A Study of a Comprehensive Solution to the Problems of the Włocławek Dam and Reservoir

Anticipated Social, Economic and Environmental Effects

An Overview

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Executive Summary

The government of Poland is actively considering proposals to manage the numerous problems that have arisen with the operation of the aging Włocławek Dam on the lower reaches of the Vistula, the longest Polish river. The purpose of this report is to broaden the range of options under consideration by the government to address the problems introduced by the Włocławek Dam, and to ensure that the future generations of Polish citizens enjoy beneficial uses of the Vistula.

The most significant threats arising from the existing Włocławek Dam include the following:

- The movement of ice along the river during the winter is blocked once it reaches the frozen storage reservoir. This increases the threat of flooding caused by ice-jams upstream of the dam.
- The flow capacity of the dam is 20% less than that required by regulations for new projects. This lack of capacity could lead to disastrous flooding downstream of the dam, should it be breached during a high discharge event.
- The transport of sediment by the river has been interrupted by the dam. As a result of the sedimentation process, the capacity of the reservoir has been decreasing. Downstream effects have included an increase in the fluvial erosion of the channel bed and, consequently, the dam itself is actually being undermined and is becoming unstable.

After a preliminary assessment of seven potential management schemes, three options for mitigating the threats arising from the Włocławek Dam were considered in depth:

- The decommissioning the Włocławek Dam and restoration of the Vistula into a free-flowing river while maintaining the current motorway crossing (Described in the text as Option III). This option eliminates all threats and:
  - restores the natural process of sediment transport and stops the erosion of the river bed,
  - removes the principal cause of ice-jams,
  - increases the flow capacity, ensuring safe conditions in the downstream valley,
  - resolves the accumulation of toxic sediments and nutrients in the storage reservoir through the natural cycling of material,
  - ensures the restoration of natural processes, and the associated environmental, social and economic functions of the Vistula river.
- The full modernisation of the existing Włocławek Dam and leaving it operating as the only one on the Lower Vistula (Option II). Modernisation does not resolve all of the problems and threats and is more expensive than Option III, but is technically the most feasible and:
  - ensures dam stability at the lowest cost,
  - stops further erosion of the river bed; however, transporting accumulated sediments from the storage reservoir to downstream sites by barge is not a sustainable solution,
  - reduces, but does not eliminate, the probability of ice-jam formation and consequent flooding,
  - increases flow capacity during high floods.
- Constructing a new dam at Nieszawa and undertaking necessary supplementary work on the Włocławek Dam (Option I). This option does not solve most of problems caused by the Włocławek Dam and reservoir, and may exacerbate some:
  - river bed erosion, causing the degradation of the river valley downstream of the new dam,
  - the probability of ice jam formation behind storage reservoirs and the area vulnerable to winter flooding.

None of the three favoured options withstands rigorous tests of economic efficiency and financial viability. Considering investment costs, which are as follows: I – 346 million EUR, II – 83 million EUR and III – 48 million EUR and their as public spending implications, Option III – deco-mmissioning the Włocławek Dam, clearly emerges as the favoured option.

Contents

Contributions to the work on „A Study of a Comprehensive Solution to the Problems of the Włocławek Dam and Reservoir – Anticipated Social, Economic and Environmental Effects" were made by experts in hydro-engineering, hydrology, economics, energetics, regional development, hydrobiology, ecology, ornithology, botany and ichthyology.
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Introduction

More than half of Poland's land area is situated within the basin of the Vistula, the longest river in Poland (1047 km). For several hundred kilometres, the Vistula has retained a semi-natural character and the dynamics of a free flowing river, despite the construction of dikes and other river engineering works. It is, therefore, considered to be one of Europe's most precious rivers. Its valley, characterised by very high biodiversity, is considered a haven for species of threatened birds and an ecological corridor of international importance. The international recognition of the natural value of the Vistula is demonstrated, amongst others, by the recommendations of the Contracted Parties of the Ramsar Convention on Wetlands calling upon the Polish Government to conserve the middle reaches of the Vistula River through designation of the area under the Ramsar List and developing a management plan that ensures „wise use" of the water and wetlands. Meanwhile, there have been attempts to turn some stretches of the river into a series of reservoirs, instead of implementing a conservation program.

The lower and middle course of the Vistula is obstructed, so far, by only one dam – in Włocławek. Since the 1990's, a second dam construction project near Nieszawa has been intensively promoted by some sectors of the community. As the main argument in its favour, advocates of the dam construction put forward the safety of the Włocławek Dam and the necessity of preventing a catastrophic collapse of the infrastructure.

The proposition of constructing yet another dam in the lower parts of the Vistula caused strong protest from the Ramsar and Bern Convention secretariats, as well as from numerous Polish and international non-governmental organisations. The European Commission and Parliament have been closely monitoring this project over this period, as they have recognised that the decision-making process and environmental implications of further dam construction are at odds with a number of European Union directives.

The main legal arguments against the project include the fact that it does not comply with the sustainable development principle included in the Constitution of Poland and is inconsistent with the European Union's Water Framework Directive (2000) and the Birds Directive (1979).

The decision-making process raises several concerns. The problems of the existing dam have not been considered in the context of the whole of the Vistula basin, as required by the Water Framework Directive. Poland, as a pre-accession State, is also bound by this directive. Not all solutions have been analysed in depth, although the report of the World Commission on Dams

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„Dams and Development: New Framework for Decision-Making", published in November 2000, clearly recommends that all options, particularly „non- dam options", should be assessed carefully before any decision is made.

WWF, The World Wide Fund for Nature, has been involved in the problems of the already existing Włocławek Dam and the proposed Nieszawa Dam since 1999. Its objectives include the safety and improvement of the local residents' well-being, as well as the necessity to protect the priceless environmental treasures of the Vistula valley. By meeting the recommendations of a governmental expert committee, as well as recognising the fact that the new dam will not solve all of the problems caused by the existing Włocławek Dam, WWF, in the autumn of the year 2000, started working on „A Study of a Comprehensive Solution to the Problems of the Włocławek Dam and Reservoir – Anticipated Social, Economic and Environmental Effects".

The task of the group of experts contracted by the WWF was to:

- recognise all problems and threats caused by the existence of the Włocławek Dam;
- identify all technically feasible measures;
- carry out a comprehensive option assessment;
- assess the relative social and environmental impacts, as well as conduct the relevant economic analysis.

In accordance with recommendations of the World Commission on Dams, it was accepted that none of the options should be given up before being analysed. It was also stated that the option of building a dam in Nieszawa (as the one recommended by the governmental expert committee) needed to be included amongst the options requiring a detailed assessment. All these solutions were considered taking into regard the Vistula River's position within the Polish economy, as well as its management perspectives in the future and role in the modern, sustainable development of the country. During the preparation of „A Study...", all available data and reports were submitted, most of which had been prepared for the Ministry of the Environment and the Regional Water Management Board in Warsaw. Conclusions drawn from community meetings within the region were also considered.

WWF, as well as the authors of „A Study...", hope that the presented results, particularly the economic and social arguments, will provide a basis for a decision, which, in turn, would lead to a sustainable and complete solution of all the problems concerning the dam and the reservoir in Włocławek – for the mutual benefit of the people and of nature itself.

The Formal and Legal Conditions for the Development of the Vistula River

The Vistula, its valley, the associated ecosystems, as well as material culture objects are all part of the natural and cultural heritage of Poland. The preservation of this heritage must be consistent with satisfying current social needs, as well as the safeguarding the needs of future generations. Here we are dealing with two objectives, which are difficult to meet simultaneously:

- the protection of the river, its valley and all the ecosystems as well as the cultural resources associated with it,
- satisfying the need to use the Vistula's water resources and the management of its valley (including the necessity to protect people against floods), which is a prime condition for civil and economic progress.

The obligation to reconcile current social needs with those of future generations is formulated in the Polish Constitution. Article 5 of the Constitution states: „The Republic of Poland (...) ensures environmental protection, in accordance with the principle of sustainable development". This rule, therefore, provides the basis for all legal acts regarding human activities in the environment.

The strategy for the sustainable development of Poland was supposed to be a natural consequence of the entry in the Constitution. The Polish Parliament's expectations concerning this strategy were precisely formulated in the Resolution of the Parliament of the Republic of Poland, of March 2nd, 1999, regarding the Sustainable Development Strategy for Poland being presented by the Council of Ministers. Amongst others, it states the following:
„Placing emphasis on the fact, that the concept of «sustainable development» included in the Polish Constitution, signifies a development model in which current social needs and the needs of future generations are treated with equal importance, Parliament expects the document presented by the Government to include, in a harmonious manner, care for the preservation of the Nation's natural and cultural heritage, as well as for progress in terms of civilisation and economy, in which all social groups participate."

As a condition for the efficiency of actions towards sustainable development, equal access to the environment is also encompassed by the „2nd Ecological Policy of the State", published by the Ministry of Environment in 2000. Principles of equal access to the environment described it this policy refer to:

- equality between generations
- equality between regions and stakeholders
- sustainability and equality between people and nature.

Another official document which applies to the case of the Vistula and which recommends the need to follow the rules of sustainable

development is the „Policy Concept for Spatial Management of the State", published in October 1999 by the Governmental Centre for Strategic Studies.

