (close to the natural structure of the so-called "Gwild" - Vertical slot fish pass to allow the circumvention of the new machine house - Maintenance of an adequate flow in the rest of the "Gwild" - Removal of bank reinforcement and gravel fillings over a length of 700 m up- and down-stream of the new hydropower plant - Structures like groynes, deadwood, hatcheries for the fauna which accompanies the river up- and downstream of the new hydropower plant
Costs of the measures	4 million EUR	High costs for the ecological measures (about 10 million EUR), especially for the construction of the bypass channel and the fish passes.
	After (re)construction of the plant	
Hydromorphological improvements	- Improvement of the connection of the sidewater Alb to the Rhine - Creation of a nature like bed structure in the diversion with gravelbars	- The structures create rest areas for the fish fauna and working surface for the natural erosion. Furthermore, they secure the change between dry and wet stages in the "Gwild". - The bypass channel creates a river-like, new habitat with gravel structures and different flow conditions.
Ecological improvements	- Improvement of the ecological conditions in the whole area of the river diversion and in the river course under the weir - Improvement of the ecological diversity of the shoreline	- Improvements for fishes through creation of new spawning and resting areas as well as the improvement of passability of the weir - Creation of rest and protection zones as well as hatcheries for the fauna which accompanies the river, especially birds, insects and bats - The permanent removal of the bank reinforcement restores the natural situation of the river Rhine bank and readmits natural erosion processes. - The creation of spawning, rest and protection areas upgrades the otherwise urban industrial bank zones and provides new habitats. Especially the bypass channel constitutes a significant ecological im-

Characterisation element	Hydropower plant Albbruck-Dogern	Hydropower plant Rheinfelden
		provement.

Source: UBA, 2008, adapted

Changes in status

The hydromorphological quality elements which determine the status of water bodies are the "hydrological regime", "river continuity" and "morphology". Hydromorphological deteriorations influence the water bodies' ecological status by affecting the occurrence and composition of site-typical biological communities (UBA, 2010b). Although substantially improving the status of water bodies is a precondition for receiving the increased EEG remuneration, no study is available which investigates comprehensively the real ecological functionality of the measures applied. Hence, no statement on the actual status improvement induced by the EEG can be made (Naumann, 2011 *pers. comm.*). Some investigations carried out in recent times indicate, however, that the actual status improvement is questionable in a significant number of cases (see illustration box below).

Evaluation of the effectiveness of ecological measures for selected hydropower plant installations

As data availability does not allow for a comprehensive evaluation of the effectiveness of the ecological improvement measures which led to higher remuneration according to the EEG, the analysis of selected cases has taken place as part of different studies (Anderer et al. 2011 *in print*; Dumont and Keuneke 2011; BfN 2009 *unpublished*, cited in Dumont and Keuneke 2011).

Anderer et al. (2011 *in print*) examined exemplarily 16 hydropower plants for the criteria upstream passability and minimum flow which were admitted to the increased remuneration according to the EEG. They state that only four of the investigated plants have actually reached good status, with regards to the two criteria examined.

Another study (BfN 2009 *unpublished*, cited in Dumont and Keuneke 2011) selected 10 hydropower installations which received a higher remuneration according to the EEG 2004. They found out that in four cases the biological upstream passability was not given, although the establishment of fish pass has been the modernisation measure which led to the increased remuneration in two of the cases. In the remaining six cases, the upstream passability was either moderately or considerably limited. The downstream passability is given in six of the sites, amongst others due to the implemented measures. In two of the cases, the downstream passability is interrupted, or migrating fishes get badly injured. It is mentioned that the partly bad evaluation of the measures is due to failures in the implementation of details, which could have been avoided through better planning.

Dumont and Keuneke (2011) present also a list of statements from the responsible water authorities which indicate their knowledge of cases where the implementation of inefficient measures led to the admission to higher EEG remuneration. This was linked for example to the approval of measures through environmental verifiers (instead of the water authority) or the non-compliance in practice with special requirements formulated at the moment of approval.

Impact on ecosystem goods and services

The EEG measures impact the hydromorphological situation and as well as the hydrological conditions of the river influenced by the hydropower plant. This has necessarily an effect on the ecosystem goods and services provided by the water body and might include changes for example in terms of aesthetics of the site, impact on angling activities through facilitating fish migration or water related recreational activities due to the changes in the water flow regime. The only evidence on a change in services measured, however, is linked to the hydropower generation itself. As the favourable remuneration makes the extension or the new construction of hydropower plants economically feasible, they increase the economic benefit which can be derived from the water course. At the same time, the required support of minimum water flow necessarily leads to a reduced hydropower generation. Although no overall assessment could be identified, some evidence can be found through a pilot project undertaken by Knödler and Wotke (2009). Their results indicate that the implementation of the minimum flow requirements on existing SHPs would lead to an average reduction of electricity production of 25 %.

3.2 Economic Assessment Criteria

As the ecological requirements for hydropower plants have been included in the existing subsidy scheme of the EEG, it can be expected that the introduction of the EPI was not linked to disproportionate costs. However, as no evidence could be found on a particular process which led to the selection of the EPI, no definitive statement can be made on whether it represents the least cost alternative. With regards to the costs of the ecological improvement measures which render eligible for the increased EEG remuneration, it is foreseen that responsible local authorities ensure that the corresponding investments are reasonable with regards to the additional receipts provided by the EEG (Naumann and Igel, 2005; Dumont, 2005).
Furthermore, no command-and-control mechanism has been replaced by the EPI. Potential alternatives to the instrument chosen could have been for example direct subsidies to ecologically friendly investments on hydropower plants or the introduction of an eco-labelling scheme, but no cost-effectiveness analysis has been carried out. The EPI chosen has, however, the great advantage of favouring both ecologically friendly practices and of providing incentives to increase hydropower production activities. The amendments made on the EEG are furthermore not linked to negative effects for hydropower operators compared to the previous situation, as the status quo is conserved for plants which received remuneration from the EEG before.

Distributional effects
Distributional effects of the EPI can mainly be seen within the hydropower sector, through the different provisions of hydropower plants according to their size. The different remuneration rates take into account that, in general, smaller plants have to deal with proportionally higher costs for their efforts to comply with ecological minimum standards as bigger plants. This has an impact on the economic efficiency of the SHPs, which is often already characterized by higher electricity production costs (Nitsch et al., 2004).

The costs of the EEG implementation are paid by the electricity consumers (see Chapter 3.3). In 2004, EEG remunerations paid for hydropower electricity amounted to 366.6 million EUR (BMU, 2007).

Effects on risk
Once the ecological improvement of the plants approved and the higher remuneration accorded, it is guaranteed for a period of 30 years for plants up to 5 MW according to the EEG amendment of 2004 (20 years since the EEG 2009). The EPI provides hence for investment security, taking the importance of the investments and the long depreciation periods of the hydropower stations into account. It would have been

difficult to provide this risk reduction for the operators through another instrument, like e.g. certification schemes.

Cost recovery effects

As the higher electricity remuneration is paid by the electricity consumers, costs are recovered from the users. In fact, the financing of the ecological measures for hydropower plants can be seen as a way of internalizing the external costs of the plants. The cost recovery is possible in a much more direct way through the electricity tariffs as it would have been the case for example through state subsidies to investments – which are indirectly paid by the tax payer. The question of whether the revenues of the EPI are earmarked or not is not relevant in this case. The tariffs finance the ecological investments with retrospective effect.

Evaluation of the incentive effect

An essential factor for the success of the instrument is given by the comparison between the surplus provided by the EEG and the corresponding investments (Naumann and Igel, 2005).

When looking at the amendment in 2004, operators which were already remunerated according to the EEG 2000 with 7.67 ct/kWh had the possibility to receive 9.67 ct/kWh if they fulfilled the ecological criteria. In order to be economically viable, necessary investments needed to be refundable by the difference of 2 ct/kWh. The scope for investments is all the more restricted the smaller the hydropower plant capacity is, as less electricity is generated and hence less remuneration received. Dumont (2005) stresses the fact that – depending on the size of the hydropower production – only limited measures can be financed through the higher revenues. He indicates furthermore, that a measure can be considered reasonable only if there remains a financial surplus to the investor, as otherwise there is no incentive for him to carry out the adaptations.

