EDF Hydro: a complete range of services

A world-renowned know-how

For 20 years, the Hydraulic Engineering Centre (CIH) has been promoting EDF's business offers to develop hydroelectricity in France and abroad.

Its know-how is structured around 4 main areas of expertise:

- **Hydro newbuilt facilities,**
- **Rehabilitation and modernization of existing structures,**
- **Operation and Maintenance (O&M) of EDF's hydro network,**
- **Integration of renewables - flexibility.**

Among those missions, sharing operation issues within EDF Group gives a undeniable competitive advantage.

Working for the sustainable management of water, environment and biodiversity, the CIH accompanies you and ensures the safety and the operation performance of your hydraulic facilities.

Interactive summary

Click on the title for direct access

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Developing PSPPs to meet tomorrow's challenges

The challenge

The growth of "intermittent" renewable energies leads every power system or portfolio manager to plan the development of system tools. Pumped storage power plants (PSPP) are one of the most proven and environmentally-friendly means of storage and regulation.

The development strategy (power, type, commissioning date) must be based on a vision of a tool integrated in the power grid or a tool that will optimise the portfolio.

You are a regulator, the manager of a generation facility, a system planner, project manager, dispatcher or developer of renewable energy projects and you want to develop this type of tool to achieve your goals (power increase or substitution, arbitration, penetration of renewable energy).

With 70 years of operation and maintenance of its own facilities, EDF Hydro engineering can accompany you.

4,300 MW
This is the total capacity of the 12 pumped storage power plants operated by EDF

Our solutions

Analysing storage requirements

Prior to a project, we analyse your requirements as regards quantity (power, time constant) and quality (response time, location), according to the technical, economic and institutional characteristics of the electrical system.

Identifying and optimising the PSPP project

We can make an inventory of all the potential sites (using models we have developed on SIG); determining the most promising projects (multi-criteria analysis) and defining the required characteristics during the operational phase.

Accompanying the developer in all the phases to the financial closing

We accompany all the technical studies, up to the consultation documents; the socio-environmental impact study, the consultation strategy and the business consultation documents, selection of the EPC company, drawing up and negotiating the PPA, selecting the operating company.

Supervising the construction, commissioning and checking performance

During the construction, we mobilize all the human and technological means adapted to each project.

Our dedicated measurements unit carries out all the factory acceptance tests of equipment.

Accompanying the owner during the initial years of operation

We accompany the take-over of the scheme, the elaboration of the operating and standard maintenance procedures, the improvement of employee skills, setting up predictive maintenance (e-operation).

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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Proof by example

A first in the hydraulic sector in northern Israel

Israël - Mont Gilboa (300 MW)

The challenge: building Israel's first large hydropower scheme.
On this project, neither the client nor the civil engineering companies had ever built hydropower schemes. For this project, EDF carried out the construction (Engineering, procurement and construction) and assisted the investors (Owner engineer).

The context: the scheme with a total installed capacity of 300 MW and 500 meter head, was built entirely underground (1.2 km from the surface).

Our response: thanks to its strong mobilisation and the constant presence of expatriates on site, EDF Hydro was able to carry out these two missions in parallel.

The results: the project has now been commissioned and no major problems have appeared.

PSPP: another step forward in the Middle East

Dubaï - Hatta (250 MW)

The challenge: building the first PSPP in the Middle East.

The context: EDF Hydro is assisting DEWA (Dubaï Electricity And Water Authority) with the project management and the construction of the first Pumped Storage Power Plant in this region, to its commissioning. DEWA wants to increase the penetration of renewable energies in the energy mix.

Our response: assisting DEWA from the start of the project to its commissioning and offering a technical hydropower solution.

The results: EDF's overall support answered all of DEWA's questions about PSPP operation and maintenance.

Seawater for the Atacama Desert

Chili - Atacama Desert (300 MW)

The challenge: optimising the design of a 300 MW PSPP supplied by seawater.

The context: our engineering department was asked to carry out due diligence for a PSPP planned by the Chilean energy company Valhalla.

Our response: a detailed review of design studies, construction methods, authorization procedures, societal consultation process and economic model for the project.

The results: project optimisation and reliability through design modification and an exhaustive risk analysis.

PSPP expertise recognized worldwide

over 40,000 MW being studied

including 10,000 MW in operation

Advantages of EDF Hydro

EDF Hydro capitalizes on its solid expertise based on numerous PSPP projects of all sizes and in a variety of contexts, in France and abroad, and also on operating and maintaining the 4.3 GW of PSPPs in its own facilities.

This cumulative experience allows our design engineers to accompany the developer in all the decision-making phases during development.

contact-hydro@edf.fr

Designing a robust and sustainable dam

The challenge

As the structure most commonly associated with hydropower, dams can be an object of both fascination and concern.

As a developer, you know that a dam cannot afford to have any imperfections in either its design or construction. You also want the hydropower facility, encompassing the dam and its equipment, to be optimized, so that it produces electricity more efficiently and for longer, whilst respecting the environment and its users.

Entrust your structure to specialists who use state-of-the-art methods and technical innovations, which will help turn your facility into an asset for local and global economic development.

622
dams operated by EDF

Our solutions

Identifying and listing the most suitable sites

Before work really gets underway on the project, we map the most favorable sites from a topographical, hydrological, geological, environmental and social point of view. On completion of a multicriteria analysis conducted jointly with you, we can select the sites worth studying further.

Incorporating the environmental and social components

Ensuring transparency on ecological and sediment impact, limiting or offsetting the effects on biodiversity, preserving water quality, accommodating other uses for the river downstream of the dams, sharing water resources, discussing issues with stakeholders: we can integrate these challenges right from the design stage of the project, to ensure social acceptance and reduce its ecological footprint. We also seek to ensure the bankability of the project.

Guaranteeing flawless safety for your project

We use the most stringent standards, right from the design stage. As an active member of the International Commission on Large Dams (ICOLD), we apply its recommendations to all of our projects.

Designing robust, optimized projects

As the operator of 622 dams of all types, we know how to adapt the design of a facility to the specific features of your site and your operating requirements. We produce robust designs to optimize structures and increase the longevity of the facility at a reduced construction cost.

Storing, sharing and processing water

Sharing water resources among various stakeholders (fishing, navigation, tourism, irrigation, etc.), flood protection, generating power when needed, incorporating intermittent energy sources into the grid, keeping users safe downstream of the dam.

A team of experts

Our experts possess a perfect understanding of the market and are able to provide the best technical solutions for your projects.

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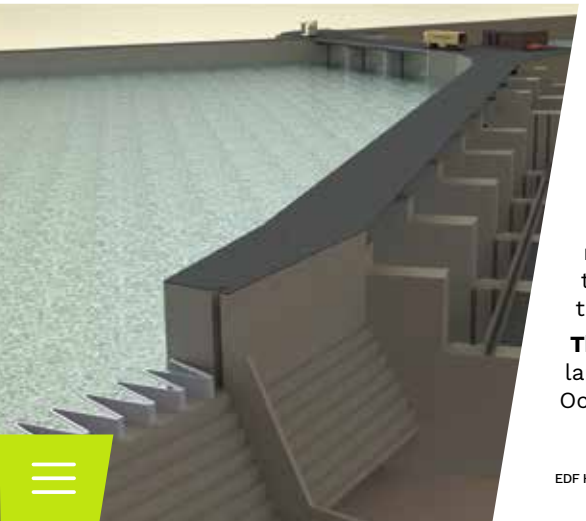
Oxygenation weir on the downstream outlet channel, Nam Theun 2



Proof by example

The turnkey approach that reassures funding partners

Laos - Nam Theun 2 (1070 MW)

The challenge: a pioneering hydropower project in Laos.

The context: the first large-scale project in Laos, which saw the World Bank return to financing major hydropower projects thanks to the application of the most stringent E&S standards.

Our response: as part of a turnkey contract, EDF assumed technical responsibility for the design and construction of the facility on behalf of the Nam Theun 2 Power Company (NTPC) whilst contributing to studying and managing E&S impacts.

The results: from a technical point of view, the project, built in five years and delivered on time, **has exceeded its production targets** since its commissioning in 2010. The project is now a benchmark when it comes to managing E&S impacts, and has been a major driver of economic development throughout the region.

> More than 10 years after commissioning, the Nam Theun 2 facility is held up as an example by all of our contacts – including shareholders, customers and representatives of the Laotian government – for its industrial, financial and environmental performance. Obviously, for an operator, running a plant or a dam that meet such high standards of design (robustness, design size, equipment reliability) provides an exceptional degree of comfort on a daily basis! A great and long-lasting success story!
>
> **Florent PERROT**
> **Chief Operating Officer / Nam Theun 2 / NTPC**

A robust scheme for extreme floods

Cameroon - Nachtigal amont (420 MW)

The challenge: designing a peak flood discharge system that takes into account the hydrological uncertainty of the Sanaga river flow rates.

The context: a project led by Nachtigal Hydro Power Company (EDF is a 40% shareholder).
EDF Hydro designed the facility and held an international invitation to tender.

Our solution: designing the most passive facility possible, by limiting the use of mechanical components. The 1,380 m-long labyrinth spillways (92 cycles) help limit the overflow wave. Two gates facilitate the release of sediment and fed water back to the bypassed section.

The results: the model is designed to guarantee structure stability, even with floods largely exceeding the safety design flood (Q10000). Commissioning is planned in October 2023.

Hatta pumped-storage plant (250 MW) in Dubai currently under construction: Cross-section of the layout of the hydropower plant prepared by the CIH's engineering office during the design phase.

Advantages of EDF Hydro

Supported by our proven experience across our fleet of dams, and possessing all the necessary technical, environmental and social skills within EDF, we work with our clients to develop the solutions that are the most suited to the context.

Ultimately, we offer a robust design made to last, complies with the most demanding international standards and is optimized to reduce construction and operational costs.

contact-hydro@edf.fr

Developing Innovative Projects at Sea

The challenge

The oceans offer a promising source of renewable energy. They also constitute a reserve of water for innovative hydropower storage solutions. Offshore and coastal projects need to meet the technical challenges of their marine environment, the challenges of socio-environmental integration and ensure their own economic balance.

You want to develop a Sea Water Pumped Storage Power Station (SWPSPS), a tidal power range, a tidal stream or an offshore floating solar power plant. You are looking for the most favourable sites.

You want to optimize and ensure your scheme's performance over time. You want your project to be well accepted by the local stakeholders. You want to control your risks and your costs.

EDF Hydro engineering can accompany you.

1966: year of commissioning of La Rance tidal energy scheme

16 km: length of the submarine cable at EDF Paimpol-Bréhat tidal test site

Our solutions

Identifying the Most Favourable Sites for Developing a Project

Based on your requirements, we cross technical and socio-environmental criteria in our GIS software. We determine the most favourable areas. We compare the areas on the basis of a multi-criteria analysis and propose a conceptual design and an economic assessment.

Analysing Hybridization and Multipurpose Opportunities

We identify the region's opportunities and constraints, in order to improve the economics of your project and its social and environmental integration. For example: coupling a PSPS with a solar or a wind farm; hybridization with a desalination plant; Using the embankments of a tidal range scheme for coastal protection.

Managing Projects or Assisting the Project Owner

Our experience of over 60 years in the field of hydropower allows us to define the overall design and to provide a solid techno-economic assessment. Our services cover include the permitting process, the design, the tender preparation and evaluation as well as owner engineer services for monitoring the construction and commissioning.

Carrying out Targeted Assessments on Issues Specific to the Marine Environment

We offer our expertise on site surveys, design of marine works, power electronics and electrical connections, construction methods and marine operations, as well as environmental monitoring protocols.

Accompanying the Takeover of the Operation

We design operating and maintenance strategies. We can train the future O&M teams on site or in our two dedicated training centres.

A team of experts

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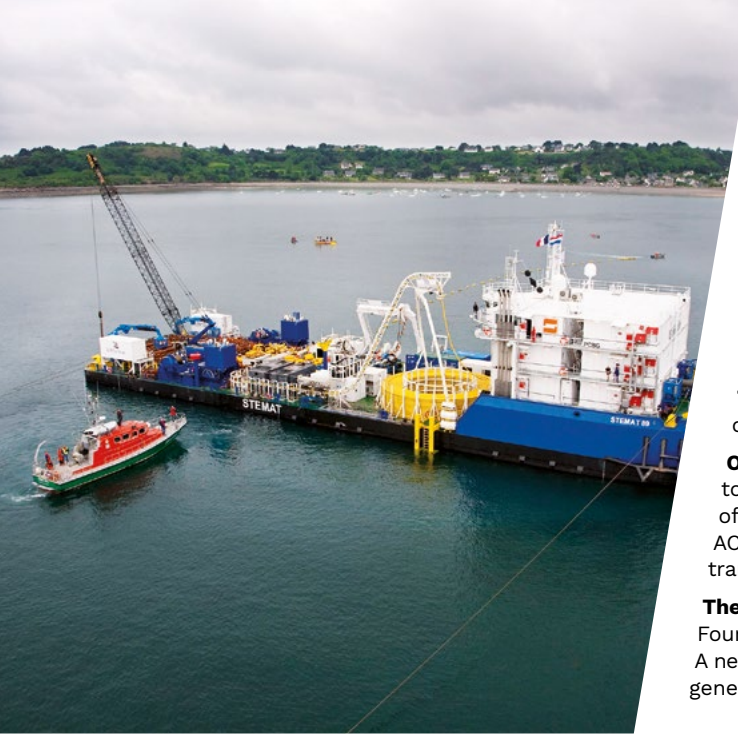


Proof by example

A Tidal Stream Site for Full-scale Testing

France - Paimpol-Bréhat

The challenge: to develop a tidal stream test site connected to the national grid, off Bréhat Island.

