Atdorf Pumped Storage Plant - Permitting Requirements for a Large-Scale Project in Germany

Michael Fink
Schluchseewerk AG
Deputy Project Director Atdorf PSP
Säckinger Strasse 67
79725 Laufenburg
Germany

Reinhard Fritzer
ILF Consulting Engineers
Hydropower, Dam and River Engineering
Feldkreuzstrasse 3
6063 Rum / Innsbruck
Austria

Martin Pehm
ILF Consulting Engineers
Traffic and Transport
Feldkreuzstrasse 3
6063 Rum / Innsbruck
Austria

Introduction

Schluchseewerk AG, which was founded in 1928, is a specialised pumped storage plant operator in the South West of Germany. The company owns five pumped storage plants (PSPs) with a total of 20 turbines/pumps and generates 1,800 MW by turbine operation and 1,600 MW by pump operation. The last of these five plants was commissioned in 1976. In 2008, plans were publicly announced to develop the Atdorf pumped storage plant (PSP). With a capacity of 1,400 MW it will be one of the most powerful PSPs in Europe.

In late 2010, a consortium consisting of ILF Consulting Engineers (ILF) and AF-Consult (AFC) was awarded the contract to perform the overall design services for this hydropower project.

The consortium is now in the process of finalising the permit application documents. A large part of the application documents has already been submitted to the permitting authority, the District Administration Office of Waldshut in the German state of Baden-Wuerttemberg. The documents have already been checked for completeness and were declared to be complete. The *Planfeststellungsverfahren*, in short PF procedure, a permit application procedure which includes the EIA, was officially launched in June 2012, and will presumably end in 2015 with the *Planfeststellungsbeschluss*, the final decision of the approval authority. A positive decision of the approval authority will cover all the permits needed for the construction and operation of the plant.

This paper starts with a short introduction of the planned HPP project. It includes a description of the location and size of the project area, the technical data, the key plant components and the design strategy. Several civil and water engineering activities have been selected to illustrate how the design of the construction works was improved to minimise possible impacts resulting from noise, dust, vibrations and land use, especially during construction. Further optimisation initiatives were aimed at improving the functionality and profitability of the project.

A quick overview is given describing the design procedure, the PF procedure as well as its timeline in Germany in general. A description is provided, which explains the comprehensive and complex nature of the application documents needed for a PF procedure and which outlines the specialist disciplines involved.

The Atdorf PSP is used as an example to explain which requirements a large-scale project, which is in the public eye, has to meet today in order to successfully complete the permit application procedure in Germany. The key role played by environmental, technical and legal issues in such a permit application procedure is also discussed. Various factors affecting the timeline of the design procedure and the permit application procedure are also indicated.

The important ecological assets which need to be protected, such as Natura 2000 areas and protected species, are addressed. The extensive planning and design works with respect to compensation measures are also presented in brief.