The comparison of the remuneration levels given in **Errore. L'autoriferimento non è valido per un segnalibro.** shows that the amendment of the EEG from 2009 significantly raised the tariff rates for hydropower plants up to 5 MW. This provides higher incentives for financing ecological improvement measures (BMU, 2008b), but has also to be seen against the background that the guaranteed remuneration period has been reduced at the same time from 30 to 20 years (Knödler and Wotke, 2009). Dumont and Keuneke (2011) calculated specific ecological modernisation costs and compared them to the average increase in remuneration according to the EEG 2009 (as compared to the remuneration of the EEG in 2000). As shown in Table 3.4 the remuneration level is in particular not high enough to cover investments for SHPs up to an installed production of 100 kW. However, existing SHPs, which are not yet modernised in accordance with the provisions of the EEG, have often significant ecological deficits (Knödler and Wotke, 2009; Deutsche Umwelthilfe, 2006).

Table 3.3 shows the electricity remuneration for hydropower plants given in the EEG amendments of 2004 and 2009. According to investigations of the BMU, investment costs per additional kW production capacity are in general the same for new constructions or extensions of existing ones, giving reason for the same tariff level (BGBl, 2004). As specific investment costs of SHPs are in principal higher than for bigger plants, the EEG differentiates remuneration according to the installed capacity (BMU, 2008b).

When looking at the amendment in 2004, operators which were already remunerated according to the EEG 2000 with 7.67 ct/kWh had the possibility to receive 9.67 ct/kWh if they fulfilled the ecological criteria. In order to be economically viable, necessary investments needed to be refundable by the difference of 2 ct/kWh. The scope for investments is all the more restricted the smaller the hydropower plant capacity is, as less electricity is generated and hence less remuneration received. Dumont (2005) stresses the fact that – depending on the size of the hydropower production – only limited measures can be financed through the higher revenues. He indicates furthermore, that a measure can be considered reasonable only if there remains a financial surplus to the investor, as otherwise there is no incentive for him to carry out the adaptations.

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Table 3.3 - Remuneration rates of hydropower plants according to the EEG in 2004 and its amendment in 2009 in EUR cents/kWh

Plants up to and including 5 MW – New plants; share in production capacity	EEG 2004	EEG 2009
Up to 500 kW	9.67	12.67
500 kW to 2 MW	6.65	8.65
2 MW to 5 MW	6.65	7.65
Plants up to and including 5 MW – modernised, revitalised plants; share in production capacity	EEG 2004	EEG 2009
Up to 500 kW	9.67	11.67

6 This is valid only for plants up to 5 MW. For plants above this production capacity, the remuneration period remained 15 years (BMU, 2008c).

500 kW to 2 MW	6.65	8.65
2 MW to 5 MW	6.65	8.65
Modernisation of plants over 5 MW – increase of capacity	EEG 2004[7]	EEG 2009
Up to 500 kW	7.29	7.29
Up to 10 MW	6.32	6.32
Up to 20 MW	5.80	5.80
Up to 50 MW	4.34	4.34
Over 50 MW	3.50	4.34

Source: Knödler and Wotke, 2009; BMU, 2008c, adapted

Table 3.4 – Specific costs for the modernisation of hydropower plants up to and including 5 MW

Installed capacity	Specific measure costs ct/kWh	Average increase in remuneration ct/kWh
100 kW	3.94 - 5.73	4.00
500 kW	2.06 - 2.57	4.00
1 MW	1.59 - 2.23	3.75 - 4.00
2 MW	1.15 - 1.58	2.83 - 3.02
5 MW	0.83 - 1.13	2.32 - 2.39

Source: Dumont and Keuneke, 2011, translated by the author

Furthermore, several sources indicate that ecological improvements are often technically possible, but that the investments are too high to be affordable for the operators (BMU, 2008b; Knödler and Wotke, 2009). Some more background information on the definition of the remuneration level is given in the box below.

Establishing the remuneration level

Naumann (2011 *pers. comm.*) indicates that the remuneration rates of the EEG amendments are fixed under consideration of the electricity production costs. The actual level is, however, not necessarily corresponding to those costs due to two reasons:

a) The life span of hydropower plants lies often between 80 and 100 years. The EEG remuneration, though, is limited to a time span of currently 20 years and is not intended to cover all electricity production costs in this time span.

b) The remuneration necessary to make investments viable for SHPs is too high and not acceptable (Naumann, 2011 *pers. comm.*). This is asserted by Ammermann (2011), which indicates that the remuneration needed to finance the ecological improvement of hydropower plants with a production capacity smaller 250 kW is in average 38 ct/kWh.

No evidence on the importance of asymmetric information could be identified.

[7] The remuneration for plants with a production capacity of over 5 MW depends on the year in which it started operation. The tariffs given here are applicable for plants which started operation in 2009 (BMU, 2004).

3.3 Distributional Effects and Social Equity

When looking at the wider impacts of the EPI, the main stakeholder groups affected are the operators of hydropower plants, electricity consumers as well as the local community living next to the installations. The focus of this chapter will lie on hydropower plant operators, but some considerations will first be presented on electricity consumers.

As electricity produced with renewable sources and remunerated according to the EEG is in average (still) more costly than electricity stemming from fossil or nuclear sources, electricity consumers see their material living standard affected by the EPI through the higher prices they have to pay per kWh[8] (Bundeskabinett, 2002; BMU, 2011b). The impact of the promotion of renewable energy sources on the electricity price is shown in Figure 3.5 for the years 2000 to 2010 (Kluge, 2009; BMU, 2011b). As can be seen, the EEG apportionment for the years 2008 and 2009 was 1.1 ct/kWh and 1.3 ct/kWh, respectively, representing about 5 % of the total price per kWh. In 2010, consumers paid 2.3 ct/kWh in addition due to the EEG (BMU, 2011b), and 3.5 ct/kWh in 2011 (EEG/KWK-G, 2011). As a general rule, entities which are high energy consumers are more affected by the higher prices. Several energy intensive industries, however, are exempted and allowed for lower prices (BMU, 2007 & 2011b). The link between the add-on of electricity prices and the specific contribution of the higher costs due to the ecological requirements for hydropower plants remains unclear, as the EEG related extra costs are going back to expenses for all type of renewable energy sources.

[8] The apportionment of the higher electricity production costs to the end consumers is following a certain methodology which will not be further detailed at this point. For more information, see for example IfNE (2011).

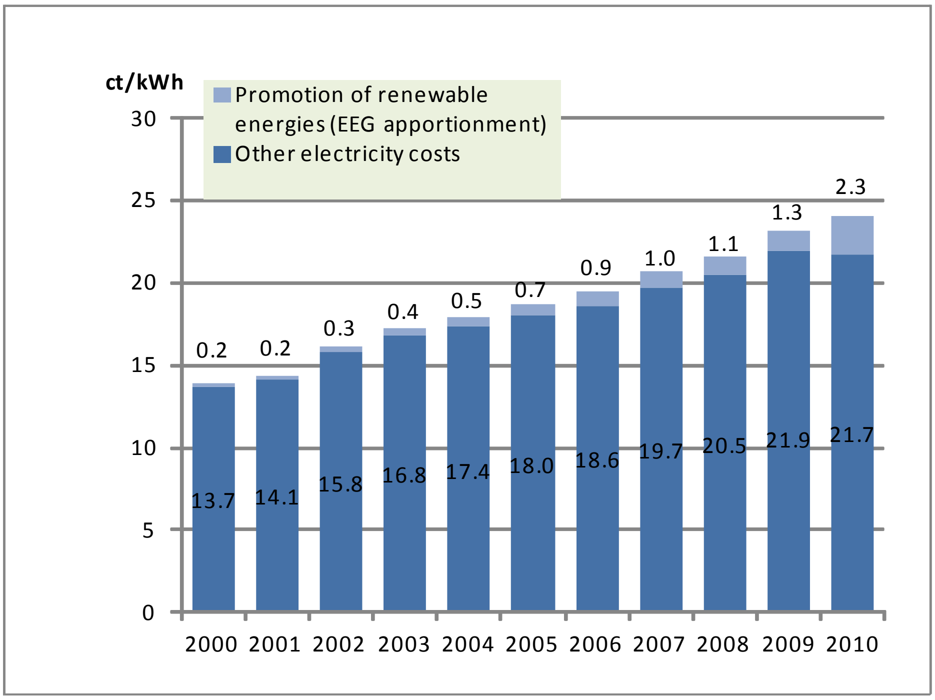

Figure 3.5 – Development of household electricity prices showing the share of the EEG apportionment