The context: the technological development of tidal turbines requires the testing of prototypes in real conditions.

Our response: full project management from the initial permit applications through to industrial commissioning. Implementing innovative solutions that take the specificities of the marine environment into account: protecting and stabilizing cables on a rock floor, AC/DC conversion, connection system to create a multi-devices farm architecture or transplanting eelgrass in the tidal flats.

The results: the site's fully operational terrestrial and maritime infrastructures. Four marine turbines of OpenHydro technologies were tested in real conditions on the site. A new test programme has started with the OceanQuest technology, which has been generating electricity on the grid since June 2019.

La Rance Tidal Power Plant Gets a Second Lease of Life

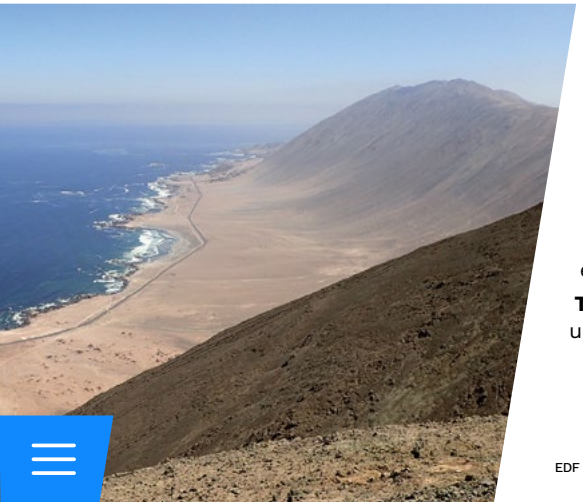
France - La Rance tidal power plant (240MW)

The challenge: to renovate a scheme that is over 50 years old.

The context: to make the facility reliable and modernize it to guarantee its safety and improve its profitability.

Our response: mechanical refurbishment of the bulb units, modernization of the IC system and optimization of the scheme's management.

The results: a modernized plant and better performances.



Value Engineering on a Sea Water PSP

Chili - the Atacama desert

The challenge: to optimize the design of a 300 MW PSP fed by sea water.

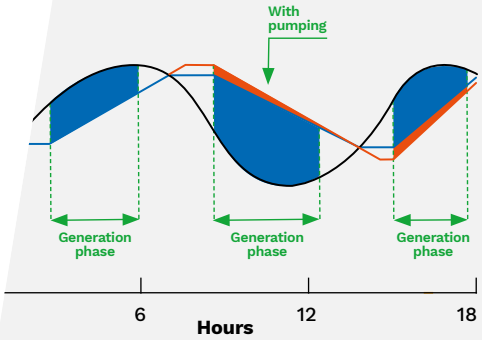
The context: very strong penetration of intermittent renewable energies on the Chilean electricity market.

Our response: detailed review of the project including the design studies, the construction methods, the permit procedures, the social consultation process and the project's economic model.

The results: a project made reliable through design modifications, a risk analysis and updated cost and schedule estimates.

10 GW: **EDF objective new storage capacities worldwide by 2035**

Dual effect operation of La Rance tidal power plant



Advantages of EDF Hydro

EDF has solid experience in maritime projects, based on:

- the construction and operation of pumping houses for coastal nuclear and thermal plants,
- developing and building offshore wind farms,
- its unique feedback from 50 years of operation of La Rance tidal power plant and 10 years of experiments with innovative technologies on the Paimpol-Bréhat site.

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Reconciling hydroelectricity with social & environmental concerns

The challenge

Even if technically state-of-the art and economically profitable, no hydropower development project will ever get off the ground unless it gains acceptance from all stakeholders. It has become crucial today to properly manage resources sharing, environmental preservation and climate change effects.

You intend to secure your development schedule and gain acceptance for your hydropower project. You want to reconcile development and biodiversity. You aim to have your project recognized as a reference benchmark of sustainability. You need your project to be eligible for green financing.

EDF Hydro Engineering will assist you in this task.

100 % **Social & Environmental permits granted on completed projects**

Our solutions

Managing social & environmental issues

We investigate E&S issues based on a multicriteria analysis: impacts, risks and opportunities. We can intervene at all stages of a project: scoping phase, feasibility studies (EIES, PGES, PAR...), contractual specifications, implementation monitoring, and ex-post assessment.

Designing hydropower facilities for optimal net environmental footprint

- Propose measures to avoid, mitigate and offset environmental impacts
- Ensure the continuity of fish circulation and sediment transport
- Propose solutions to minimize the net greenhouse gas emissions
- Monitor the quality of water and aquatic ecosystems
- Design facilities compatible with the presence of fragile natural areas
- Propose sustainable solutions of land occupancy

Designing hydropower facilities for positive social impact

- Propose solutions designed for multi-uses of water and positive social impact management
- Organize the dialogue to gain social acceptance for the project
- Assist you for land release procedures
- Define measures of benefits sharing
- Design construction site infrastructure transferable to other stakeholders
- Measure the social and economic spinoffs of the project

Making your project eligible for green financing

- Align the project with international standards: IFC, IHA and World Bank guidelines, Green Climate Fund
- Meet the E&S eligibility criteria of financing institutions
- Obtain and retain E&S operating permits
- Assist you in discussions with investors and lenders

A team of experts

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Proof by example

Helping displaced communities out of poverty

Laos - Nam Theun 2 (1 070 MW)

The challenge: reconciling hydropower development and benefits sharing.
The context: 1,310 families to be relocated.
Our response: implementation and 20-year monitoring of a social and environmental management program consistent with best practices recommended by the World Bank and Asian Development Bank.
The results:
- 97% of displaced persons were helped out of poverty,
- improved healthcare, education and material well-being,
- innovations in social management and benefits sharing.

Fish drying tables supplied to the communities in the Nam Theun 2 project

Nachtigal Amont, a role model

Cameroon - Nachtigal (420 MW)

The challenge: reconciling hydropower development, socially responsible land management, livelihood and biodiversity.
The context: new run-of-the-river hydropower development project on the Sanaga River requiring prior considerations to address all E&S issues.
Our response: mainstream IFC standards based on “Avoid/Mitigate/Offset” sequence into flagship measures: diversity plan, livelihood rehabilitation initiative for the dam area, actions in favor of the Mpem & Djim National Park, long-term local development strategy.
The results: environmental permit granted. Several action plans implemented:
- social and environmental management plan,
- stakeholders engagement plan and complaint management mechanism,
- dedicated biodiversity action plan for 8 protected species,
- 2 resettlement plans,
- local development action plan ($5 M).

Irrigating more, emitting less

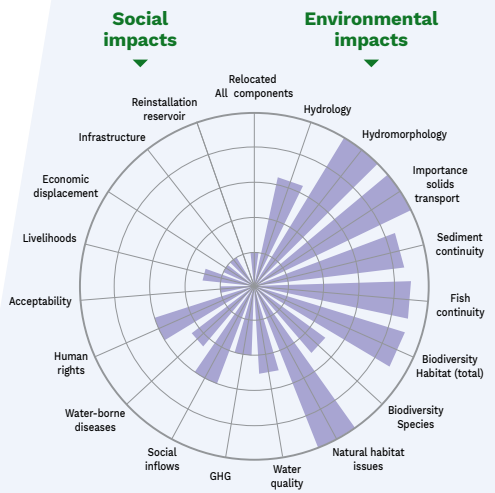
Sri Lanka - Dam projects on Mundeni Aru River

The challenge: reconciling agricultural and economic development in a catchment area combined with reduction of greenhouse gas (GHG) emissions.
The context: the French Development Agency requires a study to define the best development plan for farm irrigation reservoirs in order to reduce GHG emissions.
Our response: calculate the net (before/after) direct (creation of two reservoirs) and indirect emissions, based on several development scenarios.
The results: calculation of overall emissions from various solutions, recommendations on the lowest emission solutions.

> The experience of EDF Group, as evidenced in particular by EDF Hydro, is a decisive guarantee for all financial and institutional partners. In this project, the ability to gain the confidence of all partners in terms of industrial control and E&S expertise is a crucial factor.

Augusto Soares Dos Reis,
NHPC CEO, Nachtigal project

Key Indicators



Advantages of EDF Hydro

EDF Hydro has developed expertise in integrating hydropower facilities into their territory and generating benefits in terms of image, risk management and sustainability based on:

- Its 70 year-long experience in operating a fleet of hydropower facilities
- Renowned experts and frequent scientific publications
- Its long-standing practice of international standards

International financial institutions and governments appreciate the image of EDF Hydro as a socially and environmentally responsible developer.

contact-hydro@edf.fr

Monitoring the construction and commissioning of hydroelectric facilities

The challenge

Supervising, controlling and accepting delivery of construction or refurbishment works, and commissioning the completed facilities, are all key steps crucial for the final success of a project.

You are an investor, an asset manager or an operator of hydropower facilities. You wish to contract for services of works supervision or commissioning. You expect this assistance service to be decisive to meet your targets of completion deadlines, cost control, safety and quality.

EDF Hydro offers support & assistance services that are adapted and customizable for all or part of your project.

622 DAMS and 433 HYDROPOWER PLANTS **supervised and built in the EDF fleet**

22 PROJECTS **of hydroelectric facilities completed internationally**

Our solutions

Supervising works on jobsites

Depending on the needs of your project, EDF Hydro will second its specialists on site at each phase: project leaders, experts, engineers, experienced technicians.

Planning, oversight, coordination of interfaces, safety management: EDF Hydro will assist you at each step of your complex projects involving numerous work packages or EPC contracts.

Controlling, from design up to equipment manufacturing and installation

EDF Hydro provides expert monitoring of design & engineering ahead of the construction phase, a key asset to ensure the compliance of execution documents drafted by contractors, and to mitigate the risks during construction.

EDF Hydro provides strict external control over equipment manufacturing in factories, delivery on site and installation.

Acceptance process

EDF Hydro provides assistance for acceptance testing and clearance of reservations for final acceptance.

Commissioning

EDF Hydro offers a broad range of services: practical and theoretical training, participation in tests, structuring of maintenance and scheduling of preventive maintenance, organization of plant operation, incident management, traceability, document management...

EDF Hydro assigns to your project a team of experienced commissioning specialists who assist you to ensure the best conditions for the handover and mitigate the risks at commissioning.

A team of experts

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Proof by example

Success guaranteed by a multidisciplinary team

Laos - Nam Theun 2 (1 070 MW)

The challenge: establish a team capable of steering the project in all technical, environmental and social aspects.

The context: the facilities include a 39m-high and 439m-wide dam creating a reservoir of 3.6 billion m^3 on the Nam Theun river, a supply channel and a 2km-long feed gallery.

EDF is involved in this project as investor and prime construction contractor, which requires strict compliance with the completion deadlines subject to substantial late penalties.

Our response: creation of a multidisciplinary team of engineers and technicians to guarantee compliance with scheduled deadlines and control over operational risks, in particular with in-factory control of the major equipment components, works supervision and functional commissioning of the entire hydroelectric plant.

The results: commissioning of a $1.5 billion project (of which $730 M in construction) in compliance with completion deadlines (under 54 months).

First Pump Storage Powerplant in a Gulf country

Dubai Emirate - Hatta (250 MW)

The challenge: win and execute this engineering project under a highly competitive bidding process.

The context: the client DEWA (Dubai Electricity & Water Authority) issued a call for bids on the procurement of an all-inclusive assistance service package.

Our response: a construction supervision team with 6 experts seconded in situ and backed by support from EDF Hydro in France.

The results: thanks to strict quality control and close cooperation with the client, we ensure full compliance of the construction works with all of DEWA's specifications.

Commissioning of 2 mega-turbines on Teles Pires River

Brazil, State of Mato Grosso - Sinop (408 MW)

The challenge: build hydroelectric facilities able to withstand high amplitude flood waters.

The context: EDF owns 51% of the project company Cia Energetica Sinop and was involved in monitoring the construction and commissioning.