The obligation to assess the environmental impact of strategies, policies, programmes and plans is of particular importance from the point of view of managing and developing the Lower Vistula valley. This duty is imposed by the Law of November 9th, 2000, concerning the access to information regarding the environment, its protection and environmental impact assessment, as well as by the Law of Environmental Protection of April 27th, 2001. Both these documents represent a major step towards the unification of Polish and European Union regulations.

It should be remembered that the construction of dams, such as the Włocławek Dam on the Vistula, causes a negative environmental impact at a distance of several hundred kilometres both upstream and downstream of the river and its tributaries

It should be remembered that the construction of dams, just as the Włocławek Dam on the Vistula, causes negative environmental impact at a distance of several hundred kilometres both upstream and downstream of the river and its tributaries. Breaking or limiting the permeability of the ecological corridor naturally created by the river and its valley, causes significant reduction of biodiversity, sometimes even leading to the local extinction of some species. The legal obligation to create a strategic environmental impact assessment is, in this situation, of vital importance, since deciding to carry out such a plan based simply on the basis of local considerations and preferences (e.g. within the specific administrative unit) would constitute an infringement of the principle of equal access to the environment.

In the context of Poland joining the European Union, a legal act that is important for the future management of the Vistula and its valley resources, is the Water Framework Directive. It forces a duty on European Union governments to design plans for integrated river basin management by the year 2009. This obligation is also binding for the Government of Poland.

The integrated river basin management must also include so-called „conditions for exploitation of basin waters" which is an obligation imposed by the Law of July 18th, 2001, The Water Law. Moreover, in the case of the Vistula resources and valley management, this Law emphasises the necessity to treat these resources in a rational and comprehensive way, with a consideration for their quality and quantity. According to this Law, water management should obey the rule of common interests and should be implemented through co-operation of public administration, users of the waters and representatives of the local community in such a manner which ensures the maximum of social benefits. Besides the satisfaction of social and economic needs, water resource management should also serve to protect the waters and the associated ecosystems.

The legal acts quoted above, all lead to the conclusion that priority socio-economic objectives of managing water resources, the valley and the basin area of the Vistula should be as follows:

- the protection and improvement of water quality,
- flood management in areas threatened by flooding,
- the protection and restoration of water and valley ecosystems.

The Importance of the Vistula for the Development of Poland and the Programs for River Management

For centuries, rivers and river valleys have been the axes of civilisation's progress, as they have been serving a range of functions which are important in both a natural and an economic context. The Vistula River, in its near-natural state, is valuable in providing a number of services to people in the surrounding catchment:

– a source of water provisions and a sewage collector, both for people as well as for industry;
– a source of renewable energy which is cheap to use;
– a water transport route;
– floodplains to absorb floodwaters;
– unique, species-rich ecosystems, including habitats for numerous species threatened with extinction, and a North – South ecological corridor of European importance.

The Vistula, together with its valley, provides a range of landscapes, that make it an attractive area for tourism, sport and recreation. The Vistula also has an immense spiritual, historic and cultural importance.

Throughout our history, humans have attempted to manage water resources and the threats their scarcity or over-abundance may provide. Agricultural drainage systems, retention reservoirs, water transportation systems, flood embankments and other hydro-engineering structures are still being built around the world.

One cannot deny the obvious achievements of the technocratic approach to the problems of water management. However, it should also be remembered, that attempts to overcome development barriers that are limited by hydrographic and climatic conditions usually are:

- **ineffective** – increasingly damaging riverine flood events are a worldwide phenomena – with some of the most severe occurring in developed countries. The impact of floods of a certain height have often been exacerbated by flood protection infrastructure
- **expensive** – examination of cost-benefit ratios for hydro-engineering projects often reveals that the actual costs of investment usually exceed the plans and the benefits achieved are smaller than expected
- **harmful for the natural environment** – turning rivers into canals and constructing retention reservoirs causes irreversible damage to the most valuable and diverse river valley ecosystems, reducing the self-purification abilities of the water and enhancing riverbed erosion. The consequent costs of these environmental impacts are substantial e.g. water purification systems, flood protection measures, increased dredging costs etc.
- **unforeseeable** – very often starting a chain of unforeseen processes.

The main services of the Vistula River:

– water intake,

– collection and dilution of sewage,

– flood management,

– water self-purification,

– transport of river sediment,

– ecological corridor and refuge for plants and animals

In the case of the Vistula, the following functions attract particular attention:

▮ **Water intake**. The Vistula is the main source of water for urban and industrial agglomerations situated nearby. The gradual introduction of water-saving mechanisms such as closed water circulation in industrial plants and water pricing will help to reduce overall water consumption. There is actually no need to increase the water resources of the middle and lower Vistula through technical measures, including the construction of storage reservoirs.

▮ **Collection and dilution of sewage**. It is impossible to eliminate all the sources of surface water pollution and despite the considerable progress in technology, rivers will still serve as sewage collectors. However, it will be a European requirement in future to improve the treatment of sewage effluent to reduce the concentration of pollutants.

▮ **Flood management** to reduce the threat for human lives, the economy and cultural goods. The only totally effective way to manage floods is to stop developing the floodplains and make these areas available to store flood waters. Obviously, the existing settlement network and the associated infrastructure need to be protected. However, new investments in threatened areas should be strictly limited. Such investments involve the necessity to pay immense costs for protection systems and their on-going maintenance, which may sooner or later fail, causing human fatalities and material damage.

▮ **Water self-purification processes**. Organic and inorganic matter carried by the water, which contains nutrients such as nitrogen and phosphorus, is mineralised at a certain oxygen concentration together with the activity of organisms specific to the self-purification processes. Preventing or disrupting this process, is caused by excessive pollution and/or water retention in reservoirs, leading to the degradation of water quality and the extinction of biological life. Maintaining the river's ability to clean itself is necessary if we are thinking of using it as a sewage collector.

▮ **Sustainable transport of river sediment**. Disturbing the natural process of river sediment transport, as a result of, for example, dam construction, leads to a range of negative effects, including the initiation of certain erosion processes downstream of the dam.

▮ **Ecological corridor and a refuge for plants and animals**. Due to its environment, unique on the European scale, this function is indispensable (also in the light of the Biodiversity Convention).

The Vistula constitutes a natural axis for the development of Poland. The needs of urban and industrial agglomerations and water-consuming industries situated in its middle and lower course can be satisfied without significant technical measures or negative influences on ecosystems of the river and its valley. In fact, development perspectives are very closely linked to the fact that, throughout a large part of its length, the Vistula remains an unregulated river with the classic braid character. Thus it is capable of self-purification and has great natural, landscape and cultural value.

Amongst other reasons, this is due to the fact that the Vistula is the only large river in Central Europe, which has avoided major civilising transitions that affected practically all the river systems in Europe during the 19th and the 20th century. It has never been included in European inland navigation systems, since it is at the Odra river where the water traffic of goods for Western Europe ends. In the past, economic and technical interests in the Vistula concentrated on:

– ensuring a certain level of flood protection in the valley,
– using its military significance,

– treating the river as a source of water for the developing water-consuming industry, and as a sewage collector (mainly communal).

On a local scale, the Vistula was a source of activities for inhabitants of settlement centres within the area. Places with harbours, ferries and groups supporting themselves by fishery and water transport services have sustained their traditional connections with the river. People utilised osier beds and flood terraces which were used for orchard and berry cultivation. Between floods, most of the river's natural islands were used as pastures. People inhabiting the Vistula valley used it as the source of water for their household purposes or even for drinking, as was locally done as late as 1960's.

Over the years, transportation and defence aspects lost their significance and farming, using water for irrigation ceased to possess the principal economic status.

No integrated management plan for the Vistula, that takes full advantage of its water resources, transportation or energetic capabilities, has ever been firmly and systematically implemented. However, such plans existed and they were treated very seriously by decision-making centres (successive governments, scientific and technical advisory units).

These plans were never implemented. The construction of the nuclear power plant in Karolewo never happened. Also the idea of constructing numerous thermal power plants and delivering coal via waterways was never implemented. The construction of a cascade of dams, in the upper Vistula, instead of the mouth of the San, stopped downstream by the city of Krakow. No irrigation system that would be linked to the river was ever established. The local water transport in the so-called „Warsaw Node" has gradually lost its significance. All those relinquishments were mainly due to economic considerations, although awareness and doubts about the purposefulness of changing the river's character also played their part.

At this moment, there is no official programme for complex management of the river, and only flooding issues are being assessed. As a consequence, the technical elements of all the existing concepts for such a programme are currently not included in any valid spatial management plans. Neither are they quoted in new strategies and plans either regional and ministerial. Such a state of affairs should be considered satisfactory, since these concepts are rather questionable from an economic point of view and distant from the generally accepted principles of sustainable development.

The previously mentioned „Policy Concept for Spatial Management of the State" is the basic document which establishes the State's policy regarding spatial management for the next dozen years or so. The document is also of principal importance in establishing the role of the Vistula in the country's development. According to its statements, whenever spatial concepts and plans, formulated as government tasks, concern national issues and features, such as the Vistula and its valley, should be based on premises of legal acts, as well as national and international agreements that allow for integrated solutions. It has to be remembered that an intervention in one part of the river may have an effect in almost its entire basin and the interests of local governments along its course may be contradictory.