Source: BDEW 2009, in Kluge, 2009, and BMU 2011b for the years 2009 and 2010, adapted

With regards to wider impacts on the local community, some more investigations are necessary. In the context of this case study, only the report of Bouscasse et al. (2010) could be identified, which shows that the wider population of a hydrographic basin obtains environmental benefits from hydromorphological improvements on rivers which enhance the development of fish populations.

Wider impacts on hydropower plant operators

As the EEG is based on voluntary participation, operators will only choose to meet the ecological requirements when they are linked to financial gains in the long-term through the EEG remuneration. An increase in material living standards due to increased revenues can be expected. Uphoff[9] (2011 *pers. comm.*) notes, that this is hardly the case for SHPs, as the surplus provided by the EEG is offset completely by the investments.

No direct impact concerning education could be detected. But the EEG requirements have encouraged hydropower plant operators to think about potential improvements of their plants (Uphoff, 2011 *pers. comm.*). With regards to employment in the sector,

[9] Harald Uphoff is since 2008 the leading office manager of the German Federal Association of Hydropower Plants (BDW).

figures have been slightly decreasing in the last years (see Figure 3.6 below). This is due to an annual increase in labour productivity (Lehr et al., 2011; O'Sullivan et al., 2011), and no evidence is available on any influence of the ecological criteria of the EEG[10].

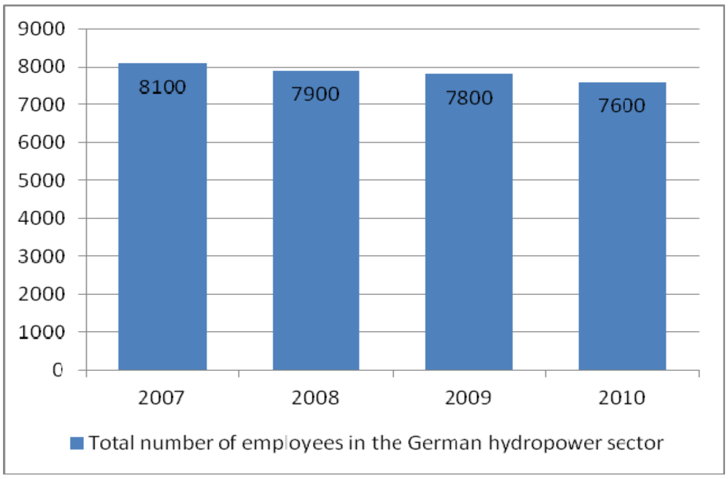

Figure 3.6 – Number of employees in the German hydropower sector from 2007 to 2010

Source: BMU, 2011a and 2011b, adapted

Although the ecological requirements of the EEG are changing the environment next to hydropower plants, operators are often not in the position to assess whether actual improvements have taken place, as for example fish migration is difficult to perceive (Uphoff, 2011 *pers. comm.*).

Concerning the political voice of the hydropower operators, it has been heard through the legal processes of the law amendments and personal exchanges on technical design issues. It is, however, very difficult to estimate whether the stakeholders have a weaker or greater say through the implementation of the EPI (Uphoff, 2011 *pers. comm.*).

Regarding security aspects, the practical list of potential ecological measures provided in the EEG amendment of 2009 gave some more security to the hydropower plant operators which found it easier to understand what was expected from them[11].

[10] With regards to employment, the ecological requirements might actually have some effect on two other sectors, the one of planning agencies and building companies which implement the measures. This aspect has, however, not been further investigated.

[11] In the most recent EEG amendment which will take into effect the 1st January 2012, the ecological requirements make a direct link to the German Water Law (WHG), indicating that the WFD river basin management plans have to be implemented in order to be eligible to the increased EEG remuneration. This entails again more uncertainty aspects for the operators. A transitory period, during which remuneration can be received according to the EEG 2009 criteria is foreseen until 2014.

Another specific aspect increased insecurity. The EEG 2009 introduced the possibility that environmental verifiers instead of water agencies can certify the ecological measures applied. Some improper practices of auditors have led to increased EEG remuneration but entailed doubts on the legal certainty of expert's report (Uphoff, 2011 *pers. comm.*).

With regards to social relationships, it is interesting to note that the EPI had no effect on the existing conflict between hydropower operators on the one hand, and nature conservation and fishery associations on the other, as the latter doubt the effectiveness of the measures applied (Uphoff, 2011 *pers. comm.*).

The EPI has no discernible impact on health and personal activities.

3.4 Institutions

The most embedded institutions relevant for the EPI are given by the existing hydropower plants landscape. The hydropower sector in Germany has a long tradition and is well established (Lehr et al., 2011). The plants are endowed with very long concession periods (up to 100 years or unlimited in case of "old rights"; Naumann, 2011 *pers. comm.*) or even unconditioned user rights (Bunge et al., 2001)[12]. Figure 3.7 illustrates the existing concession periods by indicating the theoretical reduction of production capacity through expiring licences. Concessions for about half of the installed capacity are expiring in the next twenty years (Anderer et al., 2011 *in print*). The long duration accounts for the high investments and the long amortization periods. Also the high share of hydropower plants which are considered as small (7 100 out of 7 500) form a relevant part of the embedded institutions. The SHPs are mainly relying on old infrastructure and are often part of family tradition. Economic objectives are not necessarily the principal reason for their operation. SHPs are particularly relevant from an ecological point of view as they are often situated on little modified rivers (Clearingstelle, 2011).

[12] The current legislation foresees concession periods which are in general not longer than 30 years (Anderer et al., 2011 *in print*).

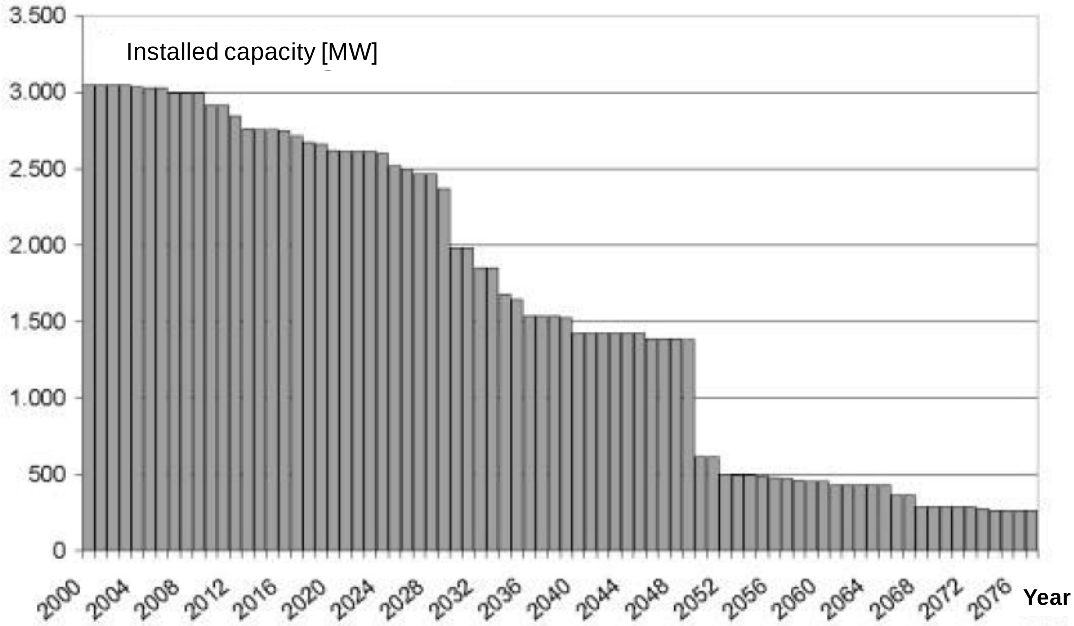

Figure 3.7 – Cumulated reduction of production capacity of hydropower plants due to expiring concessions according to water law