1. Short introduction to the Atdorf PSP

1.1 Location of the project area

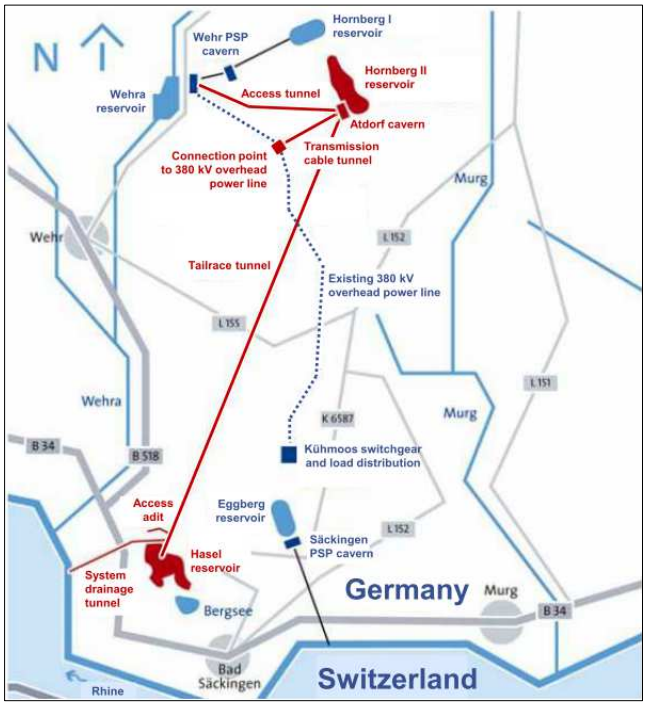

Fig. 1. Overview of the project area

The location of the project site is outlined in red in Fig. 1. The project area is located in the south of the Black Forest in the German state of Baden-Wuerttemberg. The upper reservoir (Hornberg II reservoir) of the Atdorf PSP is located in the immediate vicinity of the Hornberg I reservoir, which is the upper reservoir of the existing Wehr PSP of Schluchseewerk AG. The lower reservoir (Hasel reservoir) is located north-west of the city of Bad Säckingen, close to the Rhine river.

The space required for the above-ground facilities amounts to approx. 135 ha. The geology of the project site is well known from the neighbouring facilities of Schluchseewerk AG and was found to be well suited for this type of project. Extensive geological and mainly hydrological investigations still had to be performed.

The upper reservoir and the lower reservoir shall be linked by a system of tunnels. The powerhouse cavern is planned to be located approx. 710 m below the upper reservoir. The approx. 8.5-km-long tailrace tunnel will connect the powerhouse cavern with the lower reservoir.

The below-ground facilities in the surroundings of the powerhouse cavern and the transformer cavern will be accessible from the premises of the existing Wehr PSP via a 3.2-km-long access tunnel.

A new 380 kV overhead power line will not have to be installed, as the existing power transmission system between the Wehr PSP and the Kühmoos switchgear can be used. It only has to be upgraded with additional conductors, stronger pylons and tower cross arms. In addition to the power transmission system, the plant premises of the Wehr PSP can also be used. These synergy effects will presumably have a positive effect on the permit application procedure.

1.2 Key technical data of the Atdorf PSP

The key technical data of the Atdorf pumped storage plant (PSP) can be summarised as follows:

- Live storage: 9 million m³ per reservoir
- Head approx. 600 m
- Flow rate (pump operation / turbine operation) approx. 200 / 270 m³/s
- Installed capacity: 1,400 MW, working capacity: approx. 13 GWh
- Six machine units, machine type: single-stage Francis pump turbine, operating capacity of turbine operation: approx. 60 to 1,400 MW, operating capacity of pump operation: approx. 160 to 1,400 MW

The implementation of this power plant would lead to an increase in the pumped storage capacity in Germany of almost 25%. This underlines the importance of this project from the energy policy and security point of view.

1.3 Design strategy and operating concepts of the Atdorf PSP

The operating requirements to be met by the Atdorf PSP, especially with respect to flexibility as well as availability and reliability, are very stringent. On the one hand, the plant shall be designed for grid control (primary control, secondary control, minutes reserve) and, on the other hand, for energy storage. The operating modes comprise pump operation, turbine operation and reactive power provision.

These requirements are not just to be met by the mechanical equipment, but especially by the hydraulic system (headrace and tailrace tunnel system) in order to prevent operational constraints and to ensure a plant availability and reliability of up to 100%.

