

Harnessing the energy

# Hydropower

# Over a century of experience

Since 1895, we have been providing our Clients with hydro engineering services backed by extensive proven experience and know-how, delivered locally through global organisation.

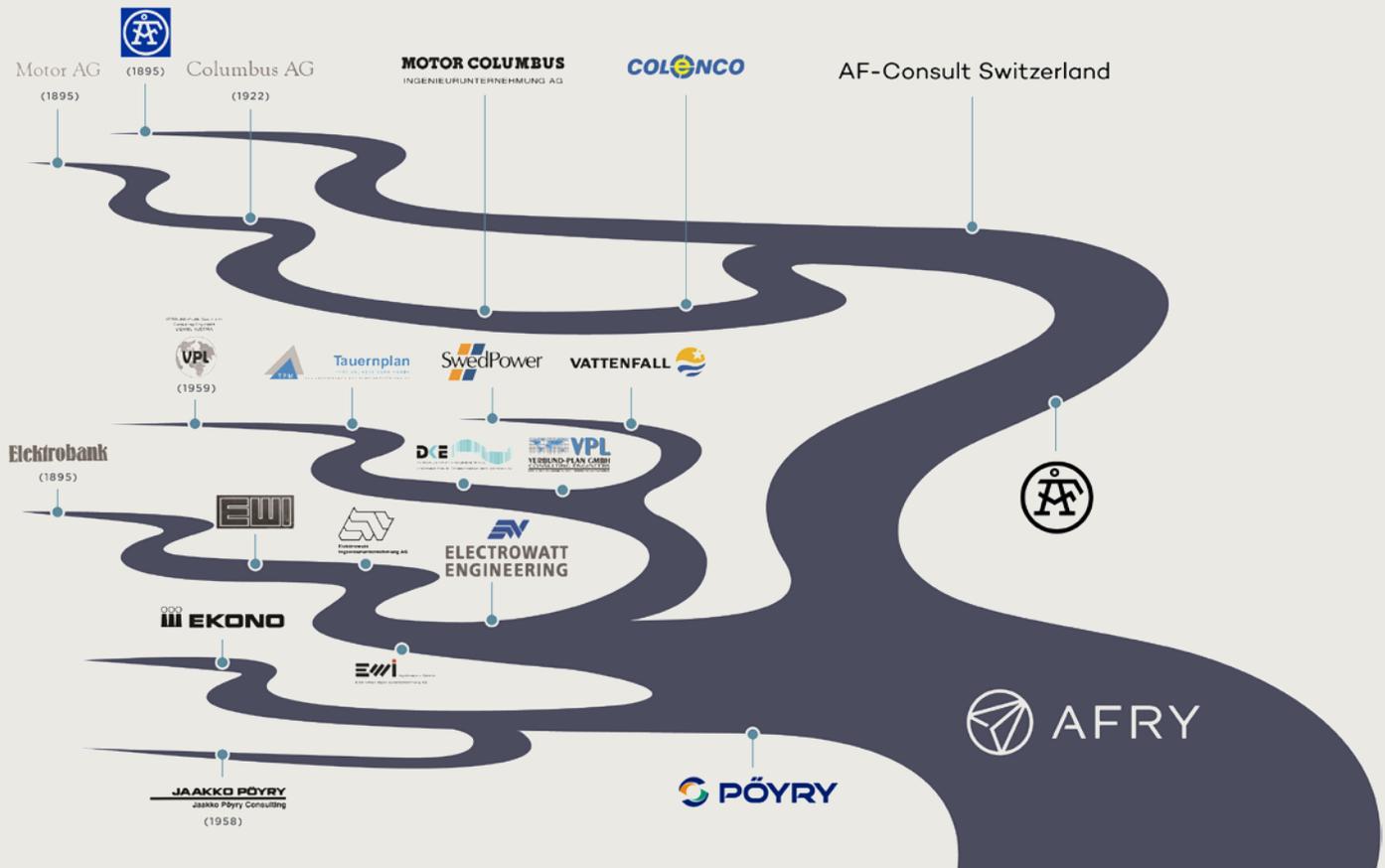
Today AFRY continues to deliver successful design and supervision services that cover all types of hydropower schemes, totalling more than 100,000 MW of installed capacity in the past 20 years alone, and significantly strengthen our standing as a world leader in consulting engineering.

## HISTORY

The history of our organisation begins in 1895, with the establishment of small independent engineering companies who initially served domestic markets. Over the next century the businesses grew internationally and

evolved into the two major companies ÅF and Pöyry who joined forces in 2019 combining their experience and know-how from around the world under the single AFRY brand.

Our long standing traditions of experience and expertise are the core of our business ensuring that your investments are safeguarded by services unsurpassed in the hydropower industry.



## ORGANISATION

To ensure our Clients are served by our 400 international hydropower experts in the optimal way, our organisation adopts a regional structure with three main competence centres, linked to strategically positioned local engineering and branch offices.

Our global competence centres in:

- Austria (Salzburg and Vienna)
- Switzerland (Zurich)
- Sweden (Stockholm)

Our three local engineering offices in:

- Czech Republic (Brno and Prague)
- Thailand (Bangkok)
- Peru (Lima)

Our five permanent branch offices in:

- India (New Delhi)
- Iran (Teheran)
- Turkey (Ankara)
- Sri Lanka (Colombo)
- Russia (Moscow)

All permanent branch offices are led and controlled by the corresponding competence centre, to guarantee the seamless know-how transfer and movement of experts to provide the most favourable blend of experts for each individual project. For project purposes, we also operate temporary branches in various countries. This overall organisation also allows the swift execution of all project services and needs locally, during all project phases.