Our response: secondment to the project owner of a team of engineers necessary to provide assistance to construction. Vetting of design for the main structures. Additional support to the crucial phase of reservoir filling (safety and environmental follow-up).

The results: Reservoir filling operations at the Sinop dam were completed smoothly between February and April 2019. The two Kaplan turbines (among the most powerful in the world) were successfully commissioned in September and October 2019.

As an overall architect, EDF Hydro contributes its expertise in interface management during the construction phase, a crucial step for a successful hydropower construction project. Our world-renowned expertise was one of the main reasons why our client approached EDF Hydro Engineering and trusted us as prime contractor for their PSP project.

Raphaël Dehandschoewercker
Project Manager in charge of construction at HATTA

Advantages of EDF Hydro

EDF Hydro experts supervise construction works in many countries and in diverse contexts, always involving high stakes.

Our engineering staff takes great care of safety issues, delivering the same high standards to its clients as for our own projects.

EDF Hydro can provide measuring, diagnosis and expertise services in supervision of civil engineering works, as well as hydrometeorological and environmental forecasting.

Our commissioning specialists will assist you in operations of acceptance, testing, and protection and performance control. Our expertise guarantees the exhaustiveness of tests and settings, thereby mitigating operational risks in the future.

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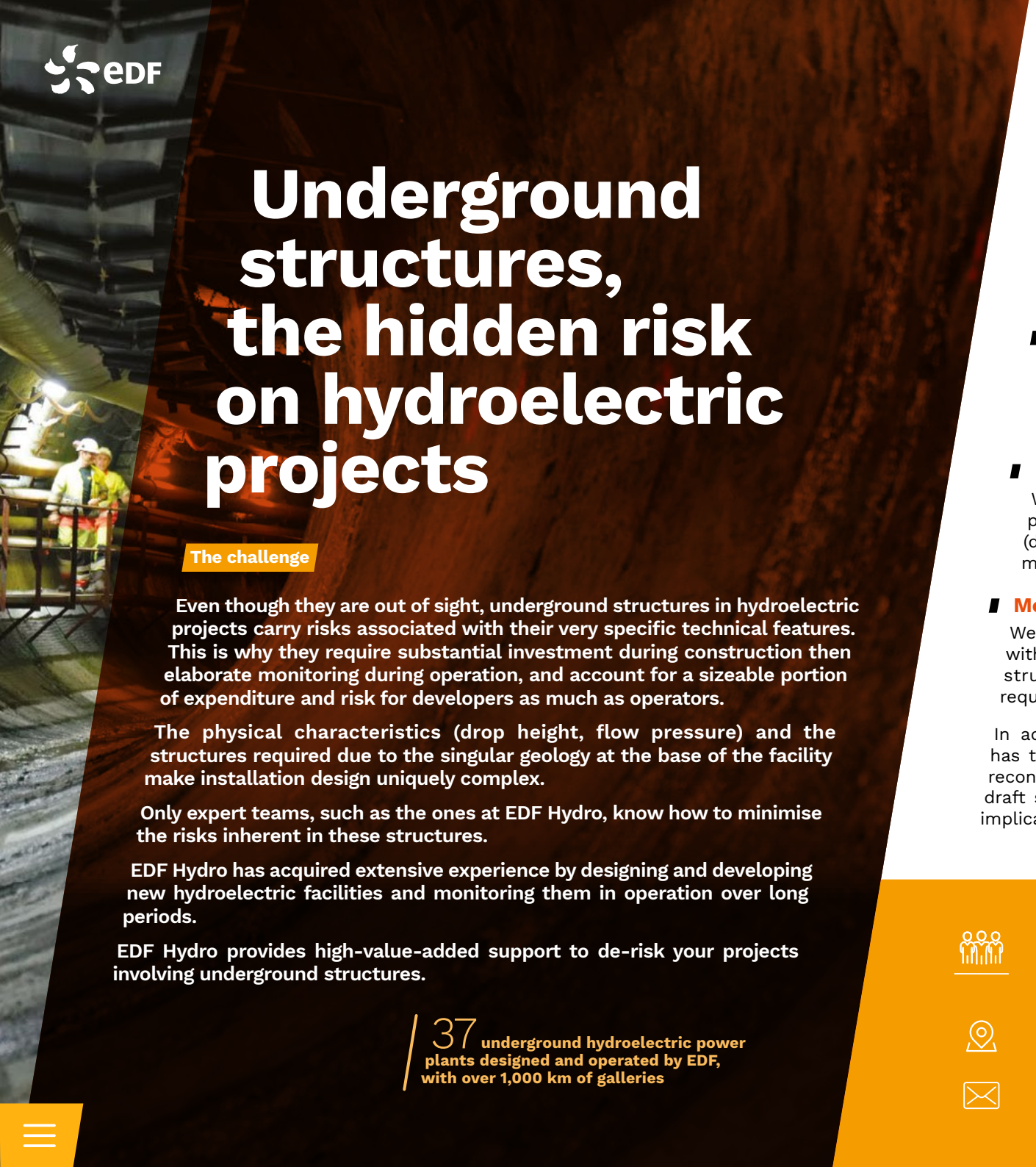

Underground structures, the hidden risk on hydroelectric projects

The challenge

Even though they are out of sight, underground structures in hydroelectric projects carry risks associated with their very specific technical features. This is why they require substantial investment during construction then elaborate monitoring during operation, and account for a sizeable portion of expenditure and risk for developers as much as operators.

The physical characteristics (drop height, flow pressure) and the structures required due to the singular geology at the base of the facility make installation design uniquely complex.

Only expert teams, such as the ones at EDF Hydro, know how to minimise the risks inherent in these structures.

EDF Hydro has acquired extensive experience by designing and developing new hydroelectric facilities and monitoring them in operation over long periods.

EDF Hydro provides high-value-added support to de-risk your projects involving underground structures.

37 underground hydroelectric power plants designed and operated by EDF, with over 1,000 km of galleries

Our solutions

Designing underground plants

We engineer underground industrial facilities using a digital tool akin like BIM (Building Information Modelling).

Optimising works

We define the execution methods according to the type of soil. This includes design-to-cost processes, optimising underpinnings and sidings, and assessing costs based on experience from a wide range of operations.

Engineering complex structures

We size load-bearing structures following international best practices and leveraging expertise in advanced digital tools (discontinuous models, behaviour law factoring in degradation of materials).

Monitoring construction

We apply the observational method, combining geologists' skills with responsive engineering teams that know how to optimise structures during the works phase. We define the monitoring requirements then analyse monitoring findings.

In addition to its sizing and engineering capabilities, EDF Hydro has the expertise to anticipate geotechnical risks by mapping out recon plans and fine-tuning risk analysis. Legal experts also help to draft specifications and contracts to formalise and manage all the implications of these geological and geotechnical risks.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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Proof by example

Dealing with asbestos

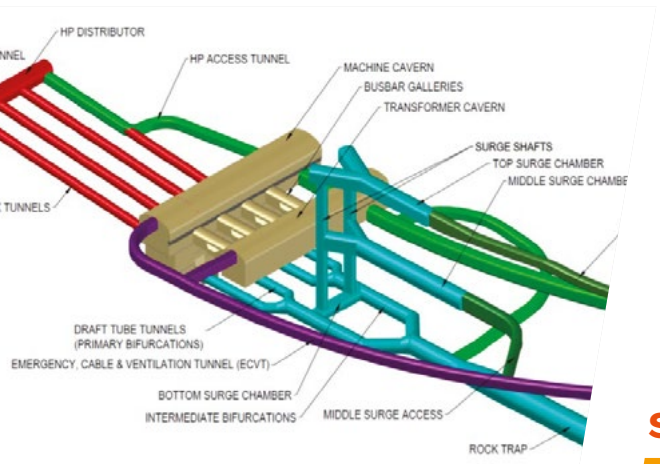
France - Gavet dam (92 MW)

The challenge: build the largest hydroelectric power plant in France in the past 20 years, in complex geological surroundings.

The context: a plant with 15 km of underground tunnels and two caverns, in an asbestos-containing environment.

Our response: studies and monitoring of construction, fine-tuning digging methods according to the surroundings (tunnel-boring machine and blasting).

The results: the plant started up operations in 2020.



Lowering risks and costs for a Pumped Storage Power Plant

Australia - Lake Cethana PSPP (Hydro Tasmania)

The challenge: assist an operator with its plan to develop new power production capacity using mostly underground facilities.

The context: the operator tasked with the preliminary studies had an engineering team, and we added our specific expertise in underground works.

Our response: combine the customer's general profiles with our specialist profiles in the back office to provide top-level technical studies.

The results: we added a number of technical upgrades that have improved the facility's integration into the site, which concurrently reduced costs and risks.

Securing a key project in the nuclear sector

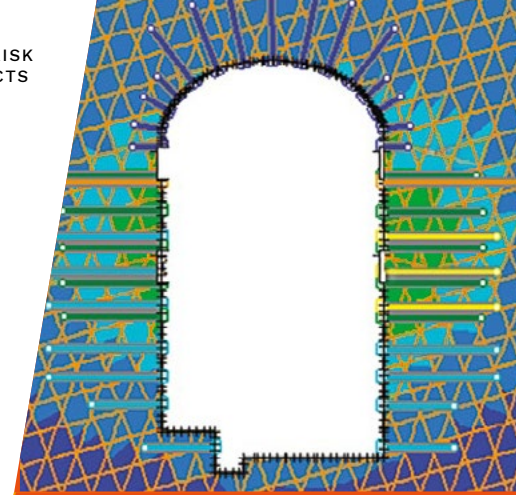
United Kingdom – Hinkley Point C EPR (3,200 MW)

The challenge: support EDF's Centre national d'équipement de production d'électricité (CNEPE), tasked with designing the seawater inlets and outlets for the system to cool the nuclear facilities at Hinkley Point C (HPC).

The context: construction of the underwater offshore circuits for Hinkley Point C, with a view to securing and de-risking complex works involving a substantial investment by EDF.

Our response: EDF Hydro designed the underground infrastructure (shafts and galleries, dug with a TBM) for each geological setting (marly limestone, sand, clay). EDF Hydro also defined the contract models for the underground works and supervised construction design.

The results: work is under way at Hinkley Point C, which will start generating electricity in 2026.



A section of the cavern including underpinning analysis

Advantages of EDF Hydro

EDF Hydro's integrated engineering capabilities (at the Hydro Engineering Centre) have all the keys to provide high-quality expertise tailored to the operator's real situation and the variety of constraints they need to accommodate (operations, safety, maintenance schedules and budgets).

The Hydro Engineering Centre has built extensive knowledge over the years, working for EDF and a variety of customers around the world. We can therefore support you throughout your project, whether it involves maintenance, work on observed damage or sizing new-build capacity.

contact-hydro@edf.fr

Improving the efficiency of hydropower facilities

The challenge

With age, hydropower facilities drift away from their optimum performance. Risks of failure increase, reflected in gradual production losses (tripping, failures, lower efficiency, lower output...). Safety risks also increase and some equipment components are no longer maintainable.

Technology upgrades and regulatory changes can provide opportunities to increase the initial power delivered to the grid, thereby generating additional revenue.

As owner or operator/maintenance operator, you need to refurbish your facilities in order to preserve or recover the efficiency of your power generation assets. You are thinking of improving the capacity of your facilities in order to respond better to grid's demands, to new safety requirements, thereby securing your revenues.

How to launch your refurbishment program? Which type of performance do you want to improve? How much power increase should you consider?

EDF Hydro Engineering can assist you throughout your refurbishment or uprating process.

Projects completed in the EDF hydro fleet over the past decade:

130 power units modernized

6,200 MW modernized or uprated: design, procurement, works supervision & commissioning

Our solutions

Conducting a comprehensive assessment

Ahead of the project, we help you conduct a comprehensive analysis of your facilities, operational indicators, incidents and annual operating losses. We factor in your special needs based on your documentation, in-depth expert assessment visits, interviews with the management and with operation/maintenance crews.

Proposing potential improvements

In a detailed report, we then offer our recommendations to optimize the equipment and systems to be refurbished in priority and increase their residual lifespan to the greatest possible extent. We suggest avenues for efficiency improvements and operational risk mitigation.

Building a refurbishment or retrofit project

We help you specify your needs and the strategy to be adopted: definition of operational improvements, scope of refurbishment or retrofitting, cost estimates and potential gains, building a workstream schedule.

Providing customized support

We provide assistance according to your needs and internal resources throughout the entire refurbishment or retrofit process, for contract awards, monitoring of detailed design, and works supervision up to commissioning and final acceptance.

Assisting operation and maintenance

We provide assistance and training in operation and maintenance of the newly installed systems. We advise you on the management of spare parts or the organization of operations and maintenance.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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Proof by example

Forty more and better years

Ukraine - 9 hydropower plants on Dniepr River (104 power units) between 2010 and 2021

The challenge: extend the residual lifespan of hydropower plants and improve their efficiency.