1.4 Components of the pumped storage plant

The main plant components are described below (please also refer to the schematic longitudinal cross-section of the headrace and tailrace tunnel system in Fig. 2, as well as to the 3-D graphic of the tunnel and cavern system in Fig. 3):

- Upper reservoir with bituminous concrete surface sealing and ring dam as rockfill dam, including two intake towers
- Two 710-m-long vertical pressure shafts with inner diameters ranging from 4.8 m to 5.0 m
- Powerhouse cavern and transformer cavern with access and logistics tunnels
- Tailwater surge facility consisting of a vertical shaft and several surge chambers
- 8.5-km-long tailrace tunnel with an inner diameter ranging from 8.5 m to 10.2 m
- Outlet structure in the lower reservoir
- Lower reservoir with main dam constructed as roller-compacted concrete (RCC) dam and two other dam structures constructed as rockfill dams, partially with bituminous concrete sealing

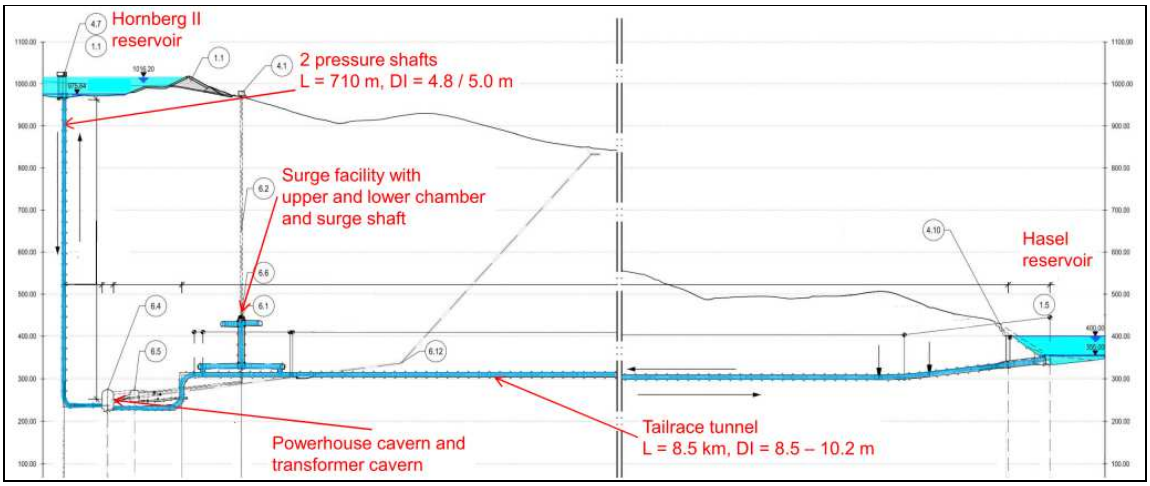

Fig. 2. Longitudinal section of the headrace and tailrace system

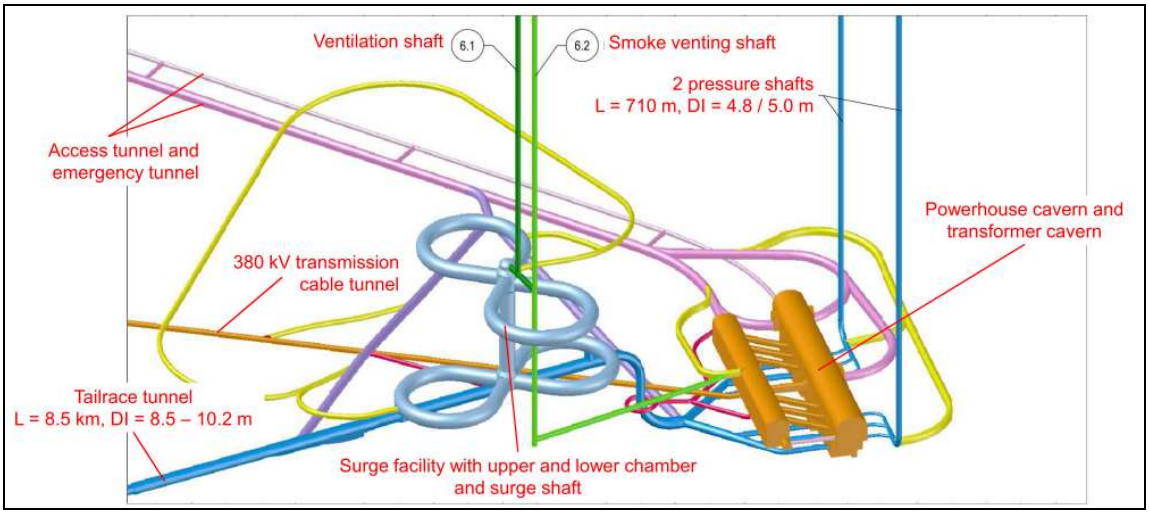

Fig. 3. Tunnel and cavern system incl. surge facility

2. Permit application requirements of the project

2.1 General requirements to be met by a project which is subject to a permit application procedure under German law

In Germany large-scale construction projects require a two-stage permit application procedure. The first stage, the *Raumordnungsverfahren*, a spatial planning procedure, serves to determine the general feasibility of the project as well as the effective integration of the project into the surrounding environment. Once the spatial planning procedure has been completed successfully, the second stage, the *Planfeststellungsverfahren*, a permit application procedure, serves to acquire the ultimate authority approval.

As a rule, the permit application procedure for a hydropower project is effected by the responsible *Landratsamt*, the district administration office, or the responsible *Landkreis*, the administrative district. Especially with large-scale projects, which affect more than one district, this procedure may be transferred to the *Regierungspräsidium*, the superior district government.