## COOPERATION MODEL

Due to the global nature of our hydropower business, AFRY also focuses on distributing knowledge by locating experts in the places that can serve the needs of our Clients locally, during both design and execution stages of our projects. A further significant advantage of AFRY is that our experts in structures, hydraulics, dams, geology, geotechnics, the environment, tunnelling, electrical and mechanical equipment, and hydro-mechanical installations are all inside each of our hydropower competence centres, without the need to interface with external divisions.

## PROJECT STAFFING

The needs of each Client are individually assessed, and the best blend of experts from all necessary disciplines for every individual challenge is put together to provide the strongest possible team for every project. This blend also differs between feasibility study, initial design, detailed design and construction phases of a project. Our approach to staffing also recognises the importance of starting a project on the right path, with very sound and well thought out concepts, to ensure that the optimal efficiency of subsequent phases is secured.

## KNOW-HOW DEPLOYMENT

To ensure the sustainability of our resources, as well as our projects and Clients, know-how transfer is considered fundamental to our future. To achieve this internally, AFRY uses a skills matrix to assess our hydropower capabilities and workforce in all competence centres and our local engineering and branch offices. Enhancement of skills is made when required by the short or long term reassignment of relevant experts to whatever location is required. This is managed in a way that can strengthen our local presence, without weakening our core competence centres.

Son La RCC gravity dam and hydro power plant, Vietnam



# Your needs define our role

We recognise that every hydropower project is unique, and that the requirements and needs of our Clients can be very different. AFRY therefore provides individual and customised services and solutions, based on our extensive experience, to ensure that our engineering role can fulfil our customers' goals.



## VALUE-ADDED CLIENT APPROACH

Our value added approach is confirmed by our exceedance of Client expectation with innovative new ideas which can reduce costs and time, and increase the revenues gained by customers' investments.

Depending on the project phase and on the specific type of Client, AFRY is able to successfully provide services for Owners, Developers and Contractors, during all project stages and for projects of all sizes, whilst continuously applying this value-added approach.

New Naga Hamadi barrage and hydro power plant, Egypt



## CONSULTING ENGINEER

As a consulting engineer we provide all possible technical expertise required from the very first master plan, through all design phases, to execution and commissioning. We can also assist during operation and maintenance, as well as with project extensions, upgrades and rehabilitations. Our long lasting experience with operators and their specific requirements have made us a sustainable partner for many Clients.

## LENDER'S ENGINEER

AFRY provides Lender's Engineer services to international and local banks to ensure that their investments are sound and sustainable, both prior to loans being disbursed, and throughout the project execution and payback periods. Services provided by AFRY include the full range of technical services, as well as auditing compliance with all environmental and legislative requirements, both during and after project execution. It is vital in this role that AFRY monitors all activities that may affect a borrower's ability to pay back loans and meet agreed repayment schedules.

## OWNER'S ENGINEER

The owner's engineer role is the classical role, where AFRY thrives as an extension of the owner's own staff throughout all stages of project development. AFRY provides every level of study and engineering services, and assist with the management of the project whilst controlling the interfaces with the contractor during all construction activities. Our proven track record in providing such services, for some of the world's largest and most successful projects, is found in our extensive list of references.

## CONTRACTOR'S ENGINEER

Commencing with services in the pre-bid phase, AFRY has been employed by EPC contractors to enhance their submissions by advising on technical risks and their mitigation, preparing design reviews and alternative designs, compiling baseline investigation reports, undertaking tender designs, and assisting during contract negotiations. In this role, AFRY has made significant contributions to the winning bids of a number of contractors, and has also enhanced the value of investments for many project owners. AFRY's innovations in this role have gained international recognition, and made us a preferred partner for challenging projects.

## SUPPLIER'S ENGINEER

The supply of electromechanical equipment is normally completely unique and based on individual design criteria specific to each project. As well as developing the technical specifications for the equipment required, AFRY also assists suppliers with the design of their equipment and provide advice and coordination services with regard to all civil work interfaces. This ensures that the civil and electro-mechanical works interfaces are seamless, thereby avoiding significant delays to project start-up, and to the generating of electricity.

## DEVELOPER'S ENGINEER

It is clearly recognised that developers have very interesting project ideas and opportunities, for both new and existing projects, and often seek due diligence assistance to ensure that all technical and non-technical risks that may be associated with their investment are made fully transparent. AFRY provide these and other due diligence services, as well as all special studies that may be required (such as environmental and hydrological studies) to enable developers to mitigate their risks, and ensure an optimal implementation of their project.

# Services along the project lifecycle

AFRY provides the full range of services for hydropower projects from the initial project conception, through to the execution and commissioning stages, and during the initial operation phase and beyond.

## LIFECYCLE APPROACH

The foundations for a successful hydropower project are laid during the preliminary design phase. At this stage, the first conceptual decisions are made, based on criteria including hydrology, geology, topography, economics, risk and revenue. Conceptual errors are difficult to correct later, or can only be rectified with a significant amount of additional work, time and money. For this reason, it is essential that the preliminary design is carried out by well trained and experienced professionals who can guarantee that the correct investment is chosen for the project. AFRY focuses on two fundamentals of know-how deployment from experienced specialists to young professionals, and the utilisation of appropriate staffing for each project phase.