Source: VDEW 2001, in Anderer et al., 2011 *in print*, adapted

Other relevant institutions, which can evolve in the context of several decades or years, are representing the political context and existing administrative procedures, in which the EPI is embedded. The very important basis of the EPI is given by the EEG, which has been adopted in the year 2000 (as an amendment of the former Act on the Sale of Electricity to the Grid (StrEG)). The main aim of the EEG is to promote the use of renewable energy sources by providing the framework for a guaranteed remuneration paid for the electricity produced. The EEG represents an important piece of the German strategy to expand the use of renewable energy sources (Bundeskabinett, 2002; BMU, 2007). The EEG created also a new institution in the form of a clearing house (Bundeskabinett, 2002). It is meant to function as a contact point in case of disputes and ambiguities linked to the implementation of the EEG and foresees several mechanisms to contribute to rapid and unbureaucratic solutions (RELAW, *after* 2009).

The second important policy which triggered essentially the elaboration of the ecologically bound remuneration system for hydropower plants is the WFD, with its objective to reach the good ecological status of all water bodies. The ecological requirements set for hydropower plants are directly referring to the WFD. The Directive has been translated into the German legislation through the Federal Water Resources Law (WHG, last complete amendment in 2009). The latter provides also – together with the water laws of the German Länder – the basis for the approval procedure for hydropower plants – which include the approval of the ecological measures according to the EEG (Anderer et al., 2011 *in print*). As an informal but persisting institution, also the existing conflict between nature conservationists and the supporters of hydroelectricity is relevant to mention.

At a more rapidly changing level of institutions, the studies which investigate the interrelationship between hydropower use and its impact on ecology play an important role. This is in particular the case for the report on experiences of the EEG, which is elaborated on a regular basis and which provides the essential source of information for the law amendments.

The most fluctuating exogenous influence on the EPI is given by the electricity prices paid for hydropower on the free market. Hydropower operators – once qualified for receiving remuneration according to the EEG – can choose on a monthly basis between the remuneration according to the EEG and the free market.

Effects of institutions on design, implementation and operation of the EPI
In the design phase of the EPI, existing institutions played a preeminent role. While little evidence is available in the literature, interviews revealed that the essential initiative for the instrument in its current design is going back to discussions between different parts of the Bundestag at that time which were either supporting the extension of hydropower use for the production of renewable energies or advocating nature conservation (Uphoff, 2011 *pers. comm.*; Naumann, 2011 *pers. comm.*). The resulting compromise was to provide hydropower operators with higher remuneration rates, while requiring efforts to increase their environmental sustainability, as it can be found in the EEG amendments since 2004. This approach has been significantly supported by the demands of the WFD. With the long concession periods providing legal security to the hydropower operators, voluntary incentives as given by the EEG seemed most appropriate to change the environmental conditions at a relatively short notice[13]. Both the studies carried out to accompany the EPI and – in particular – the report on experiences, continuously shaped the design details of the EPI. This included also the consideration of the level of the prevalent free market prices.

Concerning the implementation of the instrument, meaning the realisation of ecological measures by the hydropower operators and their acceptance by the water agency, the existing hydropower approval process according to the German water law facilitates the control of the measures on site, as it is included in the procedure (Naumann and Igel, 2005).

The tradition of very long concession periods has a strong influence on the operational phase of the EPI. Once the ecological measures implemented and approved,

[13] Please note that new concessions are obligatorily in line with the WFD as they have to comply with the current legal provisions given by the WHG.

the eligibility of the hydropower plants to the increased EEG remuneration is guaranteed and no control of their functionality is taking place afterwards.

Creation of new institutions

The remuneration system for hydropower plants linked to ecological requirements constitutes a new institution in itself, which influences the decisions of affected stakeholders.

Institutional causes limiting success

Some reluctance of hydropower operators to touch their unconditioned user rights can be observed, limiting the scope of implementation of the EEG (Clearingstelle, 2011). Also the prevailing free market prices for electricity have an essential influence on the incentive effect of the remuneration proposed by the EEG.

3.5 Policy Implementability

Flexibility

Several mechanisms are foreseen in the design of the EPI which provide for some flexibility. Those mechanisms are targeting two different levels. One is the local level on which the ecological measures have to be implemented. The decision whether the good ecological potential has been reached or substantially improved – and therefore whether the conditions for being eligible to the EEG remuneration system are fulfilled – lies in the responsibility of the competent authority which can consider local particularities. The same applies to the appraisal of the economic reasonableness of the corresponding investments – compared to the additional receipts due to the increased EEG remuneration. No exemptions to those criteria are intended or have been identified, but it is recognised that their evaluation cannot be foreseen or contested completely and that some leeway exists for interpretation and adaptation to local conditions (Naumann and Igel, 2005).

A second level of flexibility is linked to the EPI design itself. The EEG foresees regular reports of experiences every four years which include recommendations for further amendments. After the introduction of the ecological requirements for hydropower plants in 2004, an amendment was adopted in 2009, which concerns in particular the amount of remuneration provided and the duration of the guaranteed remuneration. The EEG amendment of 2009 promoted the implementation of the EPI in particular through the increase in remuneration and the clearer list of ecological requirements. A following significant increase in participating plants is shown in Figure 3.2. Another amendment has been agreed in 2011, which will enter into force the 1st of January 2012.

Public participation

The work on the content of the EEG during the amendment procedures had been transferred from the German government to the Committee on the Environment, Nature Conservation and Nuclear Safety. In this committee, a public hearing took place before each amendment in 2004 and 2009. To these formal occasions, representatives of different renewable energy sources producers have been invited, including the German Federal Association of Hydropower Plants (BDW), to present their statements (Deutscher Bundestag, 2008)[14]. A more important contribution with regards to contents took place already in the forefront of this procedure, as technical experts, including hydropower representatives, had been directly consulted (Uphoff, 2011 *pers. comm.*). From the information compiled, no indication could be found on the existence of dominant players which significantly determined the design of the EPI. Furthermore, no evidence is available that allows attributing a specific importance of the public participation process on the implementation of the EPI.

An important instrument of the EPI which supports implementation is the operational guideline (Naumann and Igel, 2005) which has been developed with the support of several stakeholder groups[15]. BMU (2008b) ascertains that the guideline had a positive effect on the approval procedure for hydropower plants and that it is highly appreciated by both the enforcement agencies and the plant operators.

In the operational phase of the instrument, public participation plays a role in the context of the work of the clearing house (see Chapter 3.4). Hydropower representatives are invited to participate and comment on the specific questions concerning the practical application of the EEG (Bundeskabinett, 2002; Uphoff, 2011 *pers. comm.*)[16].

Cooperation between authorities

Cooperation and coordination between different authorities took place according to the established procedures for legislative processes. As the EEG adoption requires the approbation of the German Bundesrat, also the responsible ministries of the different Länder have been consulted (Naumann, 2011 *pers. comm.*). During the public hearing process on the EEG amendment mentioned above, also official representatives of other government committees were present[17]. However, as the hearing proc-

[14] Hydropower representatives had been given the possibility to present their recommendations for the EEG 2012 at an earlier stage. The consulting engineers who were assigned to elaborate the report on experiences of the EEG asked them beforehand to submit their proposals for the new EEG amendment (Reitter, 2011a).