In contrast to the spatial planning procedure, the permit application procedure requires the preparation of a detailed technical design. Apart from the constructional design of the hydropower plant, this mainly involves in-depths statements on the hydrology, geology and hydrogeology but also on the seismicity of the project area. As a basis for these expert reports, exploration programmes are generally implemented and groundwater, spring and river monitoring campaigns are conducted over representative periods of time. In addition to this, expert reports on sound, vibrations, climate/air, soil, etc. but also on the project's significance from the energy policy and security perspective are prepared, using pertinent investigations and calculations.

The description of the environmental impact represents a key component of the permit application procedure. This requires a thorough mapping of the project area. The environmental study contains information on the existing flora and fauna and describes the impact of the project on the individual ecological assets. On account of the legal framework conditions, particular importance is to be attached to the application parts "Protection of Species" as well as "Natura 2000 Appropriate Assessment", i.e. an impact study for Natura 2000 sites. The *landschaftspflegerische Begleitplan*, the environmental impact mitigation plan, describes the mitigation and compensation measures needed to compensate the project impact on the individual ecological assets.

If a priority habitat type or species is affected, the opinion of the EU commission is to be sought. If significant interventions in Natura 2000 areas are to be expected, an exceptional authorisation procedure is to be performed. This procedure not only requires "imperative reasons of overriding public interest" to be stated but it also requires a compulsory assessment of alternatives to be carried out. A comparison of alternatives is to be made to demonstrate that there is no reasonable alternative to the project for which the permit application has been submitted. As a rule this also includes a review and assessment of alternative sites.