## OPERATION & MAINTENANCE

AFRY prepares operation and maintenance manuals for both civil works and equipment, as well as providing services during the design stages to reduce to a minimum the need for maintenance and associated costs, whilst still maximising the operational life of a project. We also provide monitoring services during operation of the equipment, and monitoring and geodetic surveys of civil works (including dams, powerhouses and other structures). In addition, we offer extensive rehabilitation and upgrading services to increase the return on plant investments. Our long-lasting partnership with plant operators ensures that we are constantly on top of the needs of our Clients.

## CONSTRUCTION

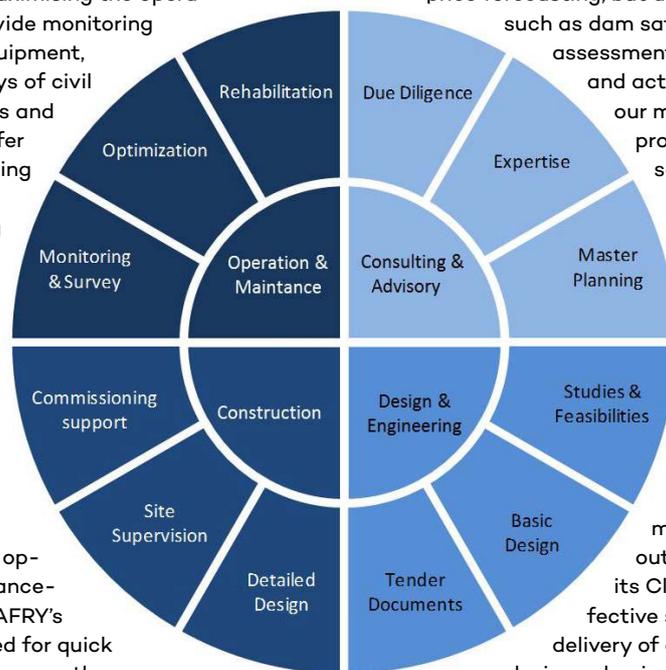
Providing construction support to adapt and enhance the detailed design of hydropower projects on site, as changing circumstances develop, is critical to the continued optimization of a project and the enhancement of the benefits to the owner. AFRY's site supervision staff are well trained for quick decision making, to eliminate problems as they occur, to move the execution forward, to eliminate unnecessary cost over-runs and delays, and to reduce the potential for claims. We also support Contractors and Clients with experienced commissioning engineers, to ensure that the generation facilities are on line as soon as possible.

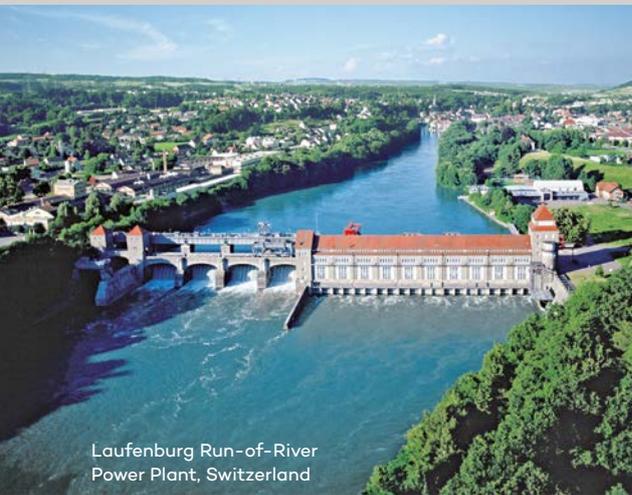
## CONSULTING & ADVISORY

Consulting and advisory services are two of our key strengths. On various occasions we have supported our Clients in asset evaluations such as technical and financial due diligences or electricity price forecasting, but also with specific technical know-how such as dam safety, dam monitoring, seismic hazard assessments, and emergency preparedness and action plans. Such services compliment our more common roles and enable us to provide the broadest possible range of services to our Clients.

## DESIGN & ENGINEERING

Whilst taking advantage of innovative designs and well developed hydropower concepts, including the most economically advantageous layouts, AFRY optimises the benefits for its Clients. We deliver the most cost-effective services whether they relate to the delivery of a study, a conceptual or feasibility design, a basic or final design (with tender documents), or a detailed design. This comes from our dedication, for over a century, to front line engineering.

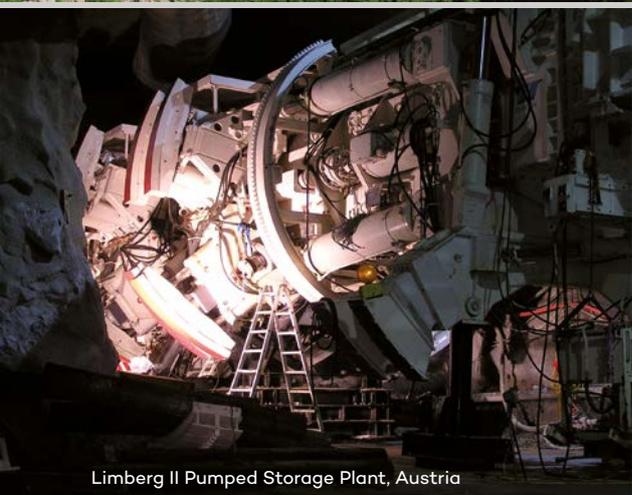




Laufenburg Run-of-River Power Plant, Switzerland



Deriner Dam and Hydropower Plant, Turkey



Limberg II Pumped Storage Plant, Austria



## RUN-OF-RIVER SCHEMES

Run-of-river schemes make an important contribution to base load electricity demands. Often constructed in the bed of large rivers, these schemes not only generate electricity but also provide flood protection and contribute to tourist development. The complex run-of-river structures require careful planning, staged construction procedures (in particular the temporary river diversion) based on a full analysis of hydrological and logistical restrictions. AFRY's experts are skilled in the challenges of working in such limited spaces, the associated de-watering of deep excavations, dealing with flood risks, and the controlled flooding of construction pits where necessary.