The context: aging power plants, downgraded performance, limited functionalities, risks of failure.

Our response: assistance to define a strategy and refurbishment scope phased over time; optimum subcontract allotment; cost estimates; preparation of calls for bids and bid review; monitoring of works execution and contract management.

The results: the lifespan of power units was extended, the overall power was increased by 7% and efficiency rates have improved. Centralized automation of operation control and a switch to digital technologies now provide more functionalities for operation.

Upgrading of pumped storage power station

France – La Coche PSPP station 2015-2019 (400 MW)

The challenge: improve availability and producible power of a PSPP station commissioned in 1976 while leveraging favorable legal provisions to increase the power, without challenging the concession contract.

The context: the facility is affected by high sediment loads in the water, and replacing the turbines is a long and complex process.

Our response: construction of a new station adjoining the existing PSPP plant in order to increase the installed power capacity. The newly installed turbine, easy to maintain and replace, was built according to an additive manufacturing technology. It is coated with a special abrasion-resistant liner.

The results: 20% flow-through increase and 35% increase of annual energy output, strictly in line with the initial budget. The turbine's power output flexibility delivers significant gains in ancillary services. Commissioning of the most powerful Pelton turbine in France, delivered 2 months ahead of contractual schedule.

Revamping of 60 major EDF hydropower facilities

France – EDF hydropower fleet between 2011 and 2022 (5,400 MW)

The challenge: modernize and standardize SCADA systems and electrical facilities in the largest hydropower plants of the EDF fleet within less than 10 years.

The context: under-capacity of industrial fabric due to insufficient demand, equipment obsolescence, increasing hazards, and reduced plant availability.

Our response: design an optimized technical specs model, define industrial and procurement strategies to be implemented. Mass-roll out with industrialized methods. Budget optimization thanks to a "design to cost" approach.

The results: 130 power units, 180 speed regulators, 70 voltage regulators modernized within 10 years. Improved efficiency rates and extension of system services. Downtime for works is minimized and the upgraded equipment is chosen carefully to extend the lifespan of electrical facilities and SCADA systems by more than 25 years without having to replace everything.

EDF operates

433

hydroelectric facilities

with an average age over 70. Our ability to optimize, modernize and uprate them efficiently is a key challenge.

Advantages of EDF Hydro

Our identity is deeply rooted in plant operation: when refurbishing, we factor in future operation and maintenance requirements from the onset of the design phase. We involve and train the operation and maintenance staff from the design stage.

Our thorough knowledge of the operation of hydropower facilities and their operational challenges enables us to refurbish up to the right level while preserving the facilities in appropriate operating conditions. Our experienced commissioning specialists contribute to securing the functional testing phases, and guarantee exhaustive testing and optimized settings.

We share with our clients the benefits of our know-how and expertise that we keep developing and leveraging every day in our hydropower plants, as well as our unique experience as engineer, producer, operator and maintenance specialist.

contact-hydro@edf.fr

Treating hydraulic structures suffering from pathologies

The challenge

Nearly one dam out of three suffers from internal expansion of the concrete (source CFBR). However, it is not always essential to reinforce the affected structures.

If you are an operator and you feel the need to analyze these singular phenomena so that you can act accordingly.

EDF hydraulic engineering center has developed numerical models capable of describing the concrete's internal state and how it will evolve. These models allow you to identify the most relevant reinforcement projects, in order to stay in operation and optimize the cost of the work.

30% **This is the proportion of dams suffering from expansion pathologies worldwide**

For dams, this creates damage that can compromise the structure's overall stability. For plants, this can lead to different issues: misalignment of turbines, oval deformation of the units, blocking of the gate components...

Our solutions

In-depth expertise

Our understanding of the challenges and the safety standards allows us to advise you rapidly on the criticality of the damage observed. Our step-by-step approach always starts with an expert analysis, which may sometimes suffice.

Numerical models for decision making

Finished element models allow the state of internal stress in the structures to be assessed. The approaches developed with the University of Toulouse are the world's top state-of-the-art techniques and have been used successfully on around a dozen structures in France and worldwide. We assess the effectiveness of the recommended solution in the most realistic way possible and predict the structure's future behavior.

Using samples taken *in situ*

We know how to specify and pilot *in situ* sample operations and we use a wide range of methods of analysis: measuring stresses by overcoring, laboratory estimations of the potential evolution through accelerated expansion and analyzing the crushed material.

Reinforcing structures

We have implemented a wide diversity of reinforcement techniques on our structures: cutting, reinforcement using dynamic tie rods, carbon mesh, waterproof membranes... Our numerical models allow us to assess their impact and predict the structure's future behavior.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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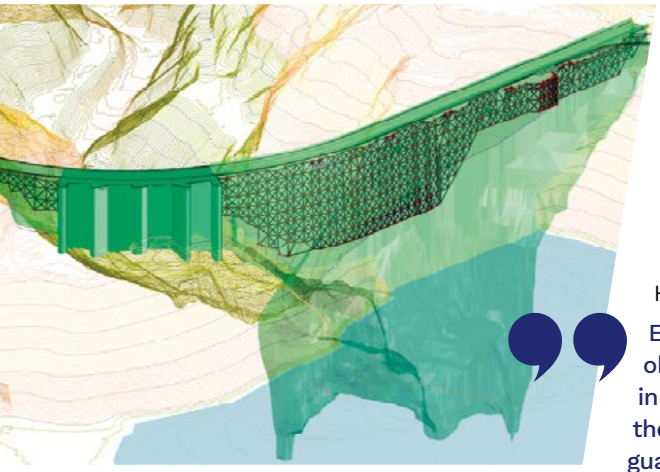

Proof by example

Chambon, reinforcing one of France's oldest dams

France (Southern Alps)

The challenge: how to ensure the long-term performance of one of France's oldest dams?

The context: with expansion rates that reach 50 µm/m/year, Chambon dam was suffering from multiple structural damage, especially continuous cracks that were likely to bring down the dam in the event of a tremor.

Our response: project managing the reinforcement, from the studies to the works; developing numerical models that allowed the observed damage and the effectiveness of the reinforcement to be assessed precisely. For example, the extent of the bank-to-bank cracking was identified using the models and the associated risks were taken into account for the reinforcement. The models were validated through samples taken on site.

The results: different internal techniques were implemented: The dam was cut again to reduce the internal stresses. Reinforcement through tie-rods and carbon mesh re-established the structure's rigidity. Monitoring since the work was carried out has reassured us that the numerical models were correct.

Assisting Hydro-Québec: planning in order to optimize

Quebec

Hydro-Québec requested the creation of behavior models for two of their structures:

> EDF's models served as a reference for describing the structural damage observed on these facilities. They will be an invaluable aid for decision-making in reinforcement works and for optimally staggering their implementation over the next few decades. This type of planning means savings in the short term and guarantees greater effectiveness in the long term.

Responsible for geotechnical expertise, geology and structures

The best calculation: proving that all is well!

France (Central Region)

Several dams in the center of France are suffering from alkali-silica reaction (ASR) or internal sulfate attack. On five of them, an ASR model was created, making it possible to estimate the internal state of stress by 2020 and 2030, as well as the flagging potential damage. The results reassured the operator and allowed the reinforcement work to be postponed.
The model also allowed the operator to take a more detailed look during monitoring rounds, for example by indicating where cracks could potentially appear and their risk for the structure's overall performance.

EDF Hydro works on EDF's behalf on

470 dams

with an average age of 70 years.

Advantages of EDF Hydro

EDF Hydro engineering works closely with operators in order to offer them the best solutions at a cost compatible with the financial challenges of design-to-cost production. As an independent engineering company, EDF Hydro is certified with the safety authorities.

The models proposed by EDF Hydro are absolutely state of the art. They describe the physico-chemical condition of the concrete better than any alternative models and couple it with its mechanical behavior. They are therefore able to describe the current state of the structure and even to project into the future (10 years) in order to plan the long-term reinforcement work as closely as possible.

EDF Hydro uses several internal specialist laboratories and its own nuclear engineering experts.

contact-hydro@edf.fr

Ecological downstream flows, a key factor for environmental performance of dam projects

The challenge

As hydropower developments can modify various aspects of natural river flow regimes, the management of downstream flow regimes to meet environmental, social and economic objectives is key to overall hydropower sustainability.

Good practices regarding downstream flows have recently evolved and are being given greater focus by stakeholders, including widespread adoption of the "environmental flows" concept (updated Brisbane declaration 2017, World Bank Group 2018).

As a hydropower company, you are seeking to optimally manage surface water through proper storage and release. EDF CIH can help you define an appropriate environmental downstream flows (E-flows) resulting from in site measures, scientific studies and stakeholders discussions (from the design to the operating phase).

Our solutions

Preliminary studies to determine the actual need for E-Flow

- We identify downstream issues (critical or natural habitats, biodiversity, riverbank populations) and pressures on water resources (water uses, irrigation, storage facilities);
- We determine the need for a basin or project-level E-flow study;
- We ascertain the adequacy of regulations and requirements, as well as the preliminary identification of design options and impact on feasibility;
- We hold discussions and negotiations with stakeholders.

Design phase: adjusting effectively project design to E-Flow requirements

We select the appropriate method for assessing E-flows using the IFC decision tree and we implement site-specific monitoring (hydraulic, sediment, ecological). Then we conduct a scoping of downstream social and environmental impacts and risks, including an analysis of climate change impacts on discharge regimes and associated possible evolution of social demands. We work with the project developper so they take into account the results of our studies. Finally we ensure that E-Flow features are well integrated in Contractor specifications and that E&S commitment/mitigation/management plans are put in place.

Operating phase: E-Flow components monitored and fostered

We monitor the implementation of environmental and social management plans relating to E-flow components: water quality, aquatic habitat and biodiversity, geomorphology dynamics, water-uses, local added value... Additionally, we propose to provide operator training to meet E-flow requirements effectively.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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Proof by example

Regaining biodiversity and geomorphological function with E-flows

France/Germany - Kembs (160 MW), from 2003 to 2016

The challenge: design a new environmental flow for “Old” Rhine River (natural riverbed), taking account of objectives defined with NGOs and Authorities to improve biodiversity without excessive energy losses.

The context: continuous decline of Rhine River biodiversity and geomorphology since first embankment works in the 1830s.

Our response: mimicking the natural hydrological regime (seasonal and daily variations)

The results: restoration of alluvial dynamics (sediment recharge and controlled bank erosion); connectivity for all aquatic mammals species. Since commissioning, 45,000 m³ of gravel were re-injected and more than 22,000 individuals of 19 fish species (including 3 long-distance migrators) used the fish pass in one year.

E-flow as a main design criterion

Myanmar - Shweli 3 (672 MW) under development since 2019

The challenge: review the design a of dam in accordance with international standards on downstream flow regimes.

The context: braided river with settlements on riverbanks, large alluvial lands, social and cultural river uses and a hydropeaking project.

Our response: the E-flow assessment used a high-resolution holistic model and evaluated all E-flow aspects (including base flow, maximum flow, hydropeaking, backwater effect, etc.) with dedicated field data-collection surveys (aquatic and riparian biodiversity in particular). The package also included a hydraulic study, water-quality study, sediment-continuity study and downstream social-impact study covering a large area of investigation (80 km downstream).

The results: design of downstream flows and of a demodulation dam.

E-flow for an endemism mitigation measure

Cameroon - Nachtigal (420 MW) under construction since 2019

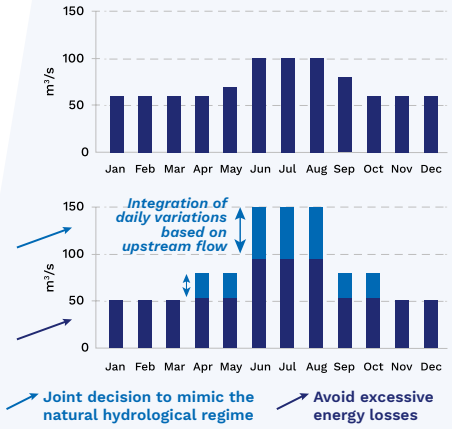
The challenge: design a new HPP taking into account major down-stream environmental and social impacts.

The context: endemic aquatic plant in the bypass reach with limited knowledge of its ecological cycle.

Our response: EDF conducted in-depth studies to determine the ecological needs of endemic aquatic plants (Podostemaceae) to define a variable e-flow based on adaptive management principles.

The results: conception of suitable habitat conditions (replicating seasonality) and implementation of an ambitious biodiversity action plan including aquatic habitat offsets to benefit endemic species.