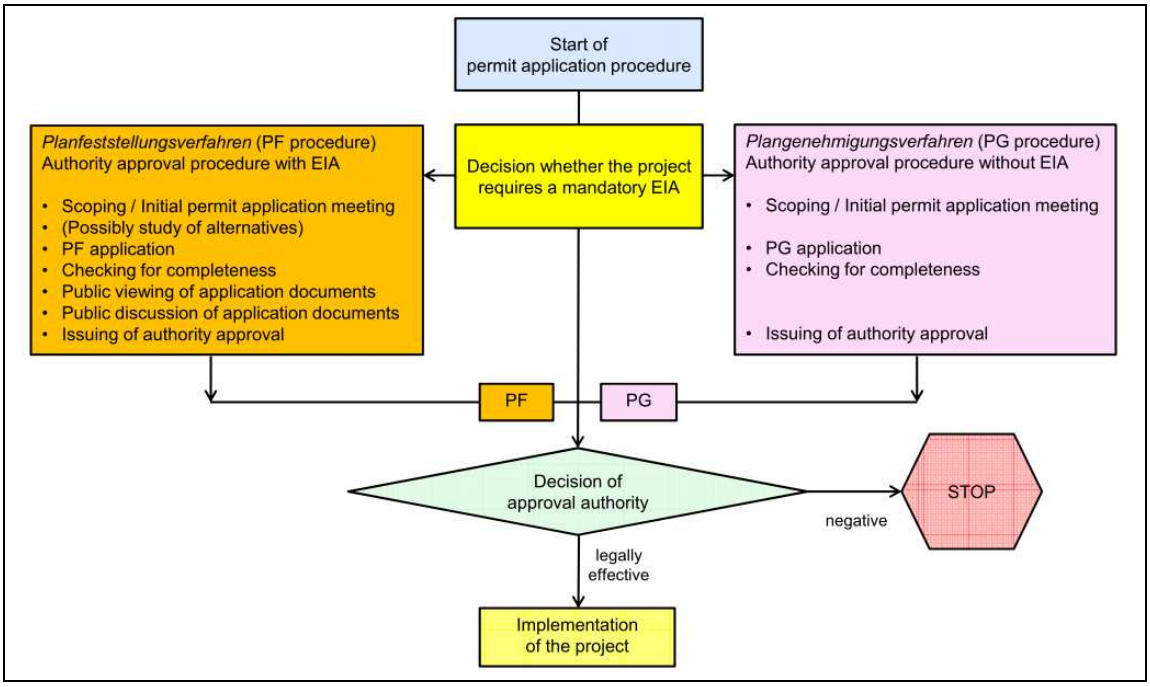

Fig. 4. Flow diagram illustrating the permit application procedure

2.2 Key challenges and optimisation initiatives during the technical design of the Atdorf PSP

After ILF and AFC were commissioned with revising the conceptual design and the permit application design, the respective design concepts were checked in detail. Following the design review, an intensive discussion and decision-making process, which involved all project participants of Schluchseewerk AG was launched, before individual project optimisation initiatives were integrated into the design (see also Lit. 4).

One key task was to optimise the existing design to improve the project's chances of receiving authority approval. The main task consisted in reducing adverse impacts during the construction phase. To this end, the construction sequence and the material logistics, as well as the excavation material and transport concept below and above ground were analysed and optimised with respect to space requirements, traffic emissions, noise, dust, vibrations and temporary material storage.

The permanent space requirements in the operating phase were also reduced to a minimum. In the course of these design activities, it was also possible to reduce the number of sites required for the disposal of material from the excavation of the upper and lower reservoir. As a result, some of the initially planned muck disposal sites in ecologically sensitive areas could be eliminated.

These modifications were presented to the authorities, but also to the communities and the residents affected, as well as to environmental organisations, and received a positive response.

In the course of the environmental planning and the permit application design as well as the preliminary review of the project by the authorities, additional topics were identified, which turned out to be very challenging for the engineers, but which could be solved successfully in a joint effort of all project participants. As an example, reference shall be made here to the topic of earthquake safety for the dam structures. In this context, new ground has been broken with respect to analysing and defining the probability of earthquakes occurring in fault zone areas located close to the project area. With the help of experienced external scientists and experts specialised in seismology it was possible to resolve this issue.

The Atdorf project involves constructing a total of 26 km of tunnels and shafts, where groundwater inflow may occur. Sealing the underground structures was found to be necessary to minimise the impact of the construction works on the groundwater regime and thus on the surface water regime including wetlands, springs and rivers. Here too, new ground has been broken as regards the systematic design of sealing solutions and the assessment of the remaining drainage impact as well as the interrelations of hydrology and ecology.

Apart from adjusting the project to obtain authority approval, the project was furthermore optimised in terms of plant functionality and operation efficiency. These optimisation initiatives included for example numerical and physical model tests for the headrace and tailrace system, the surge facility and the outlet structure in the lower reservoir (see also Lit. 1., 2. and 3.) to deliver a layout which is perfectly tailored to the project requirements.