[15] More precisely, the guidelines have been elaborated with the general agreement of the associations of hydropower users (Bundesverband Deutscher Wasserkraftwerke, Bundesverband Erneuerbare Energie and Verband der Elektrizitätswirtschaft) as well as the environmental and nature conservation NGOs Bund für Umwelt und Naturschutz, Bundesverband Bürgerinitiativen Umweltschutz, Grüne Liga and Naturschutzbund Deutschland. Other associations have been heard and the federal states consulted (Naumann and Igel, 2005).

[16] This process seems to be appreciated by the sector (Reitter, 2011a), but might not influence the overall implementation of the EPI.

[17] In particular: The Committee on Economics and Labour, the Committee on Consumer Protection, Food and Agriculture, the Committee on Transport, Building and Housing, the Com-

ess treated elements of the whole EEG – including issues on all renewable energy sources – the presence of the different representatives cannot be necessarily linked to the provisions on hydropower. No evidence could be made available on the importance of the impact of this cooperation and coordination on the development and implementation of the EPI.

Neither a considerable impact of the EPI on the regulatory burden could be identified, nor an adaptation of existing institutions – apart from the remuneration system for hydropower plants itself. The same applies to the influence of budgetary constraints. It can be assumed, however, that the choice of the instrument in its present form – where ecological improvements on hydropower plants are apportioned to the electricity consumers – has been preferred to direct subsidies, amongst others due to budgetary reasons.

Interplay with sectoral policies
If put into the context of relevant sectoral policies, some synergies and barriers can be identified, which are summarized in Table 3.5. They are focussing on the impact the policies had on the implementation and operation of the EPI.

Table 3.5 – Interactions with different EU policies

EPI-Objective	Improving the ecological status of water bodies next to hydropower plants by improving the hydromorphological situation	
Other sectoral policies	Objectives of the sectoral policy	Synergies and barriers
Water Framework Directive	Reaching good ecological status for all water bodies	+++ Supported the establishment of the EPI; provides a broader legal background.
EU Energy Policy	Promoting the use of renewable energy sources	++ Promoting renewable energy sources is an essential reason for the existing design details.
EU Nature Conservation Policy	Ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora	+ No direct interaction. But nature conservation aspects play a role in the selection of the ecological criteria.

Note: + represents a positive synergy between the objectives of the EPI and the other policy; 3 levels: + (low positive interaction),++ (medium),+++ (high positive interaction)
0 represents no discernible interaction
- represents a negative effect between the objectives of the EPI and the other policy; 3 levels: - (low negative interaction),-- (medium),--- (high negative interaction)

With regards to the WFD, a high positive synergy between its objectives and the ecological preconditions of the EEG for hydropower plants is obvious, as they are de-

mittee on Education, Research and Technology Assessment, and the Committee on the Affairs of the European Union.

fined by an improvement of the ecological status / potential of water bodies. The WFD represents furthermore the European legal background of the instrument.

The EU energy policy which is promoting the use of renewable energy sources is also reflected in the choice of the instrument, linking ecological criteria to the promotion of hydropower production. A positive interaction is therefore assigned.

No direct interaction is discernible with EU nature conservation policies. The protection of species – in particular fishes – play, however, an important role in the ecological criteria.

3.6 Transaction Costs

Definition of transaction costs in the context of the EPI

No study could be identified which analyses in particular transaction costs (TCs) linked to the implementation of the ecological requirements for hydropower plants in the framework of the EEG. Breitschopf et al. (2010) define TCs as all costs which are directly linked to a transaction (e.g. purchase, sale) of goods. They divide them according to Richter and Furubotn (1996) in three types: a) research and information costs; b) negotiation and decision costs; and c) monitoring and enforcement costs. A German law from 2006 defines that bureaucratic costs of all laws have to be determined for all stakeholders addressed by those laws. In this context, bureaucratic costs are defined as costs which exist due to information duties. These are obligations to provide data and other information to administrations or other parties. Other costs are not included (Breitschopf et al., 2010).

Breitschopf et al. (2010) indicate that TCs for operators of electricity production plants are not relevant, as those costs are considered by the operators in their reflections on whether they will follow the ecological requirements of the EEG or not. They are hence internalised – because refinanced by the remuneration. The only cost component identified is linked to the proof that the good ecological status has been reached for big hydropower plants according to § 6 EEG, which has to be given by the distribution system operators. It is estimated to be 20 Euros per demand (Breitschopf et al., 2010).

Stakeholders involved

The elaboration and implementation of the EEG lies in the responsibility of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). According to the legislative system in Germany, the EEG amendment of 2004 has passed through several instances during its approval process. This included three legal "passages" through the Bundestag, with several periods of consultation and statements from the Bundesrat as well as meetings of the mediation committee (LEXEGESE, 2011). The control of the environmental measures on site lies in general in the responsibility of the local water agencies (Anderer et al., 2011 *in print*).

Study background of the EPI

The EEG amendment of 2004 was based on the recommendations stemming from the report of experiences from the former EEG 2000, which has been published by the BMU end of June 2002. The specific recommendations for the different energy sources, among which hydropower, are based on a study done by a private research institute (Bundeskabinett, 2002). The EEG amendment has been approved in July 2004 and entered into force the 1st of August 2004. This duration of the amendment procedure of about two years has also been confirmed by the following amendments (Naumann, 2011 *pers. comm.*).

In 2004, also the results of a research project financed by the BMU have been published (Nitsch et al., 2004), dealing with the ecologically optimal extension of the use of renewable energy sources. Two further research projects could be identified with a direct link to the EPI; investigating the area of conflict between biodiversity conservation and climate change in particular for SHPs (Dumont, *unpublished*, mentioned in Ammermann, 2011) and the ecological effectiveness of measures induced by the EEG (Anderer et al., 2011 *in print*). Relevant studies investigating the interface between the positive climate mitigation effects of hydropower plants and its negative impact on nature conservation issues had also been carried out before; partly several years before the EPI was developed (e.g. Meyerhoff et al., 1998).

Implementation process

Concerning the development but also the implementation process of the EPI, it is crucial to emphasise that it forms part of the provisions proposed for the remuneration of all renewable energy sources in Germany, which are all regrouped in one legal text (the EEG). Furthermore, the ecological conditions for hydropower plants have not been introduced together with the remunerations of the plants, but they have been added to the existing system. Hence, not the remuneration per se is of interest (regarding TCs), but only its obligatory link to the ecological requirements.

With regards to monitoring and enforcement costs, the control whether the ecological improvements have been carried out by the energy provider is done as part of the approval procedure of hydropower plants according to water law (Knödler and Wotke, 2009). This lies in the responsibility of the competent water agency. Since the EEG amendment in 2009, the approval of the ecological measures can also be done by an environmental verifier[18]. No additional controls are foreseen afterwards.

Records of meetings, discussions, and negotiations

As for all legal approval processes, a formal record exists for all official meetings, discussions and negotiations in the so-called Parlamentsarchiv (Deutscher

[18] This specification has been partly removed again in the EEG 2012 which requires that the auditor's reports have to be approved by the competent authorities (Uphoff, 2011 *pers. comm.*).

Bundestag, 2011). However, those records do not necessarily allow identifying the parts of the process which are specifically dedicated to the ecological conditions of hydropower plants, as the EEG is approved as a whole, including other energy sources like wind power, photovoltaic etc.

Synthesis of transaction costs

Table 3.6 tries to provide summarized information on the TCs of the EPI in its different steps of establishment: research, design, legal process, support to implementation (in the form of information provision), administrative control (controlling the fulfilment of the ecological requirements), monitoring and enforcement. It indicates furthermore the level on which the TCs occur and their specific attribution to the EPI. As no comprehensive quantification of the different TCs was possible, an indicative score is provided and commented.