There is only one document which concerns the Vistula and stands in agreement with the current law, the opinion of the Parliament and the Polish government, and also with obligations resulting from the European integration process. This is the Pro-ecological Strategy for the Vistula Management „Wisła XXI". This document was prepared at the beginning of the 1990's for the Ministry of Environmental Protection, Natural Resources and Forestry. It is in line with sustainable development principles, the ecological policy of the State, the concept of spatial management of Poland and European Union directives.

This strategy, prepared by an interdisciplinary team, includes a set of rules of conduct. It offers a firm basis for designing a spatial plan for the Vistula valley management in the future, obviously through negotiations among all stakeholders.

The diversity of fish and bird species and landscape values, together with old architecture of ancient cities (Sandomierz, Kazimierz, Czerwińsk, Warsaw, Toruń, Chełmno and numerous other places), makes the Vistula one of the most attractive areas for tourism and recreation in central Europe. Regulating the river and dam construction may destroy this potential. Services for tourism are probably the only realistic chance to reduce unemployment and improve the living standards of the inhabitants of villages and towns within the Vistula valley.

Directions of the Lower Vistula Management

So far, the attempts at complex hydro-engineering management of the lower Vistula have failed to address the sustainable development model. After the Second World War, priority was given to water transport needs in the area. Initially, large-scale regulation was suggested, but there was never enough means to bring such a concept to life and fragmentary actions did not have any apparent effect.

During the 20th century, plans concentrated on canalising the river's lower course and/or constructing water reservoirs for transferring water towards areas with a water deficit. The following concepts came the closest to being fulfilled:

- the construction of several dams with hydro-electric power plants between Warsaw and the Nogat branching,
- the straightening of the upper parts of water swellings for sailing purposes,
- the construction of a central canal transferring Vistula waters from the area of Duninów towards the cities of Łódź and Częstochowa,
- utilising Vistula waters to irrigate the relatively dry areas of eastern Wielkopolska, Kujawy and northern Mazovia provinces,
- as a water source for the purposes of the new industrial region Bydgoszcz-Toruń-Włocławek, which was planned in the 1960's and 1970's.

In the 1950's, concept work was initiated for the construction of a cascade of dams on the Vistula. It was meant to be a transportation and hydro cascade, situated between Warsaw and the river mouth. Dams were supposed to be located in Wyszogród, Płock, Włocławek, Ciechocinek, Solec Kujawski, Chełmno, Opaleń and Tczew. Due to technical and economic reasons, a decision was made to build the dam in Włocławek as the first one. The construction was accomplished in 1970. However, mainly because of problems with the funding of the investment, the Włocławek Dam remains the only one built in the lower Vistula. Successive construction of other dams (beginning with the designed one in Ciechocinek) was abondoned.

Lessons Learnt from the Assessment of the Dam and Storage Reservoir at Włocławek

Construction of the Włocławek Dam commenced in 1962 and lasted for 8 years. Beside the main structures of the storage reservoir – the dam, the weir, the sailing gate, the power plant and the fish pass – as well as side dams, flood embankments, canals and drainage ditches for depression area protection were made. The actual exploitation began in October of 1970. The dam's principal function, as seen today, is electric power generation and water release strategies are designed to serve this function (on average, 95% of water flowing into the reservoir is used for energetic purposes annually).

Converting a running river into a retention reservoir led to typical environmental changes, involving a decrease in the rate of water flow and a consequent increase in sedimentation. It is estimated that, so far, 45 million cubic metres of sediment has accumulated in the reservoir. If the current rate of sedimentation (about 1,7 million m^3 annually) is sustained, the reservoir will cease to exist in approximately 80 years.

The chemical content of sediment accumulated in the reservoir may constitute a serious ecological problem in the future. The available data concerning the toxic sediment composition are derived from a small number of study sites and, as such, they are of limited worth. However, it is certain that the average content of heavy metals and other analysed toxic substances in these samples does not exceed the levels acceptable in countries such as Germany or the Netherlands (there are no standards in Poland). In other words, currently there is no apparent need for their removal.

As a result of the sedimentation of transported material, waters downstream from the reservoir are much cleaner than those flowing to it. Nevertheless, the Włocławek Reservoir does not absorb the pollutants, since materials deposited in its bottom sediments, containing pollutants carried by the river, are not removed and they gradually accumulate over time. Moreover, waters downstream from the dam have a higher content of nutrients than the inflowing water and they may, therefore, be subject to quicker eutrophication, that, amongst others, leads to a decrease in transparency. Also the self--purification potential, based on oxidation of the carried pollutants, is drastically reduced due to the significant decrease of the flow rate. This potential is extremely high in a natural river. In the Włocławek Reservoir, deep deposits of organic sediment frequently leads to anoxic conditions in water layers close to the sediment. In the anaerobic process, phosphates are released causing an increase in water fertility and consequently, algal blooms.

The ecological changes caused by the reservoir are significant and „classical" in terms of the

The Włocławek Dam has caused deterioration of the natural environment along the lower reaches of the Vistula river, between Płock and Włocławek

The toxicity of the sediments accumulated in the storage reservoir does not exceed the intervention levels

deterioration of the ecosystem caused by a large dam and artificial reservoir. The number of fish species has decreased significantly. Migratory fish like salmon and trout have disappeared in the river upstream of the reservoir (fig. 1).

Plant species and communities of riverbed, oxbows, slopes and banks that are characteristic of meandering rivers have also been affected by creating the reservoir. The number of rare plant species in the vicinity of the reservoir has decreased by 39 with 10 of them being protected. The remaining 21 are on the endangered species list. Some plants have disappeared due to loss of their habitat (e.g. oxbows, floodplain), while others have been lost due to the changes in the water conditions – mostly the rapid increase of groundwater in the surrounding areas and a lack of water level fluctuations in the river. As a result of constructing the reservoir, unique vegetation – typical for big valleys of free flowing river, has been replaced by a common flora.

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The bird population has been affected in two ways. The number of rare birds has decreased, mostly those which are characteristic of the floodplains and sandy islands, and are

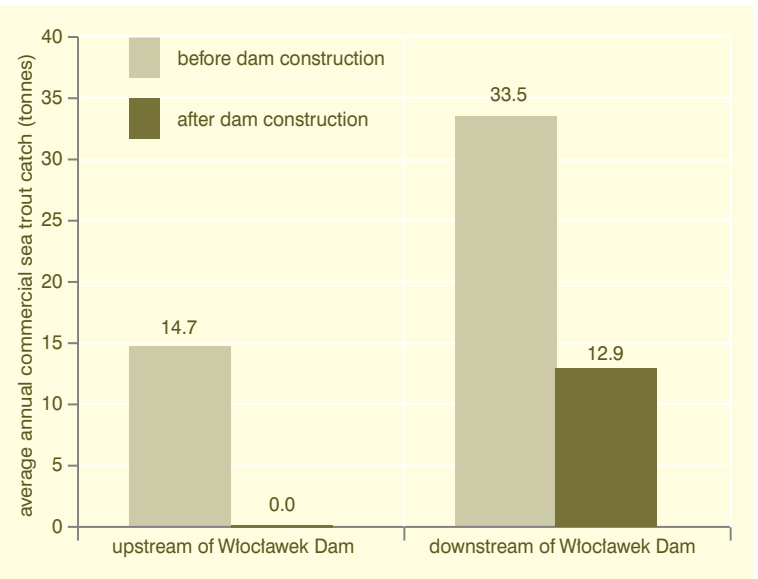


Figure 1. Average annual commercial sea trout catch in the Vistula river upstream and downstream of the Włocławek Dam: before and after dam construction

endangered in Europe and Poland generally. Most of them are listed in the Bird Directive, Bonn and Bern Conventions. On other hand, the number of common birds breeding on eutrophic lakes has increased significantly. In general, the ecological value of the area of the Włocławek Reservoir for birds is now 2 – 3 times lower then other parts of the Vistula valley (fig. 2).

The ecological losses described above have not been compensated by the economic gain. Comparative study of the communities neighbouring the reservoir (and not related with the dam) proves that there has been no increase in the economic development of the region.

The planned benefits of the reservoir construction included the increase in industrial investment in the area of Płock and Włocławek, an increase in water transport, intensification of irrigated agriculture, as well as the future development of tourism focusing on the reservoir. This forecast completely failed and none of the above points have been successfully realised.

None of the local spatial development plans of the municipalities neighbouring the reservoir connect their economic development with the reservoir. Additionally, legal obligations restrict spatial development of some lowland areas and no compensation has been offered to the landowners. It is important to keep this in mind when assessing the problems of the Włocławek Dam.

Economic analysis has shown, that the project appears to be beneficial only under the two following conditions; when:

- environmental losses are ignored,
- calculations are based on a low discount ratio, due to the low economic growth rate throughout Poland in the period 1970–2000 (in this study, 3%)

The project to build the dam at Włocławek does not achieve any economic efficiency, if environmental losses are included in the equation, or discounted at a higher rate, e.g. 10%.