### Core competences:

Weir structures and locks, head pond and bed load services, excavation concepts, powerhouses and equipment, operational concepts, positive environmental measures, and fish passes.

## RESERVOIR STORAGE SCHEMES

Reservoir storage schemes not only ensure the supply of energy mostly at peak times, but may also release water for irrigation, to protect the downstream environmental, and to provide flood retention and recreational benefits. The planning and design of such schemes with high dams of many different types, large hydraulic structures, long tunnels and shafts, and surface or underground powerhouses, call for very diverse and sound expertise. Our specialists have designed some of the largest hydropower storage schemes ever built. If required, we can also include other specialists working within the AFRY Group, to ensure that we provide optimized and sustainable solutions based on the specific needs of our Clients.

### Core competences:

All dam types, large hydraulic structures, power waterways and linings, powerhouses, mechanical and electrical equipment, balance of plant, plant operation concepts, seismic analyses and monitoring.

## PUMPED STORAGE SCHEMES

Pump storage schemes are designed to pump water to an upper reservoir when there is a surplus of electrical energy (low revenue electricity), and to release water back to a lower reservoir during periods of high energy demand (high revenue electricity). They are able to provide electricity instantly which gives them advantages over other forms of energy production. AFRY's experience in reversible and tandem turbines, as well as with adjustable speed machines, coupled with our proven track record in this field, makes us one of the leading hydropower consultants in the world.

### Core competences:

Hydraulic and operational concepts, optimization of power tunnels, caverns and logistics, reversible and tandem units, adjustable speed machines and multi-stage pumps.

## MULTIPURPOSE SCHEMES

Hydropower facilities are sometimes added to existing or greenfield schemes which provide water for irrigation, drinking water or other purposes. These schemes require additional know-how that can easily be found within AFRY. Combining classical hydropower skills with specific plant know-how creates additional Client value. Since water is precious, it is always worthwhile to investigate a combined usage which can also increase economic returns and add value to the environment and the Client. In fact, 30% of large dams worldwide are used for multiple purposes. Using our broad expertise in international projects, AFRY can advise Clients on an optimal combination of irrigation, power generation, water supply, flood control, environmental protection and navigation.

### Core competences:

Irrigation concepts, water supply and flood protection, groundwater management, plant operation support, navigation, and recreational and environmental services.

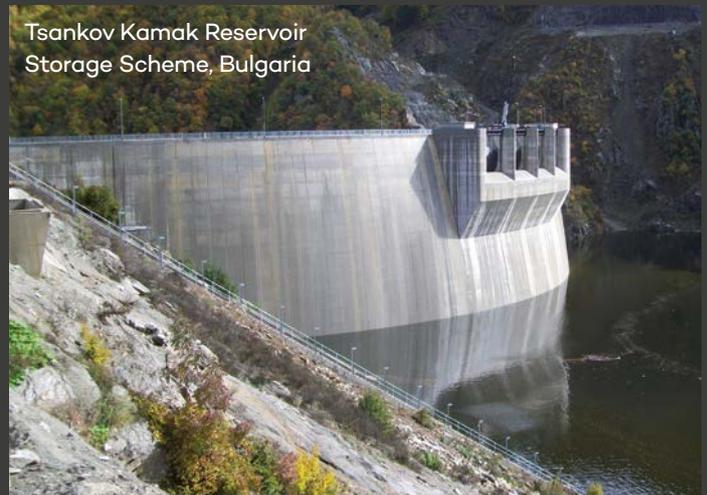


# Customized solutions

Our services are never repetitive due to our wealth of knowledge enabling us to introduce new innovations to all projects, and to deliver highly customised and well-adjusted concepts that exceed the expectations of our Clients.



Lüen Hydropower Station,  
Switzerland



Tsankov Kamak Reservoir  
Storage Scheme, Bulgaria

## ASSET EVALUATION

Investing in hydropower means buying an existing scheme, or developing a new hydropower project. When buying an existing asset, specific know-how is necessary to assess all technical and economic risks. The technical risks relate to the existing condition of the project, its life expectancy, maintenance requirements, and upgrading and/ or rehabilitation potential. The economic considerations relate to hydrology, generation potential, electricity price forecasts, market conditions and capital costs. AFRY is successful in combining both technical and economic skills to offer a full range of asset evaluation services, including:

- Technical due diligence and rehabilitation assessments
- Upgrading and operational improvement analysis
- Electricity price forecasting
- Hydrological and reservoir operation studies
- Financial and economic analyses of civil works and plant

Our in depth knowledge of hydropower, and hydropower projects, as well as our wide range of internal resources, enables AFRY to mobilize economists, environmentalists, hydrologists, geologists, modellers, dam engineers, structural engineers, hydraulic engineers, hydro-mechanical engineers and electro-mechanical engineers, to meet project demands.