Table 3.6 – Summary of transaction costs

Type of transaction costs	Level	Specific attribution to the EPI	Likely importance of the transaction costs	Explication
Research	National	High	++	Specific studies have been carried out to support the design and implementation of the EPI.
Design of the instrument	National	Medium	+	The design phase of the EEG included a part which is specific to hydropower. It considers, however, also significant aspects which are not directly linked to the ecological criteria.
Legal process	National	Low	+	The whole legal process of the EEG amendments includes only a relatively small part on hydropower issues.
Support to implementation	National and local	High	++	Instrument specific information is provided in the form of an operational guideline as well as specific discussions in the EEG clearing house.
Administrative control	Local / Regional	Low	+	The control of the ecological measures on site forms part of the legal approval procedure for hydropower plants.
Monitoring / Enforcement	Local	High	0	As no controls are carried out after the approval process, no transaction costs occur on this step.

Note: +++ indicates a very high importance of the transaction costs; ++ indicates significant transaction costs; + indicates low transaction costs; 0 indicates no transaction costs.

Indications on the impact of transaction costs on the EPI
In the official rationale for the EEG 2004, some limited additional costs at national scale due to the amendment are stated. Those elements mentioned cannot, however, be directly linked to the ecological requirements for hydropower plants, but are due to the implementation of the whole EEG (BGBI, 2004). In BMU (2008) it is furthermore stated that no evidence is available indicating that TCs in terms of time spent for the approval of hydropower plants are disproportionally high. An indication on the attempt to reduce TCs is the change of the reporting period of the EEG from two years (EEG 2000), to four years (since the EEG 2004).

In summary, no evidence could be found that the TCs linked to the ecologically bound EEG remuneration for hydropower plants have been significant. Furthermore, no evidence indicated that asymmetric information influenced the implementation process.

3.7 Uncertainty

Definition of the objective
The objective of the ecological criteria for hydropower plants as included in the EEG is to provide incentives to the hydropower plant operators to implement measures in order to improve the ecological status of water bodies in the area of influence of hydropower plants. Neither quantified targets in terms of a number of hydropower plants which should comply with the requirements of the EEG were set at the beginning, nor has there been a time horizon set in which the measures should be applied (Naumann, 2011 *pers. comm.*).

Measurability of success
The success of the instrument can hardly be quantified with sufficient confidence due to several reasons. In the first years after the EEG amendment in 2004, neither a centralised register of all existing hydropower plants existed, nor was it possible to know how many and which ecological improvement measures had been implemented. In the last years, research projects have been launched to shed light on this question. By now, good knowledge about the number of existing hydropower plants is available, and also some information could be collected on the type of measures applied (Naumann, 2011 *pers. comm.*; see Chapter 3.1). However, the information on the measures applied does not provide any indication about their ecological effectiveness (Anderer et al., 2011 *in print*). The actual achievement rate of the objective remains therefore very uncertain.

Another source of uncertainty lies in the evaluation of the measures by the responsible water authority or the environmental auditor, respectively. Although guidelines are available (e.g. in Dumont, 2005), the existing powers of discretion leave some leeway for interpretation.

Attribution of achievements to the EPI

As mentioned before, according to the current level of knowledge it is not possible to decide whether the objective of considerably improving the ecological status of water bodies has been reached. However, the proxy of the number of measures applied can be used. As shown in Chapter 3.1, Anderer et al. (2011, *in print*) found out in a survey that more than half of all ecological measures implemented on hydropower plants have been carried out without any financial support (see also Dumont and Keuneke, 2011). This means they have neither financed their measures with the increased EEG remuneration nor through any other mechanism. The background for those outcomes remains unclear[19], but the results indicate that part of the environmental improvement would also have been taken place without the EEG amendments.

Appraisal of the instrument at the time of introduction

In general, the ecological criteria for hydropower plants have been welcomed from all different parties (Naumann, 2011 *pers. comm.*). Some scepticism prevailed, however, on the site of the hydropower plant operators, in particular regarding the approval procedures which were apprehended to be too restrictive (Uphoff, 2011 *pers. comm.*).

So-called pedigree tables for the most important information available on environmental objectives, economic incentives, and distributional effects can be found in Annex II.

4 Conclusions

Hydromorphological pressures represent a major barrier for Germany to reach the good ecological status of river water bodies following the European Water Framework Directive. Hydropower use is an essential driver behind this situation. At the same time, the production of electricity from hydroelectric power stations forms an important element of the German strategy to promote the use of renewable energy sources. The favourable electricity remuneration guaranteed for hydropower plants which implement ecological improvements are the main instrument chosen in Germany to handle these conflicting objectives between energy and water policy in the short term.

The analysis of this EPI in the present case study showed that its choice and design details very strongly depended on existing institutions. The WFD requirement to reach good ecological status until 2015 on one side, and the existing, long lasting user rights for hydropower plants which provide them with legal security on the other

[19] Potential explications are, that the measures indicated had been applied according to legal requirements or as a result of a personal commitment of the hydropower plant operators. Missing consistency in answering the survey questions could also be relevant.

side, made it necessary to give economic incentives to power plant operators in order to accelerate the ecological improvement process of the plants. The German Renewable Energy Sources Act from the year 2000, which guarantees a certain remuneration level for the renewable energy produced, provided the suitable framework for introducing ecological conditions. Using the already existing system – including the remuneration procedure, reporting rules etc. – significantly helped to keep the transaction costs of the EPI low.

In terms of environmental outcomes, the defined objective of the instrument is to improve (if not reach) the good ecological status of water bodies in the sphere of influence of hydropower plants. This objective has neither been quantitatively specified nor has a time span been defined at its introduction for achieving results. As there is no centralised database indicating how many hydropower plants have been granted an increased remuneration rate after the application of measures or which type of measures has been implemented, the actual effect of the instrument is difficult to estimate. However, a recent research project (Anderer et al., 2011 *in print*) showed that most of the measures applied concerned the passability of the weir structures and the provision of minimum water flows. This corresponds to the most important ecological improvement needs, indicating therefore a positive effect of the EPI. At the same time, once the measures applied and approved, there is no control of their ecological functionality. No statement can therefore be made on whether the ecological status of the water bodies concerned has actually improved. The results of the same research project indicate that the ecological functionality of a significant part of the measures is in fact doubtful and needs further investigation.

Regarding the economic incentive effect of the EPI, the level of remuneration paid is crucial for the extent of application of the measures. It is widely recognised that the fees are not high enough to provide sufficient incentives for the ecological modernization of most of the small hydropower plants. According to the policy makers, the level that would be required is not justifiable from a political point of view. In the EEG amendment which enters into force at the beginning of 2012, the remuneration has only been slightly increased. It is expected that most of the ecological modernisations which have been economically feasible have already been carried out and the number of new works will only be small.

From an economic point of view, it is interesting to notice that the EPI is designed to be a cost-recovery mechanism. As the consumers of electricity pay for the ecological improvement measures, part of the environmental externalities linked to hydropower production are internalised through the energy bills. The share of hydropower in the price increase is, however, difficult to determine, as it is the result of the higher production costs of all renewable energy sources together. Apart from a likely raise in revenues for the hydropower plant operators from the increased EEG remuneration, no significant social or distributional effects could be identified for this EPI. It is rather interesting to note that the instrument did not help to attenuate the conflict between hydropower plant operators on the one hand, and nature conservationists and angling associations on the other, as the latter mistrust the effectiveness of the measures (Uphoff, 2011 *pers. comm.*).

With regards to policy implementability aspects, the design details of the instrument provide for flexibility both in terms of adaptation to the local situation and in terms of foreseen revision procedures. The different amendments which have been carried out since the introduction of the ecological requirements are evidence of continued reflections on potential improvements (e.g. in terms of an improved incentive effect). Efforts are undertaken to guarantee public participation in the design phase and during the implementation of the instrument. The instrument's design is in line with other sector policies, so no negative interplay could be identified.

Uncertainty plays an important role in the evaluation of the EPI. This concerns on the one hand the already mentioned lack of control of the ecological functionality of the measures applied, and on the other hand the uncertainty regarding the link of the measures to the EEG incentives. The evidence available today does not allow providing a statement on the extent to which the EEG amendments are the essential driver behind ecological improvements of hydropower plants. However, a positive contribution from the mechanism has been widely acknowledged.