The distribution of costs and benefits throughout society has been unequal.
In particular,

- The energy sector reaps the profits from the sale of electricity generated by the hydroelectric plant, but the costs of maintaining the dam and reservoir, (providing protection from floods caused by ice jams and the losses from such flooding), are borne by the taxpayer.
- The contribution of the local community to the costs and, to an even greater extent, their share of the benefits generated by the dam, are limited.

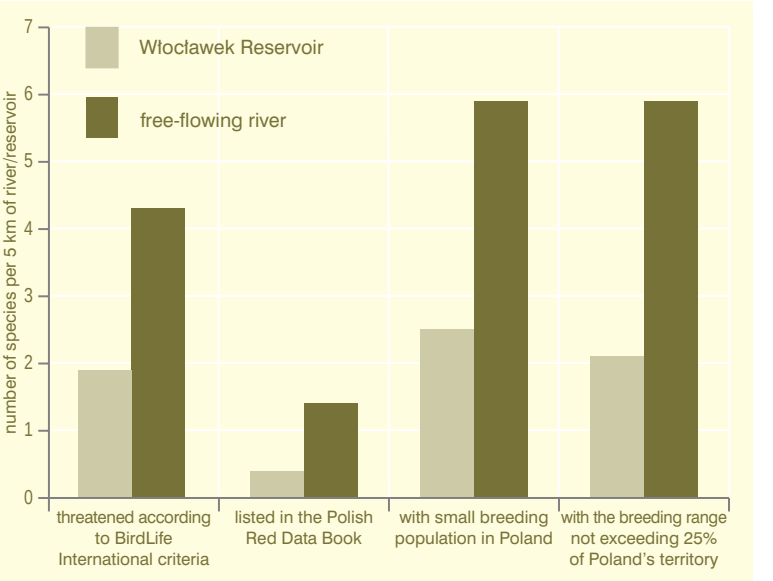


Figure 2. Comparison of the natural values of Włocławek Reservoir and free-flowing river stretch, measured by number of species of rare and threatened breeding birds

Some severe problems and threats arising from the Włocławek Dam and reservoir have been recognised. The most significant threats include the following:

- The movement of ice along the river in winter becomes blocked once it reaches the frozen storage reservoir. This considerably increases the vulnerability of flooding caused by ice jams upstream of the dam.
- The flow capacity of the dam is 20% less than that required by regulations for new projects. This lack of capacity could lead to disastrous flooding downstream of the dam, should it be breached during a high discharge event. Such a disaster could occur at a flow rate of just 10,000 m^3/s. This is particularly alarming given the likelihood of more frequent and more severe rainfall events as climate changes take effect.
- The dam has interrupted the transport of sediment by the river. As a result, sediment that has accumulated in the storage reservoir has had to be removed. Downstream effects have included an increase in fluvial erosion of the river bed. Consequently, the dam itself is actually being undermined and is becoming unstable.

None of the local spatial development plans of the municipalities neighbouring the reservoir connect their economic development with the reservoir

Insufficient flow capacity of the dam could lead to disastrous flooding downstream of the dam, should it be breached during a high discharge event

Identification of Options for Solving the Problems of the Włocławek Dam

In the course of work concerning „A Study...", seven options of solving the problems and threats of the Włocławek Dam were assessed. Hydroprojekt Warszawa submitted three proposals to the Ministry of the Environment, during the course of 1998.
During the various discussions carried out before the Parliamentary vote on resolution calling to build a dam at Nieszawa, four alternative, environmentally sound solutions were proposed by ecologists. These solutions were listed in the WWF study of May 2000 entitled „Preliminary Appraisal of Protection Methods of the Włocławek Dam, proposed by Hydroprojekt Warszawa Ltd., in Context of Potential Alternative Solutions".
Those seven options were assessed in two stages. The first stage permitted the rejection four and select the three following options for further assessment:
I – constructing a dam in Nieszawa,
II – modernising the dam in Włocławek,
III – decommissioning the Włocławek Dam.

These options were compared against the background of the „0" option, which was to leave the Włocławek Dam in its current state.

Options Rejected After the First Stage of Assessment

Four options were rejected after the first stage of assessment. The first and second options had been proposed by ecologists; the remaining two – by hydro-engineers:

- The lowering of the water level in the dam reservoir, so that the decline equals the projected one.
- Creating an additional riverbed (a passing canal) for the Vistula that would bypass the reservoir.
- Constructing the full cascade of water reservoirs.
- Constructing a permanent threshold at the lower site.

The first solution, which does not need any special investment in the dam construction, brings problems for accompanying constructions like bridges, locks, and turbine etc. Lowering the water level in the reservoir will cause the obstacles for water transport and ice passage due to significant lowering of the depth in the upper part of the reservoir. The second solution is unrealistic, as the additional riverbed should be at least 300 meters wide. The topography of the river valley makes this solution technically unfeasible.

From the point of view of solving the problems and threats of the Włocławek Dam, the last two options did not differ from the construction of the Nieszawa Dam as they all increase water levels at the lower site. For a number of reasons, it was decided that the last of the above options

will be subjected to detailed assessment and comparative analysis:

– constructing a permanent threshold at the lower site is a much worse solution than modernisation, e.g. due to lack of fish pass and navigation lock,
– the cascade of water reservoirs does not fulfil economical and environmental requirements,
– the proposal to build the new dam at Nieszawa was indicated by the team of governmental experts.

The „0" Option (comparative) – Leaving the Włocławek Dam in its Current State

This option involves an analysis of the results of leaving the Włocławek Dam in its present state and operating in accordance with the rules applied so far. Such a theoretical option should be considered in all environmental impact assessment procedures. However, due to the existing threats, this option should be only seen as a theoretical one.

Due to the existing threats linked with the dam's technical state, the analysis of this option involved, besides standard procedures, the necessity to carry out maintenance work and intervention actions in order to ensure its stability. The most important tasks, resulting from the threats and the occurring damage, are as follows:

- reinforcing the foundations and the bed of the weir's right head,
- repairing the damages under the weir's plates,
- enforcing the weir's elements which were damaged as a result of successive ice transportation actions,
- compacting the loose ground and stopping it from being washed out of the earth dam.

In order to assess the costs of this option, a scope of intervention work was accepted on the basis of the current knowledge about the dam's state and the scale of necessary work. The costs of exploitation and repair work were established as being 4 million EUR a year. With time, when the dam's technical state eventually deteriorates, the scope of necessary work will increase, and, therefore, so will the costs. However, currently, there is no budgetary allowance even for the necessary maintenance and intervention measures. This is a very unsatisfactory situation.

Option I – Construction of the Nieszawa Dam, with the Necessary Measures in Włocławek

Option I includes a solution that was considered by the government on the basis of the „Management Concept for the Lower Vistula", designed by Hydroprojekt Warszawa in 1998. It involves constructing a new dam in Nieszawa, at the 703.75 kilometre of the Vistula, which would swell the waters at the lower site of the Włocławek Dam to an altitude of 46.00 m above sea level. In the authors' opinion, this would fulfil the requirements of the necessary protection of the dam and technical infrastructure objects situated in the area. The proposed Nieszawa Dam would consist of a head dam, a weir, a power plant, a sailing gate and two fish passes. The reservoir would be 30 km long and it would reach up to the dam in Włocławek.

It should be emphasised that the suggested construction of the Nieszawa Dam would only allow for a reduction of problems arising from the bottom erosion at the lower site of Włocławek, thereby decreasing the threat of the dam's instability. Other problems concerning the dam

Construction of the Nieszawa Dam would only address the problem of the Włocławek Dam's instability, while other problems would remain unsolved

and reservoir in Włocławek would remain unsolved. These problems include:

- Insufficient flow capacity of the Włocławek Dam objects, an additional weir has to be constructed to increase flow capacity by 2,000 m^3.
- Accumulation of sediment in the reservoirs (material transported by the river), at least 300,000 m^3 of sediment must be dredged and removed from the Włocławek reservoir annually, but erosion of the riverbed downstream of the new dam at Nieszawa is an unavoidable process.
- Accumulation of ice in reservoirs and ice-jamming – this problem cannot be solved while the main reason of ice-jamming, the Włocławek Reservoir, exists.
- Halting fish migrations across the Włocławek Dam – two modern fish ladders have been planned for the Nieszawa Dam, so the very same ladders must be constructed at the Włocławek Dam. However, examples from different rivers and dams indicate, that the best fish pass will not lead to a significant increase of migratory fish populations.
- Flooding threat and insufficient drainage in low areas – side dams must be modernised, drainage systems improved and losses to landowners compensated.

The investment costs of building the Nieszawa Dam amount 346 million EUR

Before the Nieszawa Dam can be built, it is also necessary to ultimately repair the damages occurring at the lower site of the Włocławek Dam.

The estimated costs of building the Nieszawa Dam, calculated with price relations from 2000, are 302 million EUR. The costs of supplementary work described above are 44 million EUR. Altogether, the investment costs amount to 346 million EUR. Operating costs of both dams and reservoirs are estimated at 8 million EUR a year.

Option II – The Full Modernisation of the Włocławek Dam without the Necessity to Construct the Dam in Nieszawa

In this option, a proposition has been made to carry out a comprehensive modernisation of the Włocławek Dam, which would remove most of the currently existing problems and threats, and amend the dam status to one of safe operation as an independent structure on the lower Vistula. The main issue is to secure its permanent stability of all structures and preventing the erosion of the riverbed downstream of the dam.