« Old » Rhine River Flow, *from the initial proposal to the final one, fostering local biodiversity while minimizing energy losses*



E-flow scenarios evaluated during relicensing of Kembs HPP (Barillier & Garnier, HYDRO 2017)

Advantages of EDF Hydro

EDF rigorously applies the highest E&S international standards and is an active member and contributor to IHA: EDF Hydro experts have been assigned as peer reviewers for IHA How to Guide about Downstream Flow Regimes (2020)

A team of dedicated environmental and social experts covers the full range of downstream flow questions (aquatic biodiversity, sediment management, stakeholder engagement) and works daily with design and O&M engineers. Our internationally recognised specialists make regular scientific contributions on downstream flow management topics in collaboration with EDF R&D.

Our experts have extensive experience with about 500 current HPP schemes in France (20 GW) seeking to develop models for the appropriate river flow and sustain biodiversity, manage sediment environmental down-stream flow and provide adequate extreme drought support.

contact-hydro@edf.fr

Optimizing Penstock Maintenance

The challenge

Did you know that the main causes of incidents on penstocks are due to steel corrosion and fatigue problems? These problems that are invisible, or hard to see, can cause serious accidents involving people's safety and heavy revenue losses.

You are the asset manager of medium- and high-head hydropower production facilities. You want to set up an effective, long-term refurbishment or maintenance strategy. You want to guarantee optimum safety while controlling costs.

EDF's hydraulic engineering can assist you.

10 penstocks **replaced in our own facilities over 10 years**

Our solutions

Establishing a Complete Situational Analysis

Prior to a project, we analyse the existing facilities. We identify all the strengths and weaknesses of the sites and equipment. We map out the remaining risks so that the decision maker can make informed decisions.

Estimating a Facility's Service Life

By taking the operating method into account, we determine the installations' remaining service life. The goal: to allow the asset manager to plan a refurbishment operation in the best economic conditions.

To build a Long-term Maintenance Strategy

In order to preserve assets' best productivity, we draw up a long-term schedule of planned maintenance. We aim for the best balance between minimum risk and optimum efficiency.

Acting as Prime Constractor on High-risk Sites

We are familiar with the regulatory requirements and we have established the measures ensuring the safety of all those involved. We plan the coordination of the different works successively or simultaneously. We are involved in both design and refurbishment.

Commissioning a New or Refurbished Penstock

We accompany you during the operational implementation. Our expertise is based on the 270 km of penstocks on EDF's hydraulic sites. We have accumulated expertise that can be applied to a variety of topographical conditions.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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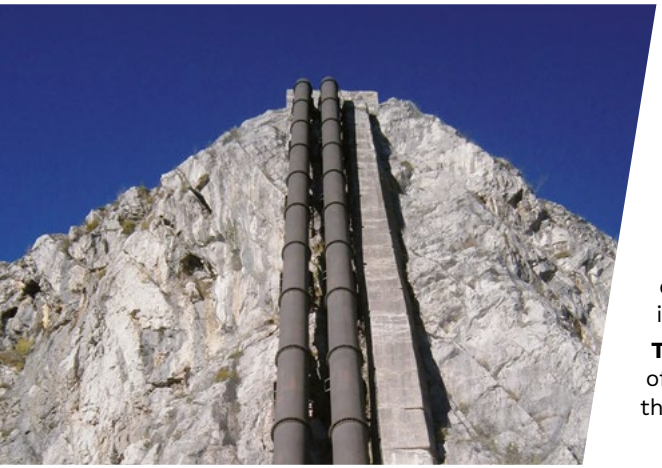


Proof by example

A Second Youth for Penstocks

France - La Coche (320MW)

The challenge: to reinforce a penstock installed forty years ago.

The context: renovating a penstock within a limited timeline.
An opportunity: the temporary stop of La Coche plant.

Our response: a complete diagnosis of the penstock and mapping of the weak points: limiting the number of areas to be treated.
Recommendations: closed-circuit high-pressure water blasting. Using a robot to treat the interior of the penstock.

The results: 1800 m of penstocks and 650 m of galleries treated. Minimal environmental impact. The replacement of complete sections prevented.
10 years gained before having to repaint the interior.

Turning Old into New

France - Sabart (34MW)

The challenge: to replace a penstock installed 90 years ago.

The context: carrying out a replacement project while minimizing the CAPEX minimum in order to keep the scheme's profitability with strong site constraints (rocky spur and maximum gradient of 73 degrees).

Our response: work perimeter reduced to the "strictly necessary": replacing the steel penstock sections and re-using anchor blocks and piers from the time of initial construction, requiring a demonstration of the feasibility and the interest in keeping such old structures.

The results: 2 x 320 m of penstocks treated and a gain of 6 months unavailability of the scheme compared to a "conventional" solution with full replacement of the penstock.

Minimizing the Unavailability of a Productive Scheme

France - Aston (104 MW)

The challenge: to replace a penstock installed 60 years ago.

The context: replacing a penstock while minimizing the unavailability of a highly productive scheme.

Our response: installing a new penstock next to the old one optimizing the level of civil engineering implemented (using methods developed by the CIH) and unavailability limited to upstream and downstream connections.

The results: 400 m of penstocks treated with a strong gain on the volume of civil works (volume of the toe block reduced from 400 to 150 m^3) and unavailability limited to the strict minimum.

EDF Hydro's Engineering Has Realized

20% of Europe's major projects

on penstocks in power plants of with a capacity exceeding 10 MW over the past 10 years, i.e. 10 of the 50 major projects.

Advantages of EDF Hydro

Our experience and expertise have been tested on EDF's facilities and beyond.

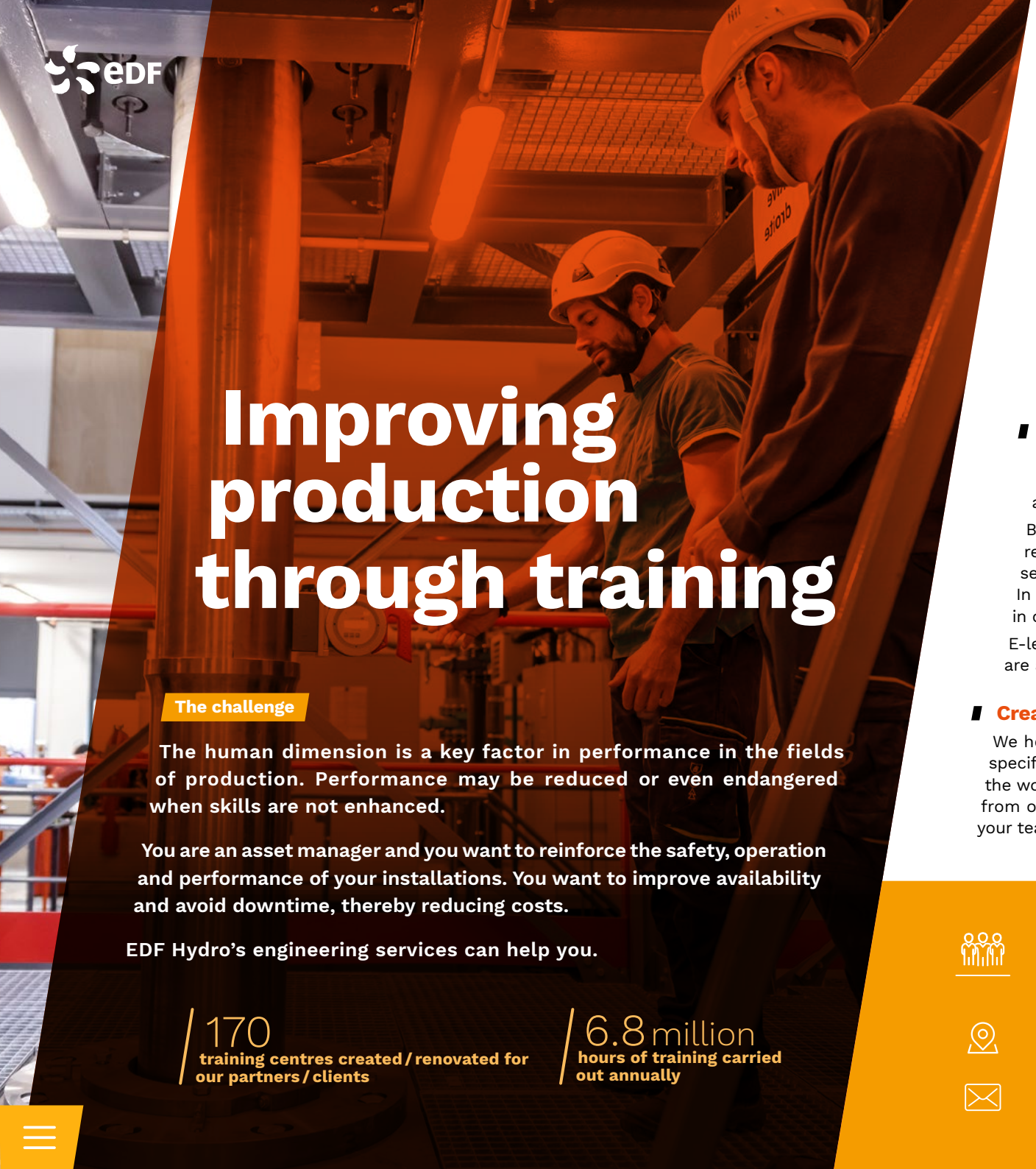
Our fleet includes nearly 500 penstocks, with a diversity of configurations, vertical drops and diameters.

We work on facilities of all ages.

Over the past 10 years, EDF's hydraulic engineering has strengthened its savoir-faire and its expertise over the whole life cycle, from design, refurbishment and diagnosis up to operation, in particular by developing tools for analysis, diagnosis and monitoring.

contact-hydro@edf.fr

EDF HYDRO - **CF_JUIN_2020_UK** - SUGAR - PHOTO CREDITS: @EDF - FRANCK ODDOUX, CHRISTOPHE HURET, BRUNO CONTY



Improving production through training

The challenge

The human dimension is a key factor in performance in the fields of production. Performance may be reduced or even endangered when skills are not enhanced.

You are an asset manager and you want to reinforce the safety, operation and performance of your installations. You want to improve availability and avoid downtime, thereby reducing costs.

EDF Hydro's engineering services can help you.

170
training centres created / renovated for our partners / clients

6.8 million
hours of training carried out annually

Our solutions

Establishing your business strategy

We offer our expertise to help you build a training policy. We assist you to meet your strategic challenges and to guarantee the adaptation of your teams' skills to deal with changes in the profession. We accompany you in the predictive management of jobs and skills, which enables you to anticipate the HR consequences of changes in your environment.

Defining customized professionalization programmes

With over 1500 training courses, our sessions are available in France or on your production sites for the employees managing and maintaining your schemes.

Based on an analysis of your existing methods, we define your required training goals with you and create customized training sessions for all your employees: technicians, trainers or managers. In order to put the training into practice, immersions are offered in our operational units.

E-learning courses including 360 courses in French and English are also available.

Creating / renovating your training centres

We help you to define your training centre project and the specifications for the required infrastructure. We assist you throughout the works phase and during commissioning and operation. You can benefit from our experience as the operator of over 35 training centres. We help your teams to start running the training centre (training the trainers).

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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Proof by example

A new training centre in Laos

Laos - Nam Theun 2 (1070 MW)

The challenge: to train EDL's trainers and the O&M staff and renovate the EDL (Électricité du Laos) training centre.

Our response: support in the fields of human resources and predictive skills management, renovation of EDL's training centre with new teaching equipment (models, etc.), training of 17 EDL trainers in Laos and also in France, and training of operators.

The results:

- effective trainings adapted to your needs and rich of feedbacks from similar services carried out for EDF's French facility operators.
- links forged between two operators: EDF and NTPC (Nam Theun Power Company), ensuring support in the long and short term on specialized subjects.
- immersion of Laos trainers on Nam Theun Hinboun and in EDL's existing plants.

Field training of local operators in Uganda

Ouganda - Isimba (183 MW)

The context: UEGCL is the main hydropower producer in Uganda and Isimba, on the Nile, its first owner-operated plant.

The challenge: to offer EDF Hydro's technical assistance during the first year of operation to accelerate the reinforcement of UEGCL's operational skills.

Our response: we accompanied and *coached* the UEGCL teams in order to identify the areas of operation in need of strengthening. We also carried out adapted training sessions and shared our best practices for operators.

The results: EDF defined a strategic action plan for optimising the plant's organisation and performance.

The training given: the basics of hydropower, safety and reliability of interventions, best practices for subcontracting maintenance works, repairs, etc.

This support was beneficial for UEGCL for Isimba as well as for the upcoming commissioning of Karuma (600 MW), the second plant that UEGCL will operate on its own.

Innovation requires training

Andorre - FEDA

The context: dealing with the obsolescence of certain equipment and constant innovation.

The challenge: training the operator in the new technologies.

Our response: providing the training on *"Maintaining and updating a hydropower plant I&C system".*

The results: the operators' training is being carried out on a long and evolving cycle that keeps skills at the highest level.