## HYDROPOWER CONCEPTS

The art of hydropower design always starts with the sound basis of accurate knowledge of hydrological, geological and topographical conditions. To ensure this is achieved, AFRY advises on, or carries out, hydrological data assessments, geological and hydro-geological investigations and mappings, and topographical surveys. Our in depth knowledge and extensive experience enables us to develop concepts of extremely high quality, leading to optimal returns on investments for our Clients. Our services in these disciplines include:

- Provision of safe and innovative hydraulic concepts
- Dam type and powerhouse design studies
- Surface and underground excavation design studies
- Operational concept and economic assessments

Our focus on commencing projects with sound concepts minimises Client investment in engineering services, and ultimately offers significant savings in the capital cost of the overall projects. AFRY is highly recognised for the high quality concepts that are well documented in our pre-feasibility studies, bankable feasibility studies and tender and detailed designs.

## SUSTAINABLE ENGINEERING

AFRY provide all services from a single source whilst co-ordinating engineering issues across the full spectrum of engineering using top class project managers with sound technical knowledge, who can also achieve required milestones and keep control of project costs. Our internal environmental know-how, merged with our engineering experts, ensures that sustainable engineering is very much a reality. Our services include:

- Basic and tender designs and specifications
- Contract documents and tender evaluations/ negotiations
- Detailed designs and construction drawings
- Review of suppliers designs and shop inspections
- As-built drawings, manuals and safety guidelines

Together with our Clients, we find the best designs to balance all technical, economic, ecological and social requirements.

## ADVISORY AND SITE MANAGEMENT

Provision of technical support and site supervision services during the execution of a project, and other fundamental services in the field, are further components of the comprehensive package of services we provide. Our knowledge of construction further enhances the quality and suitability of our studies and designs. These important competences enable us to offer services at the local level which include:

- Site supervision, technical assistance and advice
- Environmental and safety monitoring
- Commissioning support
- Contract and risk management
- Cost, time, project and quality management

Our more specialised services comprise earthquake assessment services, turbine efficiency measurements, dam monitoring services, hydraulic model testing, etc. This further confirms that choosing AFRY means buying from one single source.

## REHABILITATION PACKAGES

After designing and rehabilitating numerous hydropower plants worldwide, we are specialists in all civil, electrical and mechanical aspects of hydropower schemes of all sizes. Increasing the reliability of existing plants is often best achieved with a rehabilitation or simple refurbishment. However, Pöyry are also able to analyse upgrading opportunities, as well as provide lifetime expectancy assessments for all systems including:

- Turbines, pumps, generators and protection systems
- Emergency and cooling systems, fire protection and HVAC
- Switchyards, substations, I&C and water supply control regulators
- Hydro mechanical equipment including steel linings and cranes

This approach creates additional value by mitigating downtime risks, and increases the return on Client investment. Our services range from simple feasibilities and upgrading reports, to full rehabilitation service packages.



Kukule Ganga Run-of-River Power Plant, Sri Lanka



Deriner Dam and Hydropower Plant, Turkey



Kárahnjúkar Hydropower Scheme, Iceland

# Know-how at your service

Our organisation is primarily technically orientated, and is separated into seven technical departments full of high level internationally recognised experts. This approach guarantees an ideal professional exchange, and promotes optimal knowledge transfer.

## HYDROLOGY & HYDRAULICS

The engineers in this department provide specialised services in the fields of hydraulic design, hydrology, operation management and economic evaluation for all kinds of water resources schemes including hydropower plants, river training and flood retention systems, and irrigation schemes. Specialised fields of knowledge include the conceptual designs of hydraulic structures like water intakes, free flow and pressurised waterways, water release and outlet structures, sediment and floating debris handling, and air entry and transportation phenomena. Furthermore, the hydraulics department performs hydraulic and hydrodynamic analyses comprising steady and unsteady flow, transient phenomena, and vibration and stability problems for all types of hydraulic structures. The range of knowledge of this department also covers the domains of physical model testing and numerical modelling, including 3-dimensional Computational Fluid Dynamic (CFD) analysis of hydraulic structures. In addition, the latest developments in hydrological and water resource modelling are in use. Using hydraulic simulations, the available models can optimise operation patterns and prepare data schedules at 15 minute intervals based on boundary value analyses for cascades of hydropower stations.

## DAMS & GEOLOGY

Our proven experience in dam engineering covers all types of concrete (gravity, arch gravity and double curvature arch) and embankment (concrete and membrane faced rockfill, earth core rockfill and zoned earthfill) dams, of all heights and volumes. Services include design (static and dynamic analyses, of new and existing dams, and their ancillary structures) and construction supervision, for Owners, Investors and Contractors. Also included in our expertise are dam safety inspections, design of rehabilitation measures, dam heightening, dam strengthening, earthquake engineering, preparation of emergency preparedness and action plans, failure mode analyses, dam break studies, impounding procedures and risk analyses. We also provide the full range of geological, hydrogeological and geotechnical services, including site investigations and interpretations, geological mapping, laboratory testing, small and large scale excavations, slope stabilisation measures, foundation drilling and grouting, and instrumentation and monitoring systems (for excavations, dams and foundations), as well as training.

## STRUCTURAL ENGINEERING

The specialists in the structural engineering department cover all structural design aspects of hydropower schemes including intakes, weirs, spillways, channels, tunnels and powerhouses. Our engineers have a wide range of experience in the structural analysis and design of complex civil engineering works and possess specific knowledge of static and dynamic analytical methods including finite element methods, earthquake engineering and fatigue analysis. Furthermore, the engineers provide site supervision services as well as inspections and assessments of the structural condition of existing hydropower schemes. We work with and apply all the different internationally recognised codes relevant to structural design.

## UNDERGROUND & TUNNELLING

Core competences include the design and construction supervision of low and high head schemes, free flow lined and unlined tunnels, vertical and inclined shafts, surge tanks, caverns, adits and galleries. Our design work includes temporary and permanent support measures, grouting, concrete and steel linings, rock traps, penstocks, manifolds, construction adits, ventilation systems, drainage arrangements, and intake and outlet structures. Our experience is equally balanced for tunnels excavated by both drill and blast and TBM methods.