An assessment of the current state and an analysis of the 30-year long experience of the dam exploitation so far, has led authors of „A Study...” to the conclusion that it is necessary to carry out the following:

- Construct facilities supporting the weir and the power plant, and dispersing the energy of water flowing through them. This would, at the same time, solve the problem of ground erosion beneath those structures. Supporting the weir and the power plant would prevent the danger of losing stability, even if the bottom erosion continues downstream.

▮ Protect the river's stretch downstream of the weir against further erosion. In addition, it would be necessary to design a method of transporting river sediment that is accumulating in the reservoir, towards the downstream part of the Vistula using barges. The existence of the reservoir will continue to cause sediment accumulation and, just as in Option I, there is no efficient way of stopping this process. However, plans have been drawn up to implement measures which would partially mitigate it through introducing regular sediment excavation from the upper part of the reservoir, loading it onto barges, transporting it to the lower site and building it into the riverbed downstream of the dam. Such a solution of „feeding the river" has been being applied on the upper Rhine cascade since 1977, with good results.

▮ Securing the earth dam against internal erosion; ensuring its permanent stability.

▮ Supplementary work resulting from the current state of the dam and reservoir in Włocławek.

As for Option I, it would be necessary to perform all the required supplementary tasks, which would allow for the solution of other problems

that exist at the Włocławek Dam and reservoir. These include:

– adding another weir, which would allow an increase the flow capacity by an additional 2,000 m^3/s;
– preventing ice from accumulating in the reservoir and solving the problem of the safe flow of broken ice through the new weir;
– construction of fish passes that would ensure their migration;
– improving the system of protective and drainage areas on the left bank of the reservoir.

The estimated investment costs of modernising measures in Option II are 39 million EUR and the costs of supplementary work are the same as Option I, i.e. 44 million EUR – 83 million EUR in total. Operating costs, including the transportation of sediment to the lower site, are estimated at 11 million EUR a year.

The investment costs of modernisation of the Włocławek Dam amount 83 million EUR

Option III – Decommissioning the Włocławek Dam and Transforming the Existing Reservoir into a Free-flowing River.

In line with the analysis of the situation, as well as the development perspectives for the country and for the region, the third option, decommissioning the dam, was also discussed. Such an endeavour would be based on removing the earth dam in Włocławek, with all safety measures secured. After the formation of the new riverbed, the old reservoir bed would be converted back to a natural floodplain.

The proposed solution does not involve the complete removing all of the existing structures of the dam. The most rational and practical method of achieving the intended effects would be to deconstruct a 300 meter length of the earth dam and to allow the main riverbed of the Vistula to flow through there. Other engineering components would be used, and would be designed precisely to perform their new functions. The weir, after lowering its threshold, would be used to let the high waters through and its pylons would continue to serve as bridge supports. After the upstream water level is reduced, the electric plant and the sailing gate would cease to function.

The investment costs of decommissioning the Włocławek Dam amount 48 million EUR

Gradual measures that would need to be performed during the decommissioning of the dam could be divided into two basic phases:

Phase 1 – lowering the water surface to the level permitted by the existing objects

- Restructuring infrastructure items on the reservoir banks.
- Preparing the proposed route for the river in the upper part of the reservoir.
- Gradual reduction of the water level to the weir's threshold.

Phase 2 – the complete emptying of the reservoir and the restoration of a free--flowing river

- Constructing a bridge on the public road, which would replace the stretch that goes across the top of the dam.
- Constructing a coffer-dam alongside the earth dam, on the upper and lower watersides.
- Construction of a temporary bottom sink.
- Emptying the reservoir.
- Lowering the threshold of the existing weir.
- Preparing the bottom in the perspective riverbed.
- Final de-construction of the dam.
- Arranging and managing the bottom of the old reservoir and securing the sediment strata remaining in the reservoir.
- Securing the existing components of the dam and preparing them for their new functions.

The estimated cost of all the work proposed in Option III is 48 million EUR, while the costs of maintaining the river at this stretch would be 3 million EUR a year.

Comprehensive Option Assessment

In order to assess environmental and social impacts of options, it is possible to group the three considered solutions into two variants:

- the first variant (options I and II) with one or two reservoirs exist in the valley, and
- the second variant (option III), with no reservoirs.

Social Analysis of the Options

Options I and II

This variant assumes the existence of the reservoirs for a long time. It means that all the negative aspects of the reservoir's impact will remain. The construction of the second (Nieszawa) reservoir will increase the sediment transportation problems and deterioration through erosion of the Vistula downstream from the dam. The decrease of the water level in the river (at least up to Toruń) will lead to the lowering of the groundwater levels in the valley, and might negatively affect the health resort in Ciechocinek. The negative aspects of these morphological processes will affect agriculture and to some extend tourism in the region downstream of the new dam. Tourism could develop to a small extent at the Włocławek reservoir, but no one can expect the same changes with a much smaller and narrower Nieszawa reservoir. Sedimentation processes leading to the reduced water levels in the Włocławek reservoir will cause conditions for water transport and fishery management to deteriorate.

The short-term economic benefit of the construction work in Nieszawa and Włocławek has little chance of creating the sustainable development of the region's economy. The main gain of the financial flow will go towards large (multinational) construction companies. Savings of the local people and small enterprises involved in the investment will be not large enough to stimulate the development of local industry or commerce after the accomplishment of the dam(s). The current expectation to decrease unemployment in the region through the new dam's construction does not appear to be realistic. Many workers would gain employment for only a short period of time, but even then only a few local people could be employed, as most would not be qualified. Therefore, employment would be low and limited in time.

The generation of hydropower remains the only long-lasting benefit of the proposed investment. However, the main gains are to be had for in the national energy companies, which are mostly located outside the region of investment.
Alternatively, developing the energy sector based on biomass production might be much more effective than hydropower at boosting the local economy and providing employment for unskilled workers (fig. 3).

Through the modernization of the dam (option II) and the transport of the sediment downstream,

Developing the energy sector based on biomass production might be much more effective than hydropower at boosting the local economy and providing employment for unskilled workers

the reservoir could offer long-term, but low scale, opportunities for the inhabitants. However, an external financial source has to be provided for that purpose.

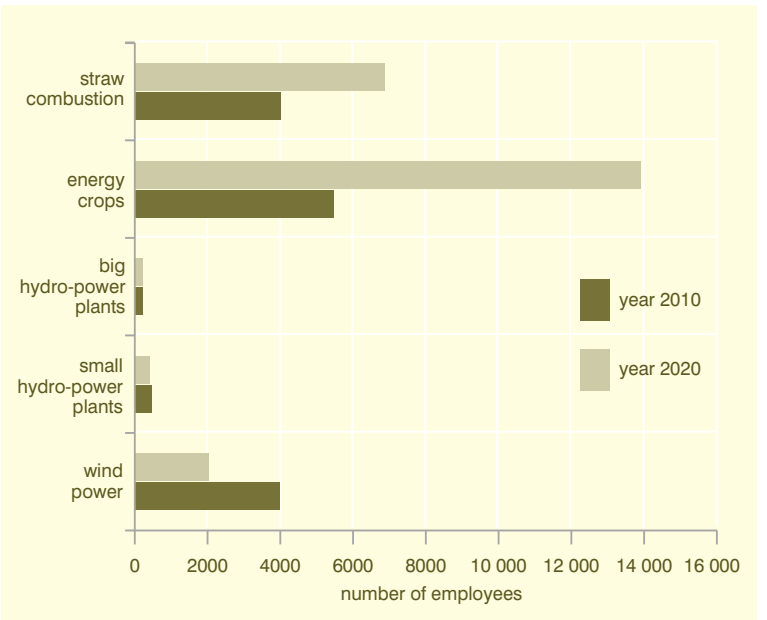


Figure 3. Predicted importance of selected renewable energy sources for creating new jobs in Poland

Option III

This option is the only one which removes the causes of:

- the floods due to the ice blockage at the reservoir,
- the bed erosion and sediment transport obstruction.

This option leads to the rehabilitation of areas which are now covered with water. The fate of these areas depends on the means of rehabilitation of the dried sediments. Some negative trends in spatial development could occur at the beginning, in some currently prospering areas. In the long-term, a free flowing river between Płock and Włocławek would attract tourists and anglers, positively influencing the community's economic development. Removal of the reservoir would help remove some of the barriers to development of some low areas, with lasting benefits.

Environmental Analysis of the Options

Option I and II

All negative changes introduced to the valley's environment by the Włocławek reservoir will remain. Eutrophication of water triggered by phosphate release from the sediment, is the main threat to the water ecosystems throughout the reservoir and downstream. The flora and fauna would remain low in terms of biodiversity, as is characteristic for shallow, eutrophic waters.

The extension of the flowthrough lake by the Nieszawa Dam will bring the same problems as indicated by the experience with the last 30-years functioning of Włocławek. The problem of sedimentation in Nieszawa should be smaller, (due to trapping most of particles in the Włocławek reservoir), however the obstruction to migratory fish would double.