The actual building structures were also optimised with regard to design considerations, material selection and construction works, and last but not least cost effectiveness. One example is the RCC dam of the lower reservoir (instead of the initially planned rockfill dam), which will now be constructed using tried and tested concrete technology.

Another key objective of the permit application design was to allow for the greatest possible flexibility in the implementation of the project, despite the very detailed preparation of the permit application documents. Ultimately, every design shall present the project in a positive light not only as regards approval but also as regards plant functionality and cost efficiency, in order to reach a positive decision for the plant to be built.

2.3 Focal points of the environmental planning and the permit application design of the Atdorf PSP

The environmental planning and the permit application design of the Atdorf PSP require very comprehensive environmental investigations. In the scoping of the permit application procedure, an investigation area of more than 4,500 ha was defined, which was later even expanded to 6,000 ha due to additional findings. At times, teams of more than 30 biologists were in the field to collect survey data.

The main focus of these survey works was on a comprehensive and detailed documentation of biotope types, as well as groups of plant and animal species, including mosses, lichens, birds, bats, reptiles, fish, locusts, beetles, dragonflies, crayfish and macrozoobenthos. In addition to this, comprehensive investigations were performed focusing on the remaining impact during construction, which could not be eliminated despite successful optimisation efforts (see information above). These investigations included projections of construction noise exposure for the resident population down to the individual building, as well as residual air pollutant imissions. The investigations also included a separate expert opinion on vibrations due to blasting, construction and traffic, and even an expert impact assessment on construction site lighting during morning and evening hours. In the end, also as a result of extensive optimisation measures with respect to construction sequence and logistics, compliance with the respective

legal limit values could be ascertained in almost every respect. Where compliance cannot be achieved, additional protection measures (e.g. sound protection measures for certain residential buildings) will be taken.

As regards the impact of the underground structures' drainage effect on the environment, especially on rivers, springs and groundwater-dependent biotopes, extensive mapping and investigation activities will be required. Due to the size of the project area and a lack of precision in the phrasing of the legal regulations, in some instances new ground has also been broken with respect to the methodological approach.

2.4 Special challenges in the permit application procedure

The authorities responsible for project approval are generally positive towards the project, and initially were optimistic about the timeline for the permit application. However, in the course of the permit application procedure some challenges emerged, mainly concerning the following issues:

- Scope and complexity of the project which led to very comprehensive design and planning documents and expert opinions
- Involvement of many different authorities
- Local and regional authorities' limited experience with large hydropower projects and the necessity to employ additional experts on part of the authorities
- Ambiguous or non-existent legal regulations and policies due to the fact that no pumped storage projects have been approved or built in Germany in the last decades
- Additional requirements regarding public participation which resulted in an exemplary but also very complex solution in the form of round table discussions
- A lack of experience and specifications for implementing nature conservation requirements for pumped storage projects, such as how to handle hydrogeological effects with regard to Natura 2000 (Habitats Directive)

The most recent pumped storage projects were planned and built in the 1970s in Germany, in a completely different regulatory environment. (The Goldisthal pumped storage plant built in the 1990s is a special case which was implemented with simplified procedures in the course of the German reunification). That is why initially the authorities and Schluchseewerk AG had no up-to-date experience of how to proceed with the permit application and approval of a pumped storage plant in Germany. This challenging initial situation was also analysed by the EU research project "Facilitating energy storage to allow high penetration of intermittent renewable energy – stoRE" (Lit 5).

2.5 Legal situation

Another particularity is that in the relevant laws and regulations PSPs are not explicitly mentioned in the lists of projects. As a consequence, the project had to be broken down into several separate permit application components: the upper reservoir as technical water storage facility, the lower reservoir as artificial water body, the headrace and tailrace systems as pipelines, and the caverns as structures. The overhead power line was the only component for which directly applicable legal specifications were in place. These separate permit application components are now combined in one permit application procedure. There are a number of other subject areas for which sufficient legal regulations are not available in Germany, such as nitrite pollution of construction site wastewater or assessment of earthquake safety. That is the reason why in some cases international regulations were used, as were legal regulations of neighbouring countries (especially Switzerland and Austria) having more experience with large-scale hydropower facilities.