## ELECTRICAL AND MECHANICAL ENGINEERING

Our specialists in the design of electromechanical equipment provide the necessary design work and technical specifications for new build schemes, and for the rehabilitation and upgrading of existing plants. Our experts create in depth solutions for turbine and pump concepts, generators, excitation and protections systems, emergency and cooling systems, fire protection and HVAC systems, switchyards and substations, instrumentation and control systems, and transmission line planning. Our skills also cover hydro mechanical equipment such as gates, valves, penstocks and steel liners, as well as expertise on metallurgy and dynamic processes. We are also equipped with all measurement devices for thermo-dynamical efficiency measurements of Francis and Pelton turbines as well as pumps and pump turbines.

## ENVIRONMENTAL

For the last 30 years, AFRY has been successfully engaged in environmental engineering and management projects worldwide. After working for international financing organisations, private enterprises, national and regional governments, and local municipalities, we are now the partner of choice for environmental and social impact assessments, environmental consulting and auditing during project implementation, resettlement plans, air pollution and noise control, and institutional development and training. We employ highly experienced scientists, engineers and project managers from different disciplines, to ensure competent, efficient and comprehensive solutions are realised in the whole field of environmental engineering, regardless of its complexity.

## SITE MANAGEMENT

For more than 50 years, AFRY has been engaged in site supervision, and construction and project management services. Our certified engineers provide the full range of services including supervision, technical assistance and advice, environmental monitoring and quality control, contract management and risk monitoring, cost estimate and management, time management, construction and project management, safety measures and overall site coordination and interface management. We handle every issue on behalf of our Clients to make every project a success.



# Innovation made by AFRY

Client orientation means the development of the most appropriate design to match all technical requirements, and to provide innovative and fresh solutions leading to increased customer satisfaction and project value.

## LA CONFLUENCIA HYDRAULIC CONCEPT

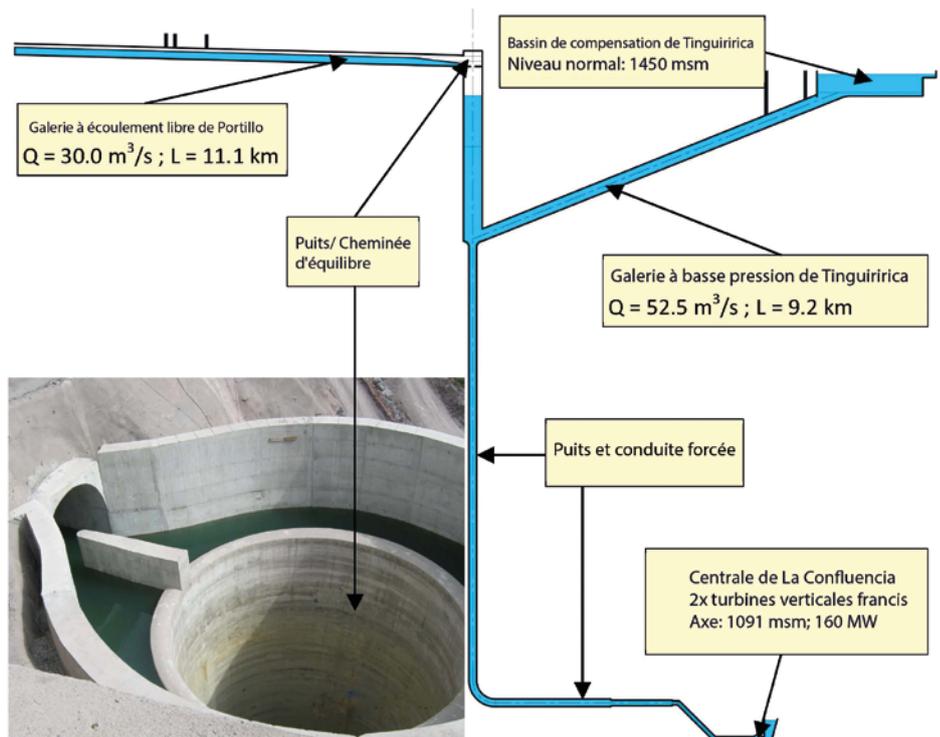
AFRY supported an EPC Contractor during tendering of La Confluencia Project in Chile. Following AFRY's assessment of the initial design, we suggested various changes including new tunnel arrangements to mitigate geological risks, and an off-river reservoir to cope with sedimentation issues. The size of the reservoir was also enhanced so that daily regulation and peak energy production became possible.

The EPC Contractor prepared his bid based on the improved design by AFRY and won the EPC Contract. The innovative hydraulic concept developed by AFRY included:

- Y-scheme with two branches (Tinguiririca low pressure tunnel and Portillo free-flow tunnel)
- Tinguiririca pressure system with a reservoir, surge shaft, pressure shaft, penstock and open powerhouse, fed with additional water from the Portillo branch through the surge shaft
- Portillo free-flow tunnel acting as the upper chamber of the surge shaft
- 5 intermediate intakes feeding either the Tinguiririca or the Portillo branch

When the turbines are not operating, water from the Portillo branch and intermediate intakes can flow via the Portillo free-flow tunnel, the surge shaft and the Tinguiririca branch, in the backwards direction into the reservoir, to enhance the contained water volume.