Over 1,000 trainers

within EDF Group and 35 training centres that meet the requirements of all areas of power generation and transmission: thermal and nuclear power, hydropower, transport.

#TRAINING

Advantages of EDF Hydro

For over 70 years, we have shared our expertise in professional training in 66 countries, allowing our clients to strengthen the safety and performance of their installations.

We propose specific e-learning sessions for the hydropower sector which allow employees to progress at their own pace and to refresh or update their technical knowledge.

We reinforce our expertise in the transfer of skills through 6.8 million hours of training per year.

In the hydropower field, 5000 people are trained annually as operators or in hydraulic engineering by over 40 trainers with extensive experience.

contact-hydro@edf.fr

Flood management: combining safety, environment & economic performance

The challenge

Floods frequently cause major damage to hydroelectric facilities. It is estimated that 40% of dam breaches are due to flood waters and their inadequate management.

The requirements of flood management may challenge the economics of a hydropower facility, due to operational restrictions on water levels or energy management.

You would like to have a safe, efficient and easy-to-implement methodology for flood management at your hydro facilities.

You want to leverage the potential of your reservoir and use a panel of predictive and training tools adapted to your needs.

Backed by our experience as Engineer and Operator, EDF Hydro Engineering has developed revolutionary methods and tools to help you meet these challenges.

These technologies reduce the need for operating restrictions, while delivering a gain in producible power of approximately 2%

The 40 major lakes in the EDF fleet are being equipped with a Trajectoire Linéaire® operation law and a Game of Gates model

Our solutions

Defining more efficient operation laws in flood conditions

Thanks to our new algorithm named **Trajectoire Linéaire** ©EDF 2016, it is easier to determine the necessary manoeuvres, without requiring any in situ calculation or knowing the inflow rate. **Linear Trajectory®** is compatible with automated control and enables precise parameter settings.

Proposing assistance and predictive tools

Based on hydrological and energy forecasts, we offer tools designed to prepare the reservoir in anticipation of flood waters. By adjusting the turbines' flow-through rate, it is possible to control the probability of the need for overflow discharges without dictating permanent restrictions on the operational level.

Anticipating with Game of Gates

Game of Gates is a simulation and anticipation serious game developed by EDF Hydro as a decision-making aid. It helps you simulate and prepare for flood management of a dam similar to yours, by benchmarking your methodology against the method developed by EDF.
Read more at www.game-of-gates.fr

Training site staff

In order to keep up and upgrade the operators' skills, we offer training sessions to fit any situation. Thanks to its virtual reality interface, our flood management simulator **SIMBA** generates highly realistic mock situations. For training focused on flooding operation strategy, **Game of Gates** can quickly simulate many different scenarios.

Optimizing the economic efficiency of reservoirs

We conduct sensitivity analyses to assess optimal operational modes according to the predictable frequency of flood events in large lakes. Our methodology enables the best multicriteria operating strategies to be designed, based on the processing of large panels of hydrograms generated by our hydrometeorological models.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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Proof by example

Long-lasting floods, giant reservoir and simplified management

Brazil - Sinop (408 MW)

The challenge: set up an efficient flood management method adapted to this newly commissioned facility with a very large reservoir.

The context: commissioning of this facility subjected to long-lasting flooding periods (around one month). Flood management must fit into the contractual framework agreed with all stakeholders in the Brazilian grid.

Our response: in cooperation with the operator, implementation of a Trajectoire Linéaire© management system with dedicated parameter settings. Analysis and consulting to establish operational flood instructions, followed by in-situ training and e-learning sessions via the **Game of Gates** simulation tool.

The results: high technical efficiency of the entire system, greatly appreciated by the operators.

Upgraded algorithm and improved cost-efficiency

France - Vouglans (285 MW)

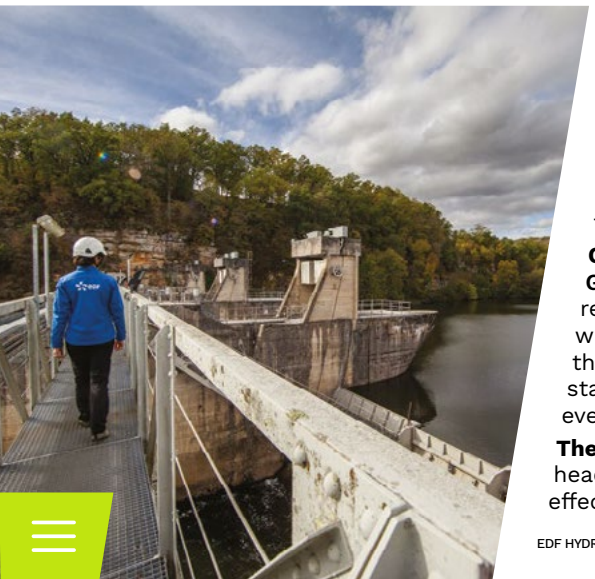
The challenge: determine the economic value of the power output in the Ain valley based on the calculated probable frequency of occurrence of flooding events at the Vouglans dam in order to upgrade the reservoir management algorithm.

The context: challenge the relevance of the very low frequency of occurrence of flooding events.

Our response: propose a technical and economic strategy for reservoir management, with upgraded flooding frequency trends and economic gains.

The results: economic gain of approximately 2% in producible output in the valley.

Game of Gates: Playing against chance



France - Vallée de la Truyère

The challenge: have a real-time operation management tool to optimize the anticipation of flood events.

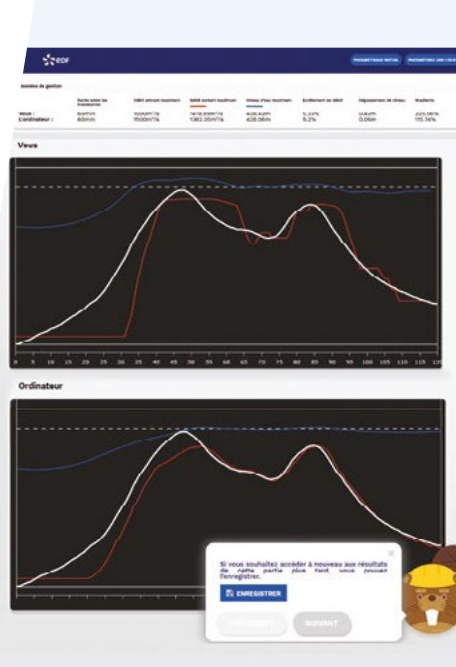
The context: reservoir management for short-term anticipation of flooding events to eliminate the need for permanent restrictions on energy regulation in this valley of strategic importance for the country.

Our response: implementation of **Game of Gates** simulation serious game to optimize the regulation in lakes when flooding is expected within a minimum of one week. The strategy is then confirmed objectively and shared among the stakeholders in order to anticipate the flooding events.

The results: optimized management of the valley's head reservoir at Grandval, 50% reduction of effective frequency of flooding events.

> We have revolutionized flooding operation management via a comprehensive approach combining safety, economics and ergonomics for our top 50 hydropower facilities. We are now offering to share our know-how and experience on the subject.

Manuel Antunes-Vallerey,
Flood Expert at EDF Hydro



Game of Gates, our decision-making tool

Advantages of EDF Hydro

In order to meet the challenges raised by the integration of renewable energy sources, EDF Hydro Engineering relies on the unparalleled experience of its engineers and experts in flood management.

We have been upgrading our expertise constantly for over 70 years of operating the EDF hydropower fleet, supporting operators to control all aspects of the flooding risk.

contact-hydro@edf.fr

EDF HYDRO - **GC_NOVEMBER_2020_UK** - SUGAR - PHOTO CREDITS: RECTO@EDF/PATRICE DHUMES - VERSO@EDF/LAURENT ROTHAN - PIERRE SOISSONS

Monitoring and Diagnosing Your Hydropower Plants Remotely

The challenge

Machine damage, loss of operation, over-solicitation of team members: Maintenance defects cause high costs and direct or indirect damage.

Equipment failure can cause an outage, penalise your scheme and, often, require curative maintenance, that is much more costly than the appropriate preventive or conditional maintenance.

You are a facility manager, you want to optimise the monitoring of your machines' behaviour. You want pertinent back-up to get the best recommendations on the maintenance actions to carry out.

EDF Hydro's engineering helps you to achieve your goal: monitoring the performance drifts of your hydraulic units as closely as possible to prevent malfunctions and even extend the service life of your facilities.

240 HYDROPOWER PLANTS
including 630 turbines monitored through e-Monitoring

18.7 GW HYDRO
e-Monitoring

93.8 GW **monitored using e-Monitoring at EDF**
(nuclear, hydraulic, thermal, wind and solar)

Our solutions

Increasing the Availability of Your Production Tools

By anticipating equipment failures, our recommendations help to reduce machine stoppages and damage. Additional close monitoring is possible, taking genegeneration scheduling constraints into account. Translated into performance indicators, the e-Monitoring system has, for example, helped to reduce **the rate of unplanned outage in EDF's hydropower facilities** by nearly 20%.

Reducing Maintenance Costs

Continuous monitoring of machines and early detection of equipment behaviour anomalies allow maintenance actions to be carried out at the right time (conditional maintenance), to extend the equipment's service life and reduce the scale of curative maintenance operations.

Defining an Appropriate Maintenance Strategy

An advanced analysis of the monitoring data by EDF Hydro's multi-disciplinary experts means an optimised maintenance strategy (preventive, condition-based and predictive) can be recommended for a plant or a series of schemes.

Proposing Your Monitoring Solution

By analysing the causes of failure of your most important equipments and adding our experience feedback, we suggest an appropriate monitoring strategy. We start by recommending sensors and the associated IT architecture and go right through to how data should be interpreted and we provide our guidance for the organisation to set up.

Improving the Performance of Your Production Tools

We can make a numerical model of your scheme's current performance, detect production deviations, and monitor yield. Translated into performance indicators, the e-Monitoring system has helped to reduce **production unit start-up incidents by 35% in EDF's facilities**.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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Proof by example

No Stoppage During the Diagnosis

France - Grand-Maison plant, Production unit N°8 (150 MW)

The challenge: to maintain operation and diagnose the cause of the rise in temperature.

The context: the G8 triggers when the alternator bearing metal is at high temperature.

Our response: the e-Monitoring team carries out a multi-parameter detailed analysis of the causes and identifies a cavern restriction phenomenon putting pressure on the alternator bearing, thereby reducing the bearing's clearance and causing an increase in the temperature.

The results: 450 k€ saved in costs (unscheduled downtime).
Maintenance scheduled at a more favourable time.

Differences of Performance Detected

France - Rhinau plant (160 MW)

The challenge: to identify the cause of a difference in power between the 4 production units, causing loss of yield.

The context: an alert is generated following the detection of abnormal vibrations. The abnormal vibrations also occur at low flows.

Our response: the analysis leads to differences in the flow/power conversion charts for certain flows. The engineers reassess and readjust them.

The results: the yields return to optimum in all flow ranges. The scheme presents optimum yield when the inflow of the 4 production units is equally distributed.
Estimated gains: 108k€.
Premature wear of the production units, caused by the vibrations, was prevented.

A "Clandestine" Resonance was noted

France - Versilhac plant

The challenge: understanding an abnormal oscillation that could affect the penstock's integrity.

The context: the e-Monitoring team of analysts detects an abnormal oscillation in the penstock, the operator is not alerted, since the maximum operating pressure is not exceeded.

Our response: we diagnose a resonance in the penstock. A more detailed analysis shows the fault to be a solenoid valve that controls the bypass.

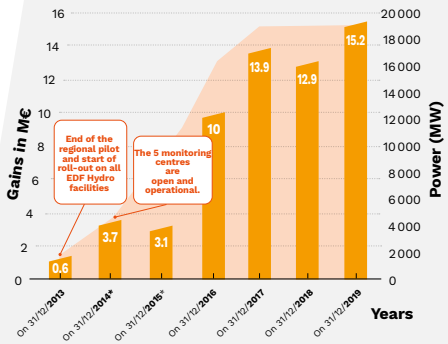
The results: after studies carry out by our penstock specialists and a resizing of the servomotor, we remove a major safety risk and prevent an outage.

We are entering the era of Formula-1: the operators are the drivers in their cars and we are in the stands.

We help them to monitor their plants better, maintain them better and keep them in better operational condition.

Analyst in charge of e-Monitoring

Gains from e-Monitoring at EDF Hydro year by year



* Figures for 2015, 2016 updated to include the new data repository for evaluating detections of precursors on penstocks.

Advantages of EDF Hydro

We use e-Monitoring to monitor nearly 240 hydropower plants of all types and have collected a wealth of feedback since 2011.
We have developed an objective method of estimating the gains realised by avoiding costs.

Our e-Monitoring offer benefits from technical assistance from over 150 internationally renowned experts in production equipment behaviour analysis, independent of the manufacturers and those involved in operation.