4.1 Lessons learned

On the whole, linking favourable remuneration of electricity generated by hydropower plants to ecological modernisation works as done through the German EEG can be considered as a successful economic policy instrument, which promotes both the use of renewable energy sources and nature conservation efforts. It is well adapted to existing institutions, only entails relatively low transaction costs and features design details which ensure its political implementability. It is designed as a cost recovery mechanism without imposing disproportionally high costs to consumers. The most important criticism refers certainly to the lacking possibility to control the actual ecological improvements on site. But even if not all measures had a positive effect or even if part of the works would have been done also without the EEG incentives, a positive net effect of the instrument is uncontested. Nevertheless, the EPI is not – at least not with the current renewable electricity remuneration level – solving the pressures exerted by small hydropower plants.

With regards to the lessons learned since the EEG amendment of 2004, the following can be cited: It is important to ensure that the ecological improvements required target the most important environmental needs. Furthermore, it was useful to specify in the amendment of 2009 the type of measures which could be implemented to be eligible for the increased remuneration. At the same time, the missing control of the actual ecological functionality limits the measurability of the environmental outcomes.

From the economic point of view, it was important to propose the guaranteed remuneration for a long period (up to 30 years, depending on the EEG amendment and the size of the plant) in order to provide the plant operators with investment security. At the same time, finding the right balance between the level of remuneration needed to provide for sufficient incentives to ecological modernisation and the politically acceptable level of financial support to a specific sector (small hydropower plants) is essential. Other distributional or social issues are less relevant for this case study.

The evaluation exercise showed that the existing institutions were very favourable to the introduction of the EPI in its present form, with the ecological criteria being introduced into the existing system. This helped to keep TCs low. At the same time, allowing for some additional TCs in the form of the control of environmental effectiveness of the measures would be useful to increase the overall success of the EPI.

With regards to policy implementability, its flexible elements, in particular the possibility of regular amendments, turned out to be very useful to improve the EPI. Public participation was to some extent part of the process, but might be less important than in other cases, as the EPI is not linked to restrictions but to subsidies to the sector. No unintended consequences of the EPI could be identified.

Room for improvement is given – as mentioned above – in particular during the operational phase of the EPI, where controls of the ecological functionality would be needed to ensure and assess the effects of the instrument. Further recommendations concern the centralised collection of information on the type of measures applied so far – including an indication of which measures led to a higher remuneration – and the financial background of measures already implemented. The latter allows identifying in how far other incentives than the EEG have launched the implementation of the ecological improvements on hydropower plants.

Another potential adaptation of the EPI, which is subject to discussions, is to loosen the direct link between the eligibility to increased remuneration through ecological investments to a specific hydropower plant (Naumann, 2011 *pers. comm.*). In its current form, the EEG promotes ecological improvements where they are economically feasible (which concerns mainly bigger plants) and not where they would be most ecologically effective. One idea is to redistribute money by means of a fund (Naumann, 2011 *pers. comm.*). This would entail, however, a significant change in the structure of the present EPI.

4.2 Enabling / Disabling Factors

With regards to the potential transferability of the instrument, it is evident that in contexts, where no harmonised remuneration system of hydropower plants exist, much more effort would be needed to create the necessary system, increasing significantly the transaction costs of the EPI. Where such a system already exists, on the contrary, ecological requirements could potentially be introduced quite easily as it has been the case in Germany. At the same time, in European countries where concession periods are shorter than in the German case, the need for this specific instrument is less present, as ecological requirements can be included as demands in the renewal procedure for the concessions. In any case, additional instruments might be needed to provide sufficient incentives also for the ecological modernisation of small hydropower plants.

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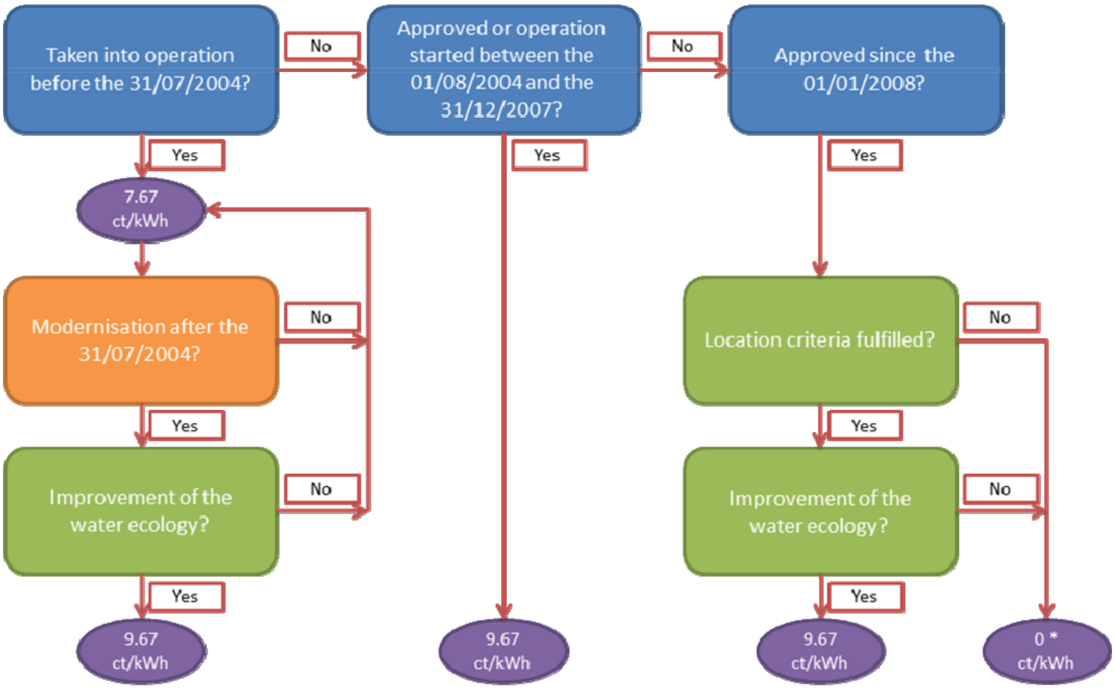
- Naumann, Stephan: German Federal Environment Agency, author of the operational guideline for the EPI implementation; telephone interview in November 2011
- Uphoff, Harald : Leading office manager of the German Federal Association of Hydropower Plants; telephone interview in November 2011

6 Annex I: Conditions for benefiting from increased remuneration according to the EEG 2004

The following schemes illustrate the conditions for remuneration according to the EEG 2004. They have been translated based on the figures given by Naumann and Igel (2005).

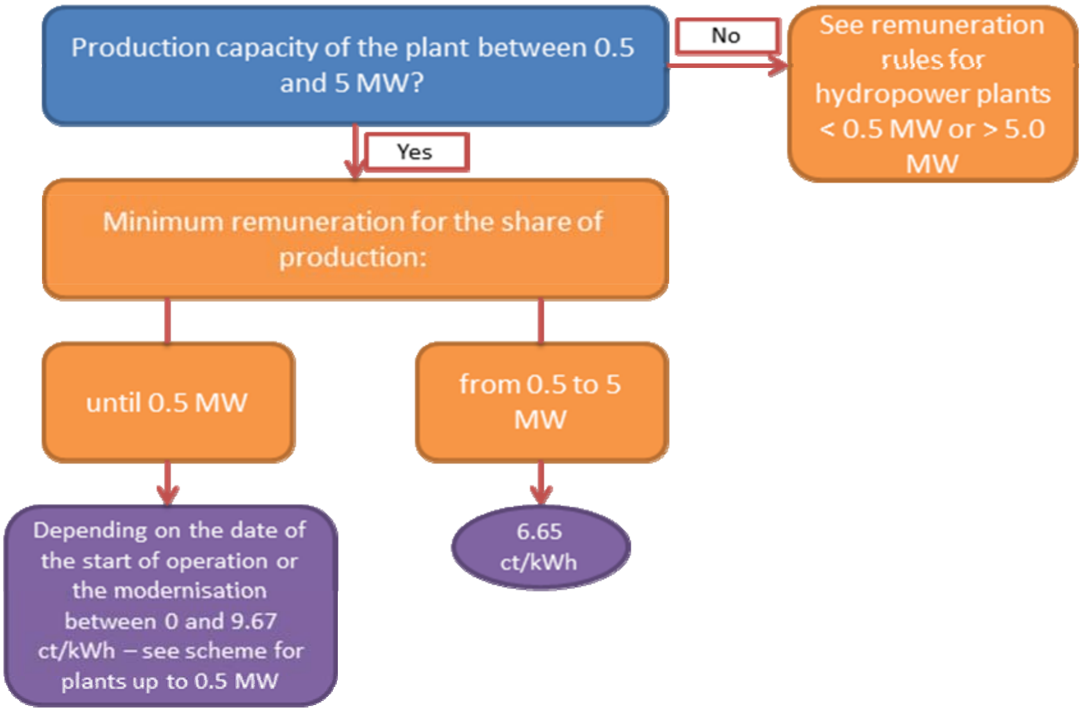
For hydropower plants with a capacity up to and including 500 kW