The hydraulic conditions in the surge shaft are complex, and extensive hydraulic model tests were undertaken. The model tests fully confirmed the correctness of the hydraulic calculations performed.





## WALDECK II+ POWERHOUSE OPTIMIZATION

Cost savings by optimizing the design of hydropower plants is one of our initiatives which we have been developing over the last few years together with our Clients.

As an example, the Waldeck II+ pumped storage plant project will be provided with a new power cavern and waterway. The upper and lower reservoir, substation, cavern access tunnel and energy transmission tunnel from PSP Waldeck II will be used. The Waldeck II+ project includes a waterway with new inlet/outlet structure at the lower reservoir, a new power cavern with access tunnel, a new auxiliary tunnel and new energy transmission.

The new power cavern will be equipped with one pump turbine unit with a capacity of 300 MW. The new waterway will be connected to the existing inlet tunnel with the inlet/outlet structure at the upper reservoir, and will lead via the power cavern and the tailrace tunnel to the new inlet/outlet structure at the lower reservoir.

The optimization of the power cavern design resulted in savings in the excavation volume of 40 %, and the alignment and lining of the waterways were revised. As a result, noticeable cost savings were achieved in excavation, concreting and finishing works.

## DERINER DAM SPILLWAY CONCEPT

When AFRY initiated the Deriner Dam and Hydroelectric Power Plant Project on the Çoruh river in Turkey, which includes a 249 m high double curvature arch dam, our experts were acutely aware of the huge scouring problem that could be potentially caused by a spillway with a capacity of 9,250 m<sup>3</sup>/s. It was therefore compulsory that an innovative solution be found to prevent this occurrence. The idea developed by AFRY was to separate the spillway into 2 independent systems.

### Service Spillway System

An overflow spillway system with a capacity of 2,250 m<sup>3</sup>/s (2 x 1,125 m<sup>3</sup>) was designed consisting of:

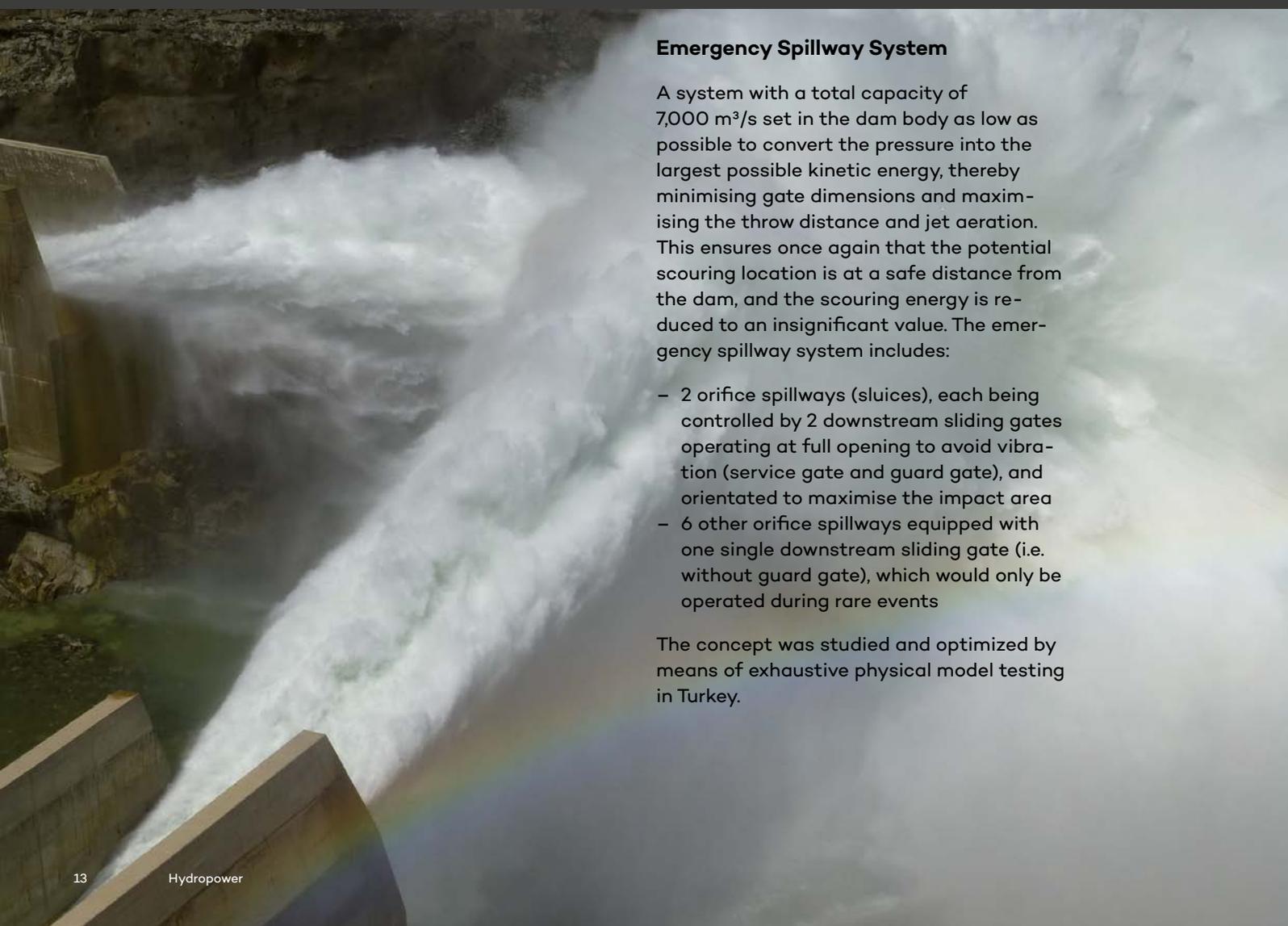
- 2 overflow weirs located symmetrically, one on each bank, controlled by 20m long flap gates to ensure a completely safe discharge from the reservoir
- 2 steeply inclined and curved 8.0 m diameter tunnels to ensure that the water release occurs at sufficient distance from the dam
- 2 symmetrically converging flip-buckets to achieve jet aeration and collision in the middle of the valley, to reduce the scouring energy at impact to a tolerable minimum