Option III

This option leads to the restoration of the river valley. A free-flowing river would shape the bottom of the valley and morphological processes of erosion and sedimentation would begin once again. The question of the sediment's chemical composition is a key concern and requires additional detailed

Table 1. Economic Analysis of Costs and Benefits Associated with the Implementation of Each Option.
Values discounted at an 8% discount rate for 30 years ahead, according to price levels of 2000 and rate of exchange: 1 EUR=3.55 PLN

	Current state	Nieszawa Dam	Modernisation	Decommissioning
BENEFITS				
Włocławek Power Plant Internally	277.42	371.72	277.42	–
Włocławek Power Plant Externally	71.76	71.76	71.76	–
Nieszawa Power Plant Internally	–	69.81	–	–
Nieszawa Power Plant Externally	–	20.88	–	–
Recreational benefits	0	0	0	–
River transport	0	0	0	–
Benefits from reclaiming 3300 ha of land	–	–	–	48.14
Benefits due to increased fish catches	–	–	–	2.25
Total benefits (EUR million)	**349.18**	**534.17**	**349.18**	**50.39**
COSTS				
Electricity production – Włocławek	39.07	39.07	39.07	–
Electricity production – Nieszawa	–	14.36	–	–
Maintaining the dam and reservoir in Włocławek	41.23	50.74	126.85	–
Maintaining the dam and reservoir in Nieszawa	–	38.05	–	–
Investment costs – Włocławek (supplementary work)	–	32.70	–	–
Investment costs – Włocławek (modernisation work)	–	–	66.10	–
Investment costs – Nieszawa	–	241.66	–	–
Investment costs – decommissioning	–	–	–	38.09
Maintenance of river banks	–	–	–	28.54
Submerged areas – Nieszawa reservoir	–	2.88	–	–
Costs of floods	9.77	9.77	9.77	–
Total costs (EUR million)	**90.06**	**429.23**	**241.78**	**66.63**
Net present value (NPV)	**259.12**	**104.94**	**107.40**	**–16.24**
Internal return rate (IRR)	**–**	**15%**	**–**	**–**
Benefits/costs ratio (B/C)	**3.88**	**1.24**	**1.44**	**–**

investigation. The plant cover of the gradually exposed reservoir bed will be crucial to the success of the rehabilitation. This would need to be carefully managed and monitored.

Recolonisation of the valley areas by animals will depend on the vegetation development. As the ecological corridor, the Vistula valley will again be open for fish, birds and large mammals.

Economic Analysis of the Options

Summing up the economic analysis of the considered options, it should be emphasised that even if we do not consider the Vistula's ecological values, none of these options withstands the rigorous tests of economic efficiency or financial feasibility (Table 1). Therefore, each of the options could be dismissed solely on an economic

basis. Even the option which appears to have a good efficiency indicator (IRR = 15%) must be questioned through a closer analysis.

The analysis of the economic efficiency indicates that Option I would be attractive as a commercial investment, with the participation of budgetary means at the level of approximately 30%. This amount is more than twice as high as the total cost of Option III. Those who advocate the Nieszawa Dam do not officially formulate such high requirements regarding a tight budget. Nevertheless, these are the realistic issues that the State budget has to deal with, if the Government decides to warrant the investment's speedy conduct.

Taking the ecological values into account, the assessment clearly indicates the option of decommissioning the Włocławek Dam as an enterprise, the relatively low cost of which is justified by the high environmental benefits.

Considering the investment and operating costs of particular options and the resulting burdens for the State budget, Option III seems to be the most attractive. Investment costs of decommissioning the dam are at the level of 14% of the investment costs in Option I, while the costs of the full modernisation of the dam amount to 24% of those (Table 2).

Considering investment and exploitation costs of particular options and the resulting burdens for the State budget, Option III – decommissioning the dam – seems to be the most attractive

An analysis of social and economic effects leads to the conclusion that the only significant benefit which justifies the maintenance of the Włocławek Dam or the construction of the new Nieszawa Dam, is energy production. However, the Polish electric and energy system possesses significant power reserves and, on the other hand, the demand for electric power has stabilised during the last 12 years (despite the rapid economic growth), indicating our economy's high potential for energy savings. Besides, the liberation of the European power market will, in the context of opening the Polish market, lead to a trend towards price reduction. It is worth noting that the current German wholesale price of electricity is 30% cheaper than the present Polish price. The above arguments, as well as the dynamic development of renewable and more environmentally sound energy sources than hydro power plants, support options II and III.

Multi-criteria Option Assessment

The purpose of the multi-criteria option assessment was to identify the preferred (the best) option amongst all the options considered. A complicated system of detailed criteria that would assess the manner of satisfying all the possible needs and expectations was not attempted. Rather, a set of simplified criteria was chosen in such a way that they represented diverse needs and interests of as large and influential social or interest groups as possible. This led to the formulation of nineteen detailed criteria in total, divided into two groups:

- **Economic and social criteria** – a group containing thirteen detailed criteria in five subgroups allowing for an assessment of the

Table 2. Investment and operating costs of each option

		Nieszawa Dam	Modernisation	Decommissioning
Investment costs	EUR million	346	83	48
	% of Option I	100	24	14
Operating costs	EUR million per year	8	11	3

Table 3. Comprehensive option assessment

All criteria in subgroups and all subgroups are assigned with the same weight. The total amount of points in the social and economic criteria group is 62.5% while in the environmental group it amounts for 37.5%.

	Current state	Nieszawa Dam	Modernisation	Decommissioning
ECONOMIC AND SOCIAL CRITERIA				
Civil safety of the Włocławek Dam and Reservoir	**1.0**	**1.5**	**3.5**	**6.0**
Safety of the dam and the reservoir structures	0.0	1.5	1.5	3.0
Minimising ice-jam flooding risk in the reservoir area	1.0	0.0	2.0	3.0
Minimising public spending (budgetary and para-budgetary)	**2.0**	**3.0**	**2.0**	**5.0**
Reducing requirements for public expenditure	2.0	1.0	0.0	3.0
Possibility of non-government investment – private and/or external (e.g. international financial institutions, private sector, the EU funds)	0.0	2.0	2.0	2.0
Maximising economic effects	**3.0**	**1.7**	**4.3**	**3.0**
NPV (mainly assessing power benefits vs costs)	3.0	1.0	2.0	0.0
Economic value of other river-based market and non-market functions	1.5	0.0	1.5	3.0
Certainty of economic effects	0.0	1.5	3.0	1.5
Maximising socio-economic effects	**0.0**	**3.3**	**3.0**	**5.8**
Sharing of costs, benefits and risk	0.0	1.0	2.0	3.0
local accumulation and spending of capital	0.0	2.0	1.0	3.0
Creation of direct and indirect jobs	0.0	2.5	1.0	2.5
Impact on land availability and prices	0.0	1.0	2.0	3.0
Maximising socio-cultural effects	**1.5**	**1.0**	**5.0**	**4.5**
Aesthetic values of the landscape	1.5	0.0	3.0	1.5
Flexibility for spatial development along river	0.0	1.0	2.0	3.0
The total assessment based on economic and social criteria	*7.5*	*10.4*	*17.8*	*24.3*
ENVIRONMENTAL CRITERIA				
Conformity to sustainable development principles	**1.0**	**1.5**	**4.0**	**5.5**
Conformity to Polish ecological policy and European Union regulations	1.0	0.0	2.5	2.5
Conformity to the integrated river basin management for the Vistula and other national plans	0.0	1.5	1.5	3.0
Maximising river basin functions (services)	**2.0**	**0.0**	**4.0**	**6.0**
Improving the quality and scope of the river system functioning	1.0	0.0	2.0	3.0
Minimising the erosion and sediment formation	1.0	0.0	2.0	3.0
Minimising negative impacts on the nature	**3.0**	**0.0**	**3.0**	**6.0**
Sustaining/restoring ecological corridor of international importance	1.5	0.0	1.5	3.0
Region's biodiversity	1.5	0.0	1.5	3.0
The total assessment based on environmental criteria	*6.0*	*1.5*	*11.0*	*17.5*
GENERAL ASSESSMENT	**13.5**	**11.9**	**28.8**	**41.8**

satisfaction of the needs and expectations concerning civil safety, minimising budgetary costs, maximising the economic effect and regional development;

- **Environmental criteria** – a group including six detailed criteria in three subgroups allowing the assessment the degree of satisfaction of the needs and expectations concerning the State's environmental policy, ecological safety and justice, the current environmental protection law, minimising negative impacts on the abiotic and biotic components of the environment, as well as the quality of cultural and natural space.

Based on the recommendations of the World Commission on Dams (2000), regarding the rules of conduct while assessing various options in the investment preparation stage, environmental and social criteria must be placed on an equivalent footing with traditional engineering, economic and financial criteria. Within this report, environmental criteria were given less weight than socio-economic ones to expose life safety and socio-economic aspects – the number of points in the environmental criteria group amounts to 37.5% of the total score, while in the economic and socio-economic criteria group it equals 62.5%.

Option III – decommissioning the Włocławek Dam, proved to be the best both in terms of socio-economic and environmental criteria

The rules of option assessment were as follows. During an open discussion within the multi--disciplinary expert group, a ranking of options for each detailed criterion was established. The best option was given three points, the second best – two points, the third option – one point and the fourth option – 0. Options which could not be differentiated were given the same number of points whilst remembering that the total number of points in a row cannot exceed six points. Points given to particular options were summed-up within each of the eight criteria subgroups and correction factors were implemented if the group contained more than two criteria – so that each group had twelve points altogether.