This expertise service is based on effective and tested diagnosis and prognosis tools that we know how to connect to your IT architecture with high cybersecurity and confidentiality requirements.

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EDF HYDRO - **SD_JUIN_2020_UK** - SUGAR - PHOTO CREDITS: @EDF - DENIS ALLARD, DIDIER MARC, CHRISTOPHE HURET

Assessing, managing & upgrading dam safety

The challenge

The operation of dams involves a number of risks for property and people, such as bursts, uncontrolled flowrates or gradients released downstream.

The main concern of any dam owner or operator is taking the necessary measures to prevent and avoid any incident.

As operator, concession holder or owner, you have the prime responsibility for the operational security and integrity of your dam. You need to understand the risks related to your dam in order to implement optimum improvement measures, regardless of their technical or operational nature.

EDF Hydro Engineering can assist you in this task.

240 large dams designed, operated, maintained and supervised by EDF Hydro under best-in-class safety standards

2 bursts in large dams annually on average worldwide over the past 30 years

300 safety risk analysis in 10 years

Our solutions

Conducting expert appraisals prior to functional safety risk analysis

We analyze the design, behavior and conditions of the various structures and equipment components. We can deploy in-depth expert diagnoses to upgrade safety level assessments based on numerical approaches (static and seismic calculations, finite element calculations on mechanical structures, concrete or geotechnical analyses, 3D hydraulic simulation, etc.).

Proposing a panel of solutions for enhanced management of flood risks

In order to enhance anti-flood safety, the main cause of most dam bursts, we combine several solutions: reduction of conservatisms related to stability calculations to limit civil works, construction of innovative flood spillways (e.g. Piano Key Weir), structural reinforcement of facilities, refurbishment or replacement of gates, upgrades of PLC and I&C architectures...

Identifying potential hazards and “weak links” in your dams

We mainstream the findings from our expert assessments and feedback on operating issues into our methodologies of functional safety risk analysis in order to identify the main potential hazards and weak links in hydroelectric facilities.

Proposing and implementing measures to mitigate risks and reduce operating and maintenance costs

Our multi-function analyses help to optimize risk mitigation measures with solutions incorporating structural, hydraulic, I&C and organizational aspects. These measures are designed to mitigate risks and reduce operating and maintenance costs.

Supporting organizational risk management and offering related training

We offer a safety management system customized to fit your needs, your facilities and your operational methods, based on an approach combining our engineering and operational expertise, along with training programs to match your requirements on topics related to dam safety and monitoring.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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Proof by example

New spillway for flash floods

France – Malarce dam (15,2 MW)

The challenge: improve the flood safety of a 50-year old gated dam.

The context: the flood spillway was undersized and is subjected to the so-called "Cévenole" flooding pattern, with record high-water gradients up to 1, 300 m^3/s/hr, requiring the operator to intervene in less than half an hour to maneuver the gates.

Our response: we proposed a new autonomous Piano Key Weir (PKW) spillway providing the necessary hydraulic efficiency and requiring no additional energy or human presence to run.

The results: 15% increase of discharge capacity at peak flood level and increased discharge capacity in extreme worst-case scenarios (e.g. absent operator or loss of main and back-up energy supply), i.e. a real gain in safety. The PKW provides flexibility as it starts running first, gives the operator twice as much time to arrive on site, and saves 30 minutes on gate maneuvering.

Delays avoided during impoundment

Brazil - Sinop dam (408 MW)

The challenge: assessment of safety level prior to reservoir filling.

The context: construction of a new 400 MW facility with civil engineering structures built on variable geological terrain.

Our response: safety risk analysis based on our comprehensive assembler's view prior to reservoir filling, to assess all contingencies linked to impoundment and propose risk mitigation measures: reinforcement of plant drainage pumping system, reinforcement of the left bank dyke, review and upgrade of the structure inspection system, reinforced surveillance procedures during filling...

The results: the Sinop reservoir filling confirmed the sensitivity of some of the failure scenarios considered. By anticipating remedies, we were able to avoid several months of delay on the impoundment, while guaranteeing an appropriate safety level.

Safety upgrade at La Palisse

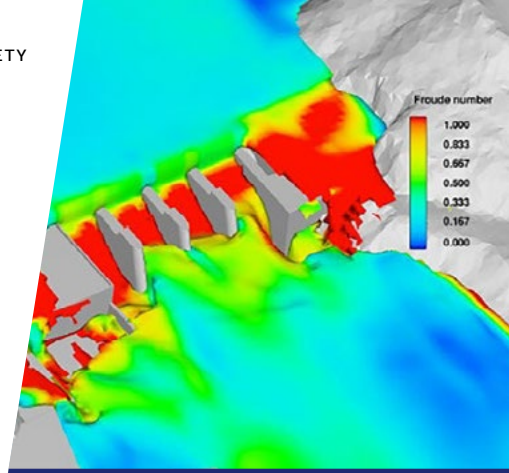
France - La Palisse dam (132 MW)

The challenge: improve the safety of a large 60-year old thin-arch dam.

The context: modification of the dam to adjust for re-assessed flood rates.

Our response: we proposed a panel of expert appraisals and studies on hydraulic, structural, mechanical and functional aspects in order to upgrade the client's knowledge on the dam's safety margins.

The results: cost-efficient project to adapt the dam, including raising the dam crest and maximum design flood level by nearly 2 meters, a limited extension of dissipators, and upgrade of drainage system. The rehabilitated dam has successfully withstood its first major flood just a few months after works completion.



3D numerical simulation of an extreme flood scenario at the Truel dam

Advantages of EDF Hydro

Our in-depth knowledge of safety challenges and multi-function standards in dam engineering and operation enables us to identify the most critical points in dam failure scenarios and propose cost-efficient solutions compatible with financial production requirements.

EDF Hydro ensures the implementation of dam monitoring on all its facilities.

EDF Hydro has built a unique expertise based on:

- Its 70 year-long experience, tracked and recorded, in operating a fleet of hydropower facilities.
- Experts who are renowned and actively involved in ICOLD, with frequent scientific publications.
- Its long-standing practice of international standards.

EDF Hydro is acknowledged for its socially responsible and independent engineering activity, and is accredited by safety authorities.

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Optimizing Dam Sediment Management

The challenge

Natural sediment production through soil erosion can cause a number of problems in dam reservoirs (loss of storage capacity, operational difficulties, safety issues, environmental issues, problems with navigation...).

This slow process is often underestimated (as are the associated risks) in structure's management policies.

You are an owner or operator and you want to optimize sediment management in your schemes? Your goal: ensuring all their functionalities in the long term.

EDF's Hydraulic Engineering Center can help you.

Every year in EDF facilities:

- Around fifteen **flushing operations**
- 500,000 m³ **of sediments extracted**
  Of which 30,000 m³ **recycled**
- Around sixty **sediment flushes**

Our solutions

Determining a "Target" Sediment State

EDF Hydro identifies the issues to be considered (safety, performance, environment, external requirements, etc.); analyses the processes that affect scheme operation; determines the optimum actions over time and provides the owner and the operator with a long-term roadmap.

Optimizing Fine Sediment Management Methods

EDF Hydro has developed the Nessie® dredging solution, which removes constraints on scheme's operation by adapting to their production and environmental criteria. Nessie® is equipped with a system that measures and regulates suspended solids, adapting to variations and re-establishing a sedimentary continuity that is close to the natural level.

Ensuring the Continuity of Coarse Sediments

Transporting coarse sediments (sand, gravel, pebbles) through dams is essential for the correct functioning of the river sections downstream. To do this, EDF Hydro optimizes the implementation of flushing and combines it, where necessary, with scouring/reinjection operations.

Valorizing the Extracted Sediments

EDF Hydro develops solutions for valorizing the sediments extracted from reservoirs. Mineral recycling (cement, concrete, brick/ceramic, road making...) or agronomic recycling (supporting crop growth, soil amendment or reconstitution) reduces the cost of managing the extracted sediments.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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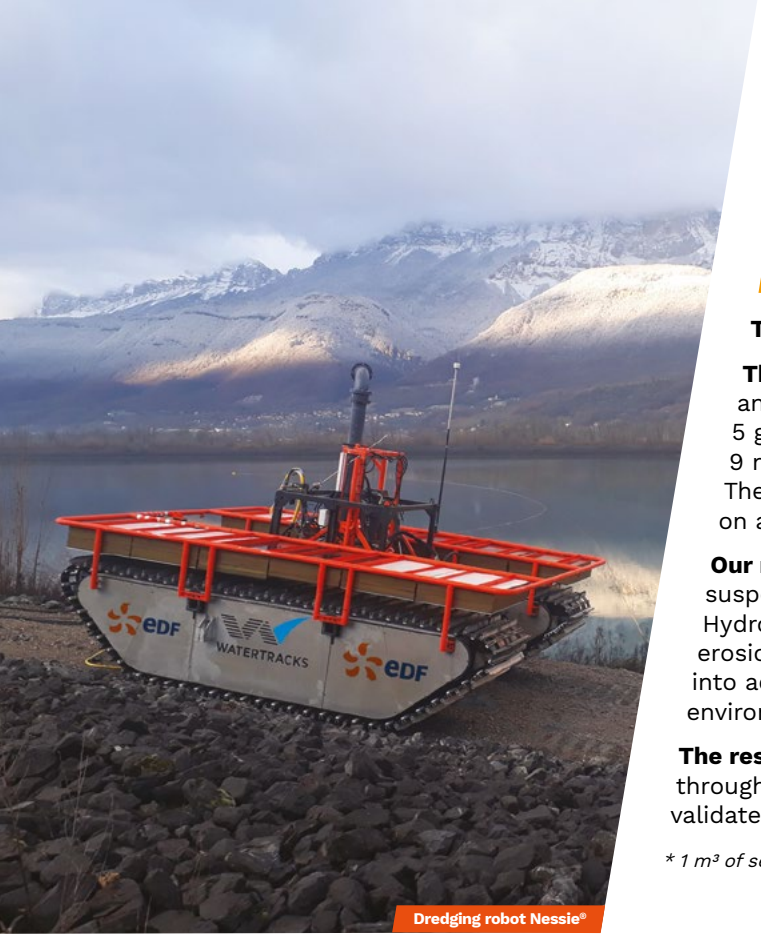

Dredging robot Nessie®

Proof by example

Saint-Égrève is Controlling Its Silting

France - Saint-Égrève

The challenge: to ensure optimum reservoir sediment management.

The context: EDF's Saint-Égrève dam, downstream of the confluence of the Isère and Drac rivers, was commissioned in 1991. It is a run of river mobile dam with 5 gates and a power station that turbines up to a maximum of 540 m^3/s under 9 meters head. The reservoir had an initial storage capacity of around 6 hm^3. The annual transit of suspended matter (TSS) is estimated at 3 million tonnes on average.*

Our response: EDF Hydro set up a measurement network to better monitor suspended solid income and the evolution of sedimentation in the reservoir. Hydro-sedimentary calculations were successful in controlling the kinetics of erosion during flushing and the silting-related risks during flooding. While taking into account all the issues at stake (civil works, safety, multi-use of water, environmental, economic...). A target state for sediment was defined.

The results: implementation of a sediment management strategy to limit silting through lowering and hydraulic flushing. These easy-to-implement measures validated by the administration have reduced silting at a lower cost.

** 1 m^3 of sediment represents 1.2 t of dry matter for the Saint-Egrève reservoir.*

Sedimentary Continuity on the Buëch River

France - Saint-Sauveur

The challenge: to carry out effective dredging upstream of the reservoir. This zone is the hardest to manage through flushing, since it is where the coarsest fractions are deposited.

The context: the Saint-Sauveur dam, commissioned in 1992, is managed by flushing during high water periods. The flushing allows upstream/downstream continuity of much of the sendimentar income, including much of the coarse sediment.

Our response: the work consisted of dredging the tail end of the reservoir (43,500 m^3) and depositing the excavated material into the downstream section in the form of two embankments on the side of the active bed.

The results: this material was rapidly carried off during flooding which made possible to maintain the aquatic habitats of the bypassed section whilst reducing the cost of the works.

900
dams and water intakes

managed by EDF, including 200 creating reservoirs with a volume of over 1 million m^3.

This management involves, in particular, approaches combining sediment flow measurement, analysis of the issues and risks, consultation with the stakeholders and numerical modelling, whilst continuing to develop scientific knowledge.

Advantages of EDF Hydro

CIH is an integrated engineering unit that works closely with hydropower scheme. Its engineers have indeed an excellent understanding of their regulatory and operational constraints.

EDF Hydro is implementing an innovative automated dredging solution called Nessie® at a similar cost to a standard solution. This robotic solution will reduce or even remove operating constraints.

EDF Hydro's engineers are working with EDF's national hydraulics and environmental laboratory and its DTG unit (General Technical Division) specialized in controlling and developing advanced metrology for dam sediment management.