### Emergency Spillway System

A system with a total capacity of 7,000 m<sup>3</sup>/s set in the dam body as low as possible to convert the pressure into the largest possible kinetic energy, thereby minimising gate dimensions and maximising the throw distance and jet aeration. This ensures once again that the potential scouring location is at a safe distance from the dam, and the scouring energy is reduced to an insignificant value. The emergency spillway system includes:

- 2 orifice spillways (sluices), each being controlled by 2 downstream sliding gates operating at full opening to avoid vibration (service gate and guard gate), and orientated to maximise the impact area
- 6 other orifice spillways equipped with one single downstream sliding gate (i.e. without guard gate), which would only be operated during rare events

The concept was studied and optimized by means of exhaustive physical model testing in Turkey.



# Selected key references

AFRY has designed hydropower plants for more than a century. A huge wealth of knowledge and successfully completed projects have been built up during this period. We have worked on projects in remote regions of the world, and have provided expertise for run-of-river plants, pumped storage plants and multi-purpose schemes. The requirements of our Clients are at the core of our business, and the projects described below provide a small insight into what we are able to achieve.



## Rheinfelden, Switzerland

### Run-of-river plant

**Services:** Study of existing scheme, environmental study, assistance during concession agreement negotiations, feasibility study, optimisation study, tender and contractual documents, and detailed design of the powerhouse.

**Technical data:** Four bulb turbines with 100 MW installed capacity, Kaplan turbine with 2 MW capacity, 600 GWh annual energy production.



## Limberg II, Austria

### Pumped storage plant

**Services:** Approval design, tender documents, guideline design, detailed design, coordination of civil construction and HEM erection, site supervision, project management and scheduling.

**Technical data:** Two reversible Francis turbines, 480 MW installed capacity, 1300 GWh annual energy production.



## Nam Ngum 2, Lao PDR

### Dam and hydro power plant

**Services:** Feasibility study, environmental impact assessment, project upgrade studies, outline design and tender documents, supervision of erection and commissioning of electromechanical equipment, hydro-mechanical equipment design and transmission line works.

**Technical data:** 185 m high concrete faced rockfill dam (CFRD), three Francis turbines with a total installed capacity of 615 MW, 2218 GWh annual energy production.



## Laja, Chile

### Run-of-river plant

**Services:** Basic design, tender design, detailed design and HEM interface of the power plant.

**Technical data:** Low-head hydropower scheme with spillway structure, and powerhouse housing two bulb turbines generating 35 MW at 250 m<sup>3</sup>/s and 16 m head, 166 GWh annual energy production.



## Memvé'ele, Cameroon

### Hydropower scheme project

**Services:** EIA and SIA in compliance with Cameroon legislation, international standards and World Bank requirements, including an analysis of the socio-economic impacts of the dam, the electricity lines and the construction works, as well as public consultation, health analysis, infrastructure analysis and study of the potential impact on opportunistic migration, gender and minority.

**Technical data:** 1450 ha reservoir, 450 m<sup>3</sup>/s hydropower plant.



## Kárahnjúkar, Iceland

### Hydropower scheme

**Services for pressure tunnel system:** Project planning, geological surveys, hydraulic analysis and model testing, transient calculations, TBM expertise, contract and tender documents, final design, construction support.

**Technical data:** Concrete faced rockfill dam 190 m high, two pressure tunnels (40 km and 13 km long), inclined surge tank, 400 m pressure shaft, underground powerhouse with a total installed capacity of 690 MW.



## Deriner, Turkey

### Dam and hydropower plant

**Services:** Feasibility study, final design, supervision during construction, progress and quality control, factory inspections of electromechanical equipment, assistance during commissioning and technical management of the project.

**Technical data:** Double curvature arch dam 249 m high, 700 m crest length, four Francis turbines with a total installed capacity of 670 MW, 2118 GWh annual energy production.



## Tsankov, Bulgaria

### Reservoir storage scheme

**Services:** Financial setup, joint implementation, review of final design, scheduling, coordination, guideline design, detailed design, geological survey, site office services.

**Technical data:** Double curvature arch dam 125 m high, installed capacity of 80 MW and a small ecological flow turbine with 1.3 MW capacity, 185 GWh annual energy production.



## Långbjörn, Sweden

### Dam safety

**Services:** System and risk analysis, restructuring of approach to dam safety analysis by focusing on possible failure modes for the dam as a whole, in contrast to the current approach in Scandinavia that considers the issues relating to embankments, concrete structures, and mechanical and electrical installations separately.

**Technical data:** Långbjörn Dam is a high risk dam (1A), 32 m high, Qdim = 2100 m<sup>3</sup>/s.

AFRY is a European leader in engineering, design, and advisory services, with a global reach. We accelerate the transition towards a sustainable society.

We are 16,000 devoted experts in infrastructure, industry, energy and digitalisation, creating sustainable solutions for generations to come.

Making Future

Contact us by email  
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