The results of the options assessment plan are presented in Table 3. Option III, i.e. the decommissioning the Włocławek Dam, proved to be the best both in terms of socio-economic and environmental criteria (in total: 41.8 points; maximum available: 48). The third position of Option I, when only the economic and social criteria are applied, indicates that it has a number of weaknesses.

An additional assessment was carried out for all the options while assigning the weight of 60% points to the subgroup „maximising the economic effect", of the social and economic group of criteria. Other subgroups were given 10% each. Within the privileged group, 60% weight was given to NPV, and 20% to other criteria. The result of this simulation indicates that if we want to maximise the economic effect, the preferred option should also be Option II or III and not Option I (fig. 4).

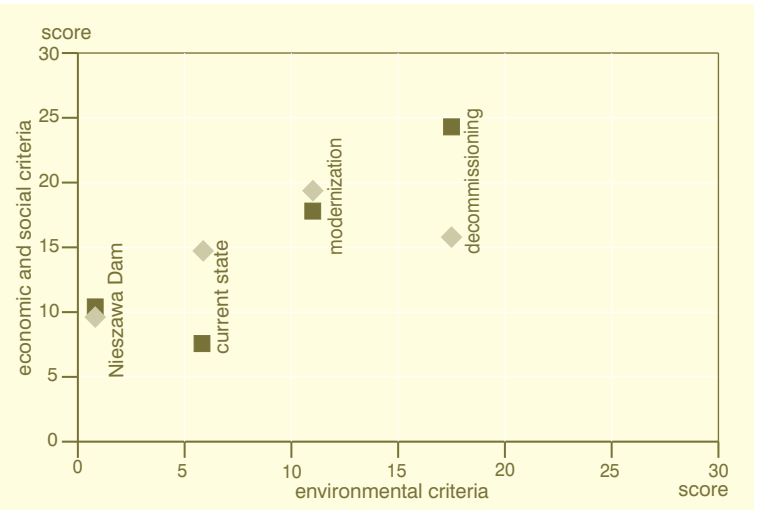


Figure 4. Multi-criteria options assessment – preference matrix

In both scenarious groups of economic and social criteria and environmental criteria were weighted so that economic and social factors accounted for 62.5% of the total score and environmental criteria 37.5%

– Scenario I – all sub-groups of criteria were weighted equally

– Scenario II – Maximizing economic effects' sub-group accounts for 60% of economic and social group score; NPV rank in turn accounts for 60% of „Maximizing economic effects" score

Conclusions and Recommendations

Lesson Learnt from the Assessment of the Dam and the Storage Reservoir at Włocławek

1. An assessment of the performance of the 1970 Włocławek Dam project on the lower Vistula river against its projected targets, and against potential national development scenarios, has shown that:

- The dam either has not met, or has only partially met, its primary and secondary objectives:
  - plan to use water from the storage reservoir behind the dam to supply industrial plants has never been implemented;
  - similarly, there have been no benefits in terms of irrigation for agriculture;
  - there have been negligible benefits for navigation; and
  - recreational use of the storage reservoir has been very limited;
  - the dam has only been successful as a source of hydroelectricity and a route across the Vistula.
- The maintenance of the dam contradicts both national development plans and long-term management objectives for the Vistula river and its catchment. There is even greater conflict between a proposal to construct a new dam on the Vistula at Nieszawa and these plans and objectives.

2. The Włocławek Dam has resulted in the deterioration of the natural environment along the lower reaches of the Vistula river, between Płock and Włocławek. There have also been negative environmental impacts immediately upstream and downstream of the storage reservoir. The most drastic impacts have been:

- the disturbance of the natural flow characteristics and hydrological regime of the Vistula river, and of the mouths of some of its tributaries;
- a reduced sediment transport downstream of the dam and a concomitant build up of sediments in the storage reservoir;
- the increased erosion of the river bed downstream of the dam;
- the increased frequency and severity of geophysical hazards – such as landslides and riverbank erosion – around the storage reservoir and an increase in the waterlogging of the surrounding area;
- a measurable reduction in biodiversity both in the Vistula river and throughout its floodplain, including the loss of many rare and important plant, bird and fish species;
- a severe or complete obstruction of the migration routes of many important fish species, many of which have now become virtually extinct upstream of the dam;
- a consequent decline in the status of the Vistula river as an ecological corridor and bird refuge of international importance.

3. Analysis of its socio-economic impacts has shown that the Włocławek Dam has failed to promote development in the region. In fact, the construction of the dam and storage reservoir, and the consequent changes to the landscape, have

contributed to a recession in the urban areas and communities lying between Płock and Włocławek:

- The presence in the landscape of the storage reservoir has not been accepted by local communities. Indeed it has been blamed for causing increased fish mortality, ice-jams, landslides, the erosion of hillsides and waterlogging of lowlands.
- The presence of the storage reservoir has been an obstacle to the economic development objectives as set out in local development plans for some neighbouring areas.
- In contrast, recent years have seen a slow but steady increase in the perceived value of the semi-natural reaches of the Vistula river – such as the reach upstream of Płock – as an attractive place for homes and recreation.
- Awareness of issues and threats among local communities continues to be low and public opinion has been distorted by the dissemination, (by both proponents and opponents of the Lower Vistula Cascade), of incomplete information and even propaganda.

4. The evidence suggests that the Włocławek project cannot be regarded as a success even from a purely economic point of view:

- The fact that land and property prices have not risen significantly shows that the perceived attractiveness of the area around the dam and storage reservoir has not resulted in any tangible benefits.
- When discounted at a low rate (3%) the estimated net present value (NPV) of the dam project – 230 million EUR – suggests that it has achieved economic efficiency. However, this does not take account of the low economic growth rate throughout Poland between 1970 and 2000. In other words, the project appears to be economically worthwhile only when considered against the backdrop of poor economic performance of the wider economy.
- When discounted at a higher rate of 10%, or when the costs of environmental losses are included in the equation, the dam is clearly economically inefficient, i.e. the costs of investment, construction and maintenance have far outweighed the benefits.
- The distribution of costs and benefits through society has been unequal. In particular,
  - The energy sector reaps the profits from the sale of electricity generated by the hydroelectric plant but the costs of maintaining the dam and reservoir, (providing protection from floods caused by ice jams and the losses from such flooding), are borne by the taxpayer.
  - The contribution of the local community to the costs and, to an even greater extent, their share of the benefits generated by the dam, are limited.

5. The most significant threats arising from the Włocławek Dam include the following:

- The movement of ice along the river in winter is blocked once it reaches the frozen storage reservoir. This increases the vulnerability of flooding caused by ice-jams upstream of the dam.
- The flow capacity of the dam is 20% less than that required by regulations for new projects. This lack of capacity could lead to disastrous flooding downstream of the dam should it be breached during a high discharge event. Such a disaster could occur at a flow of just 10 000 m^3/s. This is particularly alarming given the likelihood of more frequent and more severe rainfall events as climate change takes effect.
- The transport of sediment by the river has been interrupted by the dam. As a result, sediment that has accumulated in the storage reservoir has had to be removed. Downstream effects have included an increase in fluvial erosion of the channel bed. Consequently, the dam itself is actually being undermined and is becoming unstable.

Conclusions and Recommendations from the Options Assessment

After a preliminary assessment of 7 potential management schemes, 3 options for mitigating the threats arising from the Włocławek Dam were considered in depth:

- Option I: Construct a new dam at Nieszawa and undertake the necessary supplementary work on the Włocławek Dam.

- Option II: Maintain the Włocławek Dam as the only structure on the lower Vistula river, but undertake works to guarantee its safety and mitigate adverse environmental impacts.

- Option III: Decommission the Włocławek Dam and gradually restore the Vistula into a free-flowing river, while maintaining the current motorway crossing.

A comparison of these 3 options generated the following conclusions and recommendations.

1. Construction of a new dam at Nieszawa can only exacerbate the adverse environmental and socio-economic problems caused by the existing dam and storage reservoir at Włocławek.

2. The gradual decommissioning of the existing Włocławek Dam and reduction in the level of the storage reservoir is the most sustainable option for solving those problems.
Option III: Dismantling the earth part of the dam will facilitate unimpeded sediment transport and remove the principle cause of ice-jams. The accumulation of toxic sediments and nutrients in the storage reservoir will be resolved by the natural cycling of material. This is the only option that would ensure the restoration of the natural processes, and associated environmental, social and economic functions, of the Vistula river.
Option II: Modernisation of the existing Włocławek Dam will only partly resolve the problems caused by impeded sediment transport and associated downstream erosion. Transporting accumulated sediments from the storage reservoir to downstream sites by barge is not a sustainable option. Improved movement of ice through the dam will reduce, but not eliminate, the probability of ice-jam formation and consequent flooding.
Option I: Construction of a new dam at Nieszawa will not solve the problems caused by impeded sediment transport and the accumulation of sediments in storage reservoirs. The increased erosion of the channel bed will simply occur downstream of the new dam instead of below the existing dam. Construction of the new dam would actually increase the probability of ice-jam formation behind storage reservoirs and therefore increase the area vulnerable to winter flooding.