2.6 Coordination with authorities

On account of the challenges described above, a unique course of action for the permit application procedure was agreed with the authority at an early stage. The authority was integrated in the design process early on, with close coordination of authority, Schluchseewerk AG, designers and experts. This was done by holding intensive, regular meetings (at least on a monthly basis) and by processing the application documents.

Usually a client prepares all the application documents together with designers and experts and then submits them in a package directly to the approval authority for a formal check for completeness. For the Atdorf PSP a different procedure was chosen. In a first round, the authority received all parts of the application for an informal preliminary check. In the process, the majority of the documentation was divided into several parts and submitted progressively from mid 2011 until early 2013. The feedback from the authority was examined, discussed with the authority and either integrated into the documents or rejected stating a reason for rejection. In the 18months of the preliminary

check, the authority made several thousand comments, all of which have been processed in the meantime. Since mid 2012 the documents that have passed this quality check are submitted progressively for the formally intended completeness check. In this second round of review, the authority has only issued a few minor comments. Additionally, Schluchseewerk AG has agreed to having the authority appoint independent experts for specific topics (e.g. earthquake safety, structural analysis of caverns, underground works, hydrogeology). They will be paid by Schluchseewerk AG and will assist the authority by making their technical expertise available.

Fig. 5. Submission of extensive permit application documents for review by the authority (June 2012)

This course of action results in top quality documents, as can be seen from the low number of authority comments in the second round of review (check for completeness). However, this course of action also entails great effort in terms of time and cost. In the end, the process of compiling and reviewing all application documents will have taken more than three years.

2.7 Public participation

Public information and participation have played a very important role for the project right from the start. Since 2009 more than 100 information events have been conducted. The growing significance of public participation also becomes evident through the organisation of a “Round Table” for the Atdorf project; the Round Table was set up at the recommendation of the state government. Intensive preparations for the round table discussions took place in the first half of 2011; from June to December 2011 six plenary meetings were held as well as numerous preparatory and follow-up workshops. More than 40 stakeholders were included in this independently organised and moderated process, which contributed to making the discussions more objective. This process has so far been unique in Germany because it was financed by the client at a cost of more than 1 million Euros.

2.8 Environmental planning

Another challenge only became evident in the course of the environmental planning. Although the location of the project has been chosen to avoid any direct negative impact of construction sites on areas protected under the EU’s Flora-Fauna-Habitat Directive, it was found that indirect negative effects on nearby protected areas as a result of construction and subsequent operation cannot be excluded with the required degree of certainty. Examples are the extensive underground structures and the associated potential hydrogeological effects on wetlands, springs and rivers.

Due to the scope of the project and the partly very valuable natural assets, very comprehensive ecological compensation measures will be required in order to comply with the stringent nature conservation specifications. All in all, compensatory measures will be implemented in an area covering some 700 hectares; the earmarked budget is in the range of a high, two-digit million Euro figure. As a large portion of the interventions affects forest areas, this is where the focus of the compensatory measures is placed. In numerous individual areas in the municipalities located around the project site, the forest structure and composition will be improved, returning the forest to a near-natural state and ending its silvicultural use. For numerous rivers and springs ecological improvement measures are

also planned. In the course of this process, targeted, specific measures will be implemented for more than 70 animal species in order to improve their habitat conditions and to compensate for the areas that will disappear.

2.9 Economic framework conditions

At the time of the start of the project in 2008, the economic framework conditions for the operation of PSPs were very attractive. The project was originally pursued with great urgency: the initial plan was to start construction in 2012 and to put the plant into operation in 2018/2019, among other things because there was a time limit until 2019 for financial incentives for the construction of PSPs.