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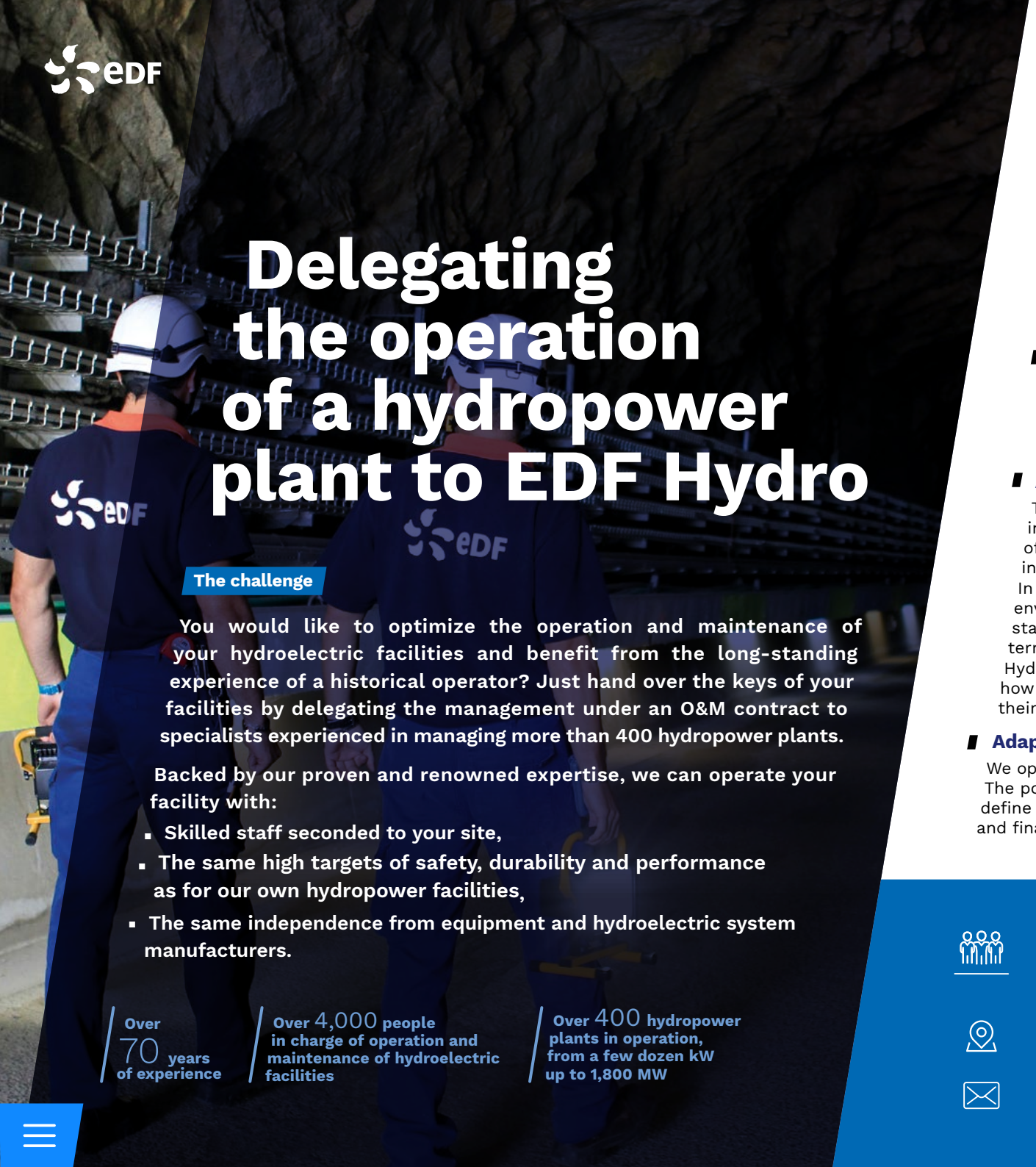

Delegating the operation of a hydropower plant to EDF Hydro

The challenge

You would like to optimize the operation and maintenance of your hydroelectric facilities and benefit from the long-standing experience of a historical operator? Just hand over the keys of your facilities by delegating the management under an O&M contract to specialists experienced in managing more than 400 hydropower plants.

Backed by our proven and renowned expertise, we can operate your facility with:

- Skilled staff seconded to your site,
- The same high targets of safety, durability and performance as for our own hydropower facilities,
- The same independence from equipment and hydroelectric system manufacturers.

Over 70 years of experience

Over 4,000 people in charge of operation and maintenance of hydroelectric facilities

Over 400 hydropower plants in operation, from a few dozen kW up to 1,800 MW

Our solutions

Seconding our supervisory staff to your facilities

Our long-standing experience gained with the EDF fleet will be a valuable contribution to the operation of your facility. This experience will be shared and transferred to your local staff.

Your local staff, supervised by our operation specialists, can also be trained, if needed, in our training centers in France, or be sent for immersion training to join our teams operating similar facilities.

Providing the same high quality level as for our own facilities while adapting to your local context

The high stringent requirements that we set for ourselves to operate our own facilities, will apply equally to manage your hydropower facility: economic profitability, availability and safety.

Anchoring your facility durably into its local territory

The commissioning of a hydropower plant is a major event in a region or a country. It is essential for the staff in charge of operation to be well integrated into the specific environment in order to foster community acceptance of the facilities. In full compliance with national laws and taking into account environmental concerns based on the most exacting international standards, we help you anchor your facilities durably into the local territory and develop relations with the local communities. The EDF Hydro expatriates dedicated to the operation of your plant know how to adapt to the local culture to facilitate collaboration with their coworkers hired in the region.

Adapting to your contractual context

We operate your hydropower plant according to the contractual context. The power purchase agreement (PPA) and the concession contract will define our operation and maintenance strategy to seek optimum technical and financial performance.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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Proof by example

Gradual transfer of expertise in remote areas

Laos - Nam Theun 2 (1070 MW)

The challenge: operate efficiently a hydropower plant in a remote region of Laos for 35 years. This hydroelectric facility is complex and includes 2 dams, 13 saddle dykes, over 30 km of channels, 5 km of galleries, a station equipped with 4 Francis turbines and 2 Pelton turbines.

The context: apart from the scale of facilities and equipment to be operated and maintained, two separate power sale agreements (one for Thailand and one for Laos) require perfectly transparent and strict operational procedures.

Our response: EDF Hydro seconded 4 senior expatriates experienced in operation and commissioning to prepare the operational phase.

EDF Hydro has gradually transferred its known-how to the local staff. To this purpose, a training center in hydroelectricity jobs was created in Vientiane (the capital of Laos).

The results: after 10 years in operation, over 70 people have been trained to operate and maintain the Nam Theun 2 facilities. The ongoing experience sharing and skills ramp-up have also enabled a gradual reduction of the EDF seconded workers and managers, with only one EDF employee now remaining at the site.

Thanks to the staff's efforts, the annual output target of 6,000 GWh has been continuously exceeded since commissioning in 2010.

The availability target has also been exceeded with an uptime rate above 96%, retained continuously throughout the 10 years in operation.

Lastly, the exacting targets on hydraulic safety have been achieved. The operational crews have proved capable of handling even exceptionally high flood events.

UEGCL shows its trust in EDF Hydro expertise

Uganda - Isimba (183 MW)

The challenge: secure hydropower plant operations at start-up.

The context: the Isimba hydroelectric facility in Uganda was commissioned in 2019. During that same year, EDF Hydro signed a contract with the owner/operator UEGCL (Uganda Electricity Generation Company Ltd) to provide assistance throughout the first year of operation.

Our response: our experts collaborated by the side of UEGCL staff to provide advice and guidance, both on organizational and strategic aspects and on purely operational topics linked to the daily running of the plant. Training sessions were also delivered to Isimba operators in order to ramp up their skills.

The results: UEGCL was able to benefit from our experience and to launch the O&M phase on sound bases.

96 %

This is the exceptionally high availability rate achieved throughout the 10 years of operation at Nam Theun 2 hydropower plant in Laos.

Thanks to the engagement of EDF Hydro operation experts, this performance was reached despite the site's remote location.

#PERFORMANCE

Advantages of EDF Hydro

Our working methods have been tested, tried, proven and optimized in our own hydroelectric facilities for more than 70 years. Our experience in international projects across all continents enables us to adapt to any type of context.

Your facility can be connected to our e-Monitoring center that already supervises 19,000 MW of hydropower plants, and thus benefit from our unique expertise.

Our hydroelectricity training centers provide a useful complement to develop and ramp up the skills of your local staff.

Backed by their long-standing experience in hydropower plant operation, our experts represent the full range of hydroelectricity jobs and can respond efficiently to any unexpected events.

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Building a Master Plan to integrate renewable energy

The challenge

Electrical systems will increasingly integrate massive injections of variable renewable energies (wind, solar PV). The integration of these VRE into the grid raises numerous technical and financial challenges due to their variability.

You wish to increase the proportion of renewable energy in your electricity mix...

You wish to assess the available natural resources and generate renewable energy cost-efficiently...

You have the ambition to develop a sustainable, diversified and affordable electricity offer...

In response to your challenges, EDF Hydro has developed high-performance methods and tools to support you and your projects.

Extensive experience

of engineering studies in countries engaged in renewables development

Our solutions

Assessing the existing electrical system

We conduct a diagnosis of the existing electrical system. We assess its quality and safety performance, and analyze the production costs of each power plant.

Predicting the power demand

Based on demographic projection models, we forecast residential and industrial power demand per geographic area, along with potential exporting projects. We correlate the demand forecast with growth forecasts.

Analyzing the future supply & demand balance

We analyze candidate projects and scenarios of availability and fuel prices. We factor in options of power generation facilities versus the renewable energy development targets. We assess how to optimize the complementarity of the various electricity sources.

Defining the optimal investment plan

We analyze the various scenarios from an economic perspective. We evaluate the demand, investment costs, construction times and fuel costs. We assess the risks linked to the best-case scenario and propose measures to mitigate these risks.

Transferring knowledge

We can train the staff in charge of planning on the use of methods and software tools specific to VRE integration studies. We can also deliver training on technical and economic optimization methods and on the tools used to build the Power Generation Master Plan.

A team of experts

Our experts understand the market perfectly and can offer the best technical solutions for your projects.

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Proof by example

Reaching 30% renewables in the grid

Morocco - Office National de l'Electricité et de l'Eau Potable

The challenge: demonstrate that integrating 30% variable renewable energies into the grid is achievable operationally, and determine the related electricity mix.

The context: Morocco wishes to extensively develop renewable energies (wind and solar) in order to mitigate its energy dependency and exposure to fossil fuel price risks, and to reduce both its emissions and energy costs.

Our response: definition of the Morocco Power Generation & Transmission Expansion Plan. Validation of the operational feasibility. Recommendation for investment and operation rules. Training of the planning staff to update the Generation Master Plan.

The results: the feasibility study demonstrated that it is possible operationally to integrate 30% of VRE into the grid.

A "greener" energy mix by 2040

New Caledonia - ENERCAL

The challenge: clarify the energy development options achievable by 2040, enlighten the choice of new fossil-fueled facilities, explore power storage solutions via batteries or Pumped Storage Plants (PSPs).

The context: New Caledonia wishes to increase significantly the proportion of renewables in its energy mix while keeping cost-competitive electricity prices.

Our response: determination of the optimal development trajectory for battery or PSP power storage. Study on grid congestion reduction based on batteries via a concept of virtual power line. Size design for new power generation facilities.

The results: a preferred development trajectory was defined thanks to our technical and economic evaluation of the various options.

Electricity market covering six countries

Greater Mekong Subregion Program supported by the Asian Development Bank (ADB)

The challenge: demonstrate the benefits of developing interconnections, and more broadly an electricity market shared by the six countries of the Greater Mekong Subregion.

The context: substantial development potential for hydropower in this region (Myanmar, Cambodia, China, Laos, Thailand and Viet Nam), conducive to the emergence of a regional electricity market.

Our response: review and update of the Mekong Master Plan. Review of regional master plans. Training. Identification and ranking of the most beneficial interconnection projects.

The results: updated interconnection master plan for the Greater Mekong Subregion.

Modelling of weekly stacking of power generation assets

Advantages of EDF Hydro

EDF Hydro Engineering is backed by a staff of some twenty experts specialized in energy strategy who can leverage EDF's long-standing experience in the Group's fleet and capitalize on the expertise gained in numerous technical and economic studies conducted internationally over the years.

Our experts design simulation models of master plans using state-of-the art software technologies based on the "Stochastic Dual Dynamic Programming" methodology. The SDDP method once adapted to contexts of uncertainties (hydrological, demand, market prices, etc.) helps determine the optimum integration solution, including for electrical systems with a large number of hydropower plants.

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