Source: Naumann and Igel, 2005, adapted

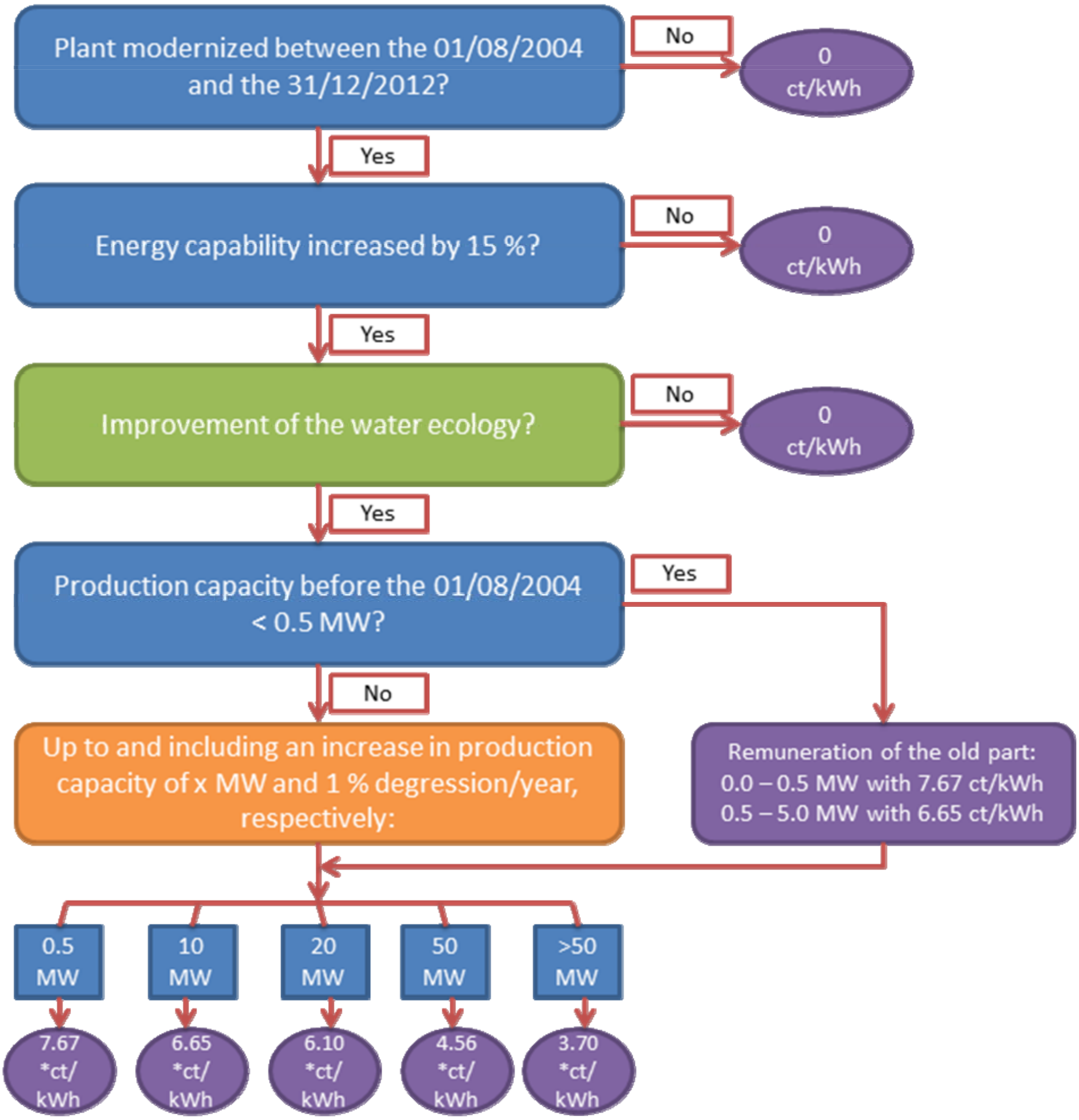
Note: * No remuneration according to the EEG. But remuneration according to general regulations is possible.

For hydropower plants with a capacity ranging from 0.5 up to and including 5 MW



Source: Naumann and Igel, 2005, adapted

For hydropower plants with a capacity ranging from 5 up to and including 150 MW



Source: Naumann and Igel, 2005, adapted

Note: * For the increased part of the production.

7 Annex II: Pedigree tables

Pedigree tables describing the degree of uncertainty for the most important information available on environmental objectives, economic incentives, and distributional effects are given below.

	Environmental outcomes	Economic incentives	Distributional effects
Ecological preconditions for hydropower remuneration in Germany	Objective: substantially improving the ecological status of water bodies	Number of plants fulfilling ecologic criteria	Income changes of hydropower plants
Proxy = variable used to describe the outputs/outcomes of the EPIs and their relationship to the policy target	Not possible – or: Number of measures applied according to the EEG → 1	Number of plants being remunerated according to the EEG → 3	Changes in employment situation → 1
Empirical = the basis on which the performance assessment draws	Recent research project (Anderer et al., 2011 in press) → 3	Recent research project (Anderer et al., 2011 in press) → 3	Reports → 4
Method = analytical tool used to assess the effects of EPIs especially if not estimated directly using empirical data	Direct estimation from empirical data → 2	Direct estimation from empirical data → 3	Direct estimation from empirical data → 4

Source: Author

Note: The following uncertainty qualifiers have been used:

Code	Proxy	Empirical	Method
4	Exact measure	Large sample direct measurements	Best available practice
3	Good fit or measure	Small sample direct measurements	Reliable method commonly accepted
2	Well correlated	Modeled / derived data	Acceptable method, limited consensus on reliability
1	Weak correlation	Educated guesses / rule of thumb estimate	Preliminary methods, unknown reliability
0	Not clearly related	Crude speculation	No discernible rigor

Source: EPI guidance document

8 Annex III: Acknowledgments

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9 List of abbreviations

BfN – Bundesamt für Naturschutz; German Federal Agency for Nature Conservation

BDW – Bundesverband Deutscher Wasserkraftwerke; German Federal Association of Hydropower Plants

BMU – Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit; German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

EEG – Erneuerbare-Energien-Gesetz ; German Renewable Energy Sources Act

EPI – Economic Policy Instrument

EUR - Euro

GDP – Gross Domestic Product

GES – Good Ecological Status

kW – Kilowatt

LAWA – Länderarbeitsgemeinschaft Wasser; Working Group of the German Federal States on Water

MW – Megawatt

NGO – Non-governmental organisation

pers. comm. – personal communication

StrEG – Stromeinspeisungsgesetz; legal act on the sale of electricity to the grid

TCs – Transaction costs

UBA – Umweltbundesamt; German Federal Environment Agency

WFD – European Water Framework Directive

WHG – Wasserhaushaltsgesetz; Federal Water Resources Law

1 billion = 1 000 millions