3. Available data suggests that the toxicity of the sediments accumulated in the storage reservoir does not exceed intervention levels. However, further detailed technical studies on this issue would be required before the Włocławek Dam could be decommissioned. Appropriate measures would be needed to limit the risk to people and wildlife of rapid flushing of the sediment during the decommissioning process.

4. The design of the fish ladders in the dam scheme as currently proposed is simplistic and inadequate. If, despite the conclusions offered by this options assessment, the decision is made to press on with the modernisation of the Włocławek Dam and/or the construction of the new dam at Nieszawa, design of the structures should take account of best European practices in fish ladder construction.

5. As mentioned above, Option II – modernisation of the existing Włocławek Dam –will not resolve all the current problems. It is also likely to be more expensive than Option III. However, it is probably the least complicated option and could be implemented over a 2–3 year period. The first phase would involve the construction of a stage to support the weir and the power plant and to stabilise the dam. The cost of this would be 16 million EUR. The next step would be the construction of erosion control barriers downstream of the dam, followed by the transportation of sediments accumulated in the upper part of the storage reservoir to a downstream reach.

6. The vast potential in Poland for energy efficiency, the existing surplus of energy supply over demand, the strong probability of substantial future reductions in energy prices in free market conditions and the rapid development of renewable energy sources other than hydroelectricity are all strong arguments in favour of Option II or Option III.

7. None of the three favoured options stood up well to the stringent tests of economic efficiency or financial viability. Taking account of investment costs, the total costs of the three options were as follows:

Option I: 346 million EUR
Option II: 83 million EUR
Option III: 48 million EUR

When the public spending implications of these figures are considered, Option III, deco-mmissioning the Włocławek Dam, clearly emerges as the favoured option. Option III would also achieve optimum socio-economic and environmental results.

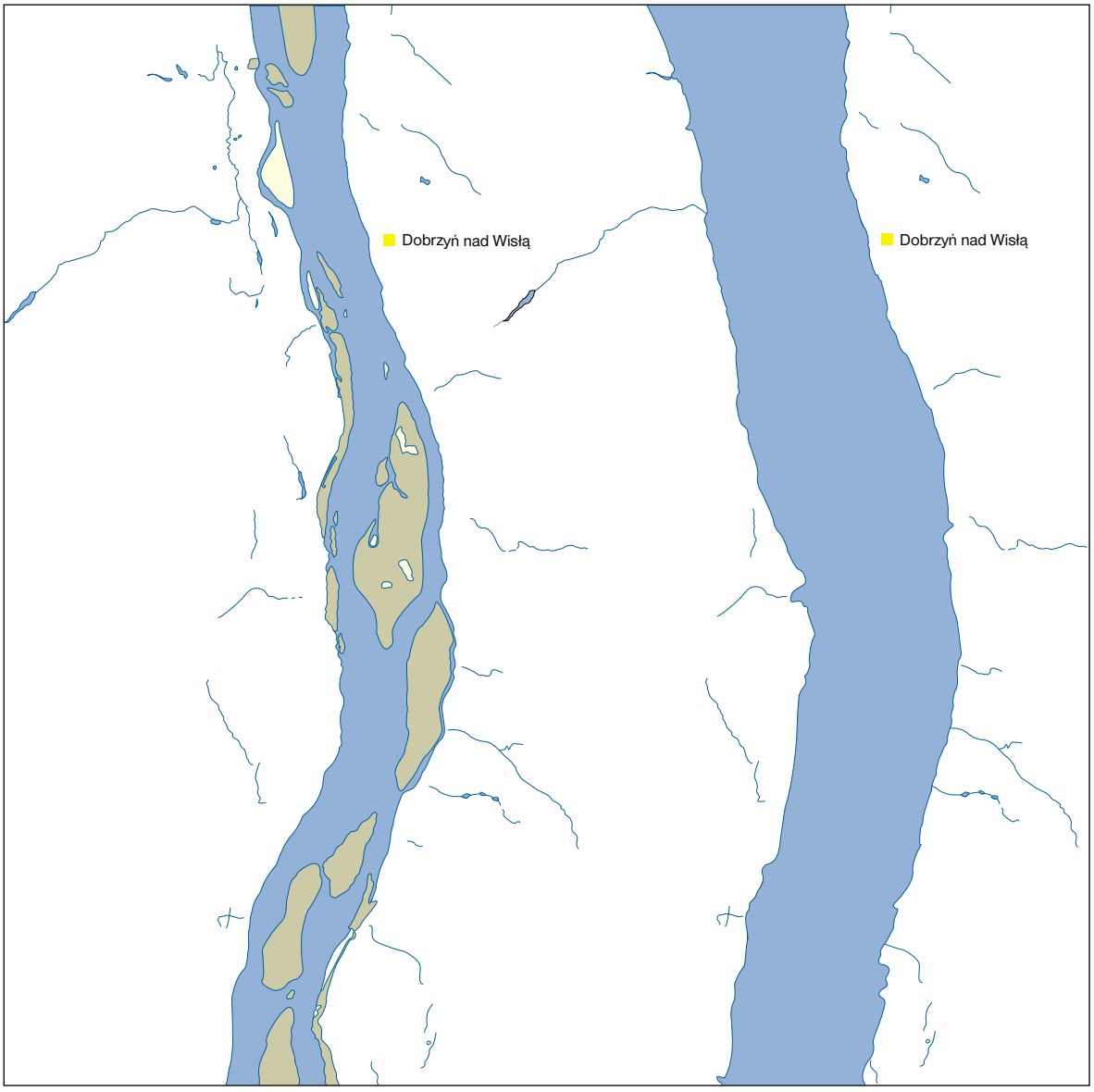
8. Comprehensive multi-criteria options assessment indicates clearly that Options II and III are better than Option I. In the final analysis, Option I was even out-performed by the option of maintaining the status quo (which was discounted after the preliminary analysis because it would not achieve the principal objective – securing the safety of the dam).

The continued maintenance of the existing Włocławek Dam and storage reservoir can only be justified as a means of generating hydroelectric power. Therefore, if Option II is taken, all costs arising from maintenance should be borne by the operator – the Włocławek Hydroelectricity Plant Co. Ltd. A water use license should set out the following obligations on this company:

- the modernisation of the dam according to the recommendations set out in this report;
- the ongoing maintenance and repairs; and
- the operation of the dam, the storage reservoir and its backwaters, including the transport of accumulated sediments to downstream reaches.

The costs of these activities should be covered by profits gained from the sale of energy. There should be no subsidy from State budgets (i.e. from taxpayers). In the future, the role of the Regional Board for Water Management in Warsaw, which has hitherto had responsibility for management of the dam, should be limited to maintaining an overview of the operation of the dam in the broader national interest.

There is a need for a long-term management strategy for the Vistula river and its catchment. The strategy should reflect the principles of sustainable development as established in Polish and EU legislation. Future decisions on schemes that are likely to have adverse and potentially permanent impacts on the ecological functioning of the Vistula, and its catchment, such as the maintenance and construction of the dams at Włocławek and Nieszawa respectively, should be made in accordance with this strategy.



The section of Vistula River valley near Włocławek, before and after the construction of the Włocławek Dam

This multi-option study, undertaken thanks to WWF, is an interesting extension of the work begun in 2000 by a Team of Experts appointed by the Council of Ministers' Economic Committee which called for a continuation of previous studies on this subject. Therefore the submitted study should be appreciated. It reassesses proposals: to build a dam at Nieszawa--Ciechocinek, to modernise the existing dam at Włocławek, and to decommission the Włocławek Dam – the latter option having been previously rejected by the Team of Experts. Without a doubt, the results of the multi-criteria assessment of these options will continue to stimulate further discussion and analysis.

Prof. Dr. hab. Janusz Kindler Eng.
Dean of the Department of Environmental Engineering
Warsaw University of Technology

I believe that this is a very objective and comprehensive study, which assesses potential solutions to the problems of the Włocławek Dam and Reservoir, including the option to construct a new dam at Nieszawa, using economic, social and environmental criteria. The conclusions from the study should be taken very seriously.

Prof. Dr. hab. Kazimierz A. Dobrowolski
Vice-chairman of the State Council for Nature Conservation

This report is very valuable and helpful, mostly because of the conceptualisation of the aforementioned „ideas", and because of the use of „independent experts' opinions" at a level enabling the comparison and analysis of multiple variants. This has led to the elimination of „unrealistic" concepts from further discussion.

Janusz Kurzelewski MSc. Eng.
Expert in hydro-construction

It may be said that this report deepens our understanding of the problems of the Włocławek Dam and its operation, and highlights possible new solutions to them. It also demonstrates the necessity of exchanging ideas and proposals from different sources, independently of current concepts. This should lead to an optimal solution.

Prof. Dr. hab. Jan Żelazo Eng.
Professor at the Faculty of Engineering and Environmental Science
Warsaw Agricultural University

The overview of the study entitled „A Study of a Comprehensive Solution to the Problems of the Włocławek Dam and Reservoir – Anticipated Social, Economic and Environmental Effects" was prepared by the WWF (World Wide Fund for Nature). The full text of „A Study..." in Polish, as well as English Overview are available at the WWF Poland Country Office in Warsaw:

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