From 2010 on the economic situation started to change, with this change becoming more pronounced recently. The price margin between base load electricity and peak electricity, and the overall price level on the electricity market have greatly decreased, partly due to the rapidly growing electricity generation from renewable energy sources and the available pertinent funding mechanisms. Furthermore, the price levels for grid services such as primary control, secondary control and minutes reserve have recently fallen. Last but not least, the investment strength of the power corporations has also decreased due to developments on the energy markets. All in all, this means that investments in new PSPs are currently not attractive from a commercial point of view, although their necessity from an energy policy and security perspective is confirmed by the great majority of experts. This situation has been addressed by decelerating and making the time schedule more flexible, offering an opportunity to react in the best possible manner to future developments on the market. Schluchseewerk AG assumes that the services of PSPs will be required on a permanent basis and that this will also find expression in the remuneration situation in the medium and long run.

3. Outlook

By the end of 2013, all application documents will be submitted to the approval authority. Subsequently, the complete package of permit application documents will officially be made available for public viewing. In this period, residents, as well as environmental organisations as well as competent authorities and other interested stakeholders will have a chance to submit comments or objections in writing.

At the end of this authority act, a public discussion of the permit application will take place. For several weeks, the approval authority will listen to all the objections raised and will once more thoroughly review the wide range of topics and interests affected by the project design. The information gathered from the permit application documents and from the public discussion is then used as a basis for the preparation of the actual authority approval, which will presumably involve a number of requirements and further provisions. The authority approval is expected to be issued by mid 2015.

Once authority approval has been granted, the next phase comprises the tender design, the tendering procedure and the pre-contract award negotiations for these large-scale construction lots. Schluchseewerk AG expects this phase to last approx. 2 years. This means that by mid 2017, the market research on construction details will be completed and all facts needed to decide if the plant shall be built, will be on the table.

Once a positive decision has been made, a series of activities requiring a longer lead time, will be initiated immediately. This includes environmental compensation measures as well as decisions on the configuration and manufacture of the tunnel boring machine (TBM). This preparatory phase prior to construction will take another two years at most so that construction works could start in 2019. With a construction period of 6 years, operation start-up would then be possible by 2025.

Once the authority approval is legally effective, it will be valid for five years. This allows the future course of the project to be slightly adjusted to market developments.

The Atdorf PSP of Schluchseewerk AG represents another vital cornerstone in the development of energy storage facilities and in the effort to achieve grid stability, which is essential for the energy transition process in Germany and especially for the further development of wind and solar energy.

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The Authors

Michael Fink is a 2006 graduate of the Department of Urban and Regional Planning of the University of Dortmund. He initially worked for the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) in the field of sustainable hydropower in Germany’s development cooperation. From 2008 to 2010 he was Programme and Business Director of the International Hydropower Association (IHA), and was closely involved in a range of Association projects, such as the Hydropower Sustainability Assessment Forum. In 2011 he joined Schluchseewerk AG and is responsible for the regulatory and environmental affairs of the Atdorf Pumped Storage Plant. Since January 2013, he is furthermore Deputy Project Director for the Atdorf PSP.

Reinhard Fritzer is a 1992 graduate of the Civil Engineering Faculty of Innsbruck University and began working in the Water & Environment Department of ILF Consulting Engineers in 1993. He has been involved in numerous hydropower projects as well as in several wastewater and environmental engineering projects. He is the project manager and design engineer for the civil and hydraulic engineering structures of the Atdorf PSP.

Martin Pehm is a 2001 graduate of the Civil Engineering Faculty of Innsbruck University and began working in the Transport & Structures Department of ILF Consulting Engineers in 1998. He has been involved in numerous ILF railway system projects as well as in several hydropower and environmental engineering projects. He is the deputy project manager of the Atdorf PSP project and is responsible for the permit application design planning and the environmental planning.