

Hydropower & dams

services





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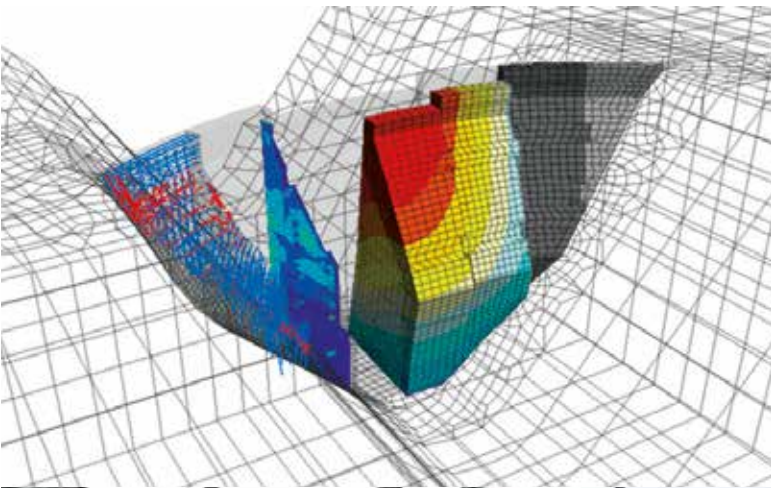
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HYDROPOWER & DAMS

From the Origins to Cutting Edge Solutions

Tracing back its origins to an hydraulics laboratory created during the original development of hydroelectricity in the early 20th Century, ARTELIA has continuously evolved to be recognized today as one of the Global leaders in the dams and hydropower sector. For close to a century, our engineers have studied hundreds of hydropower and dams projects and have directly contributed to over 80 constructed dams and 12,000 MW currently in operation.

STAFF AND OFFICES

Located in Grenoble, at the heart of the French Alps, we can mobilize staff and capabilities across the entire ARTELIA Group.

With several thousand staff in 55 offices in France and permanent offices in more than 40 countries, our reach spans most regions of the World.

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HYDROPOWER & DAMS

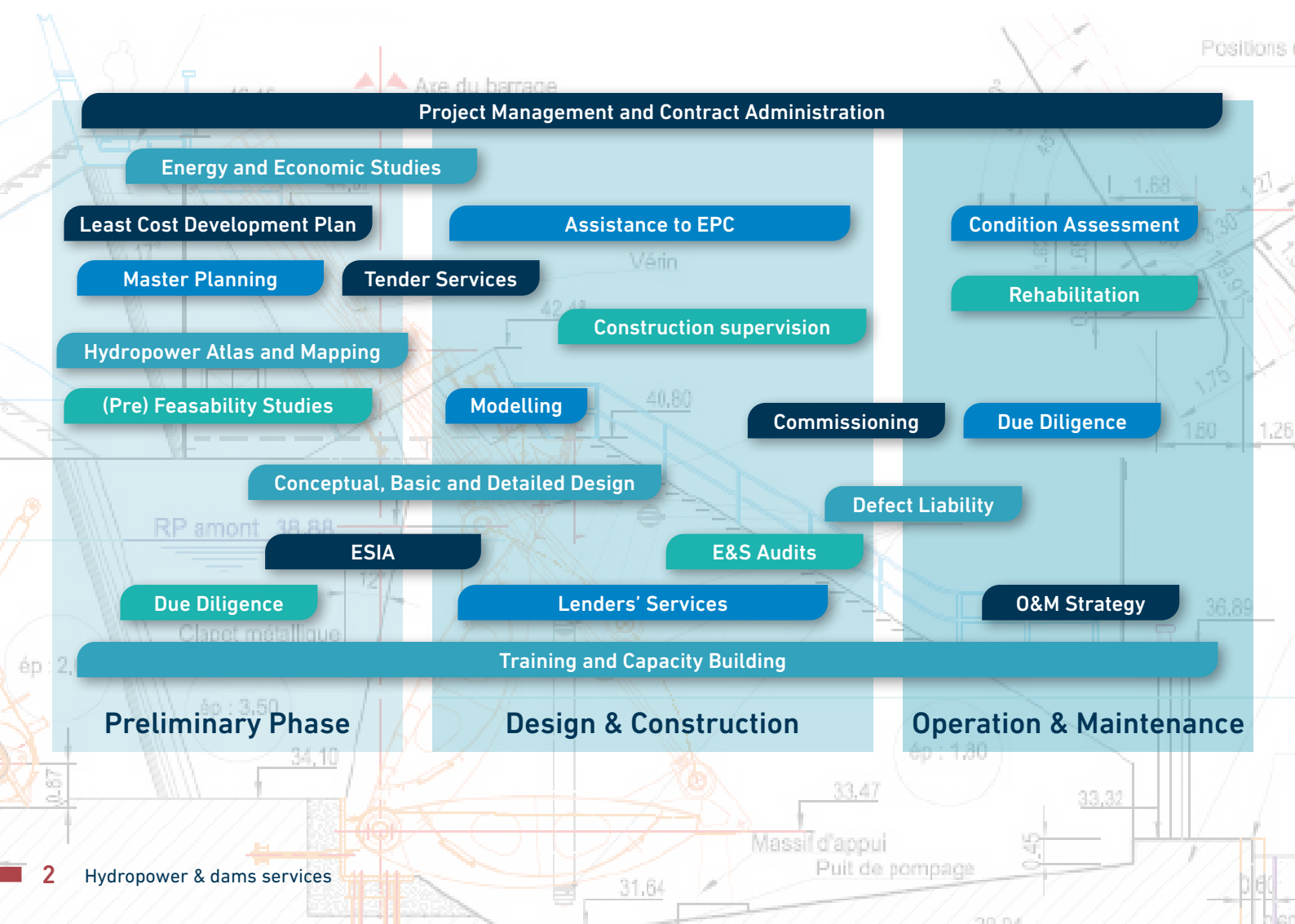
From the Origins to Cutting Edge Solutions

Capabilities

Our experienced staff covers the full spectrum of disciplines required for hydropower and reservoir projects including civil, structural, geotechnical, electrical, hydro-mechanical and electro-mechanical engineering, hydraulics, hydrology, power transmission and sub-station, economics, social and environmental management, project management and contract administration.

Services

We support our clients with the full range of technical disciplines across the entire project cycle. From the largest dams (over 200 m high) and largest plant (7,000 MW) to micro hydro run-of-river schemes, we deliver the full range of engineering, technical and advisory services to build and rehabilitate hydropower and dams projects in all type of environments. Our experience spans several decades and all continents.





Historically, ARTELIA has always had the capacity to combine the necessary expertise and technical resources to design structures blending in the natural and human environment.

We can act as traditional design engineer, Employer's Representative, EPC Engineer and Lender's Independent Engineer or Monitoring Consultant.

We provide the following services:

- Evaluations, audits, expert appraisals and consultancy (safety studies, dam safety, dam monitoring, etc.)
- Economic and financial analyses
- Environmental and regulatory studies
- Master plans, least cost development plans and sectoral studies
- Bankable prefeasibility and feasibility studies
- Preliminary studies, field investigations (hydrology, topography, geology, geotechnics, etc.)
- Hydraulic studies using physical or numerical models or both
- Preliminary designs
- Detailed design
- Assistance with bid evaluation and contract award procedures
- Working design studies
- Supervision and monitoring of works, assistance with commissioning and during the defects liability period under all type of FIDIC arrangements
- Rehabilitation services
- Design and/or construction supervision services, project management
- Training and capacity building
- Assistance during dams and hydropower operation

From water resources to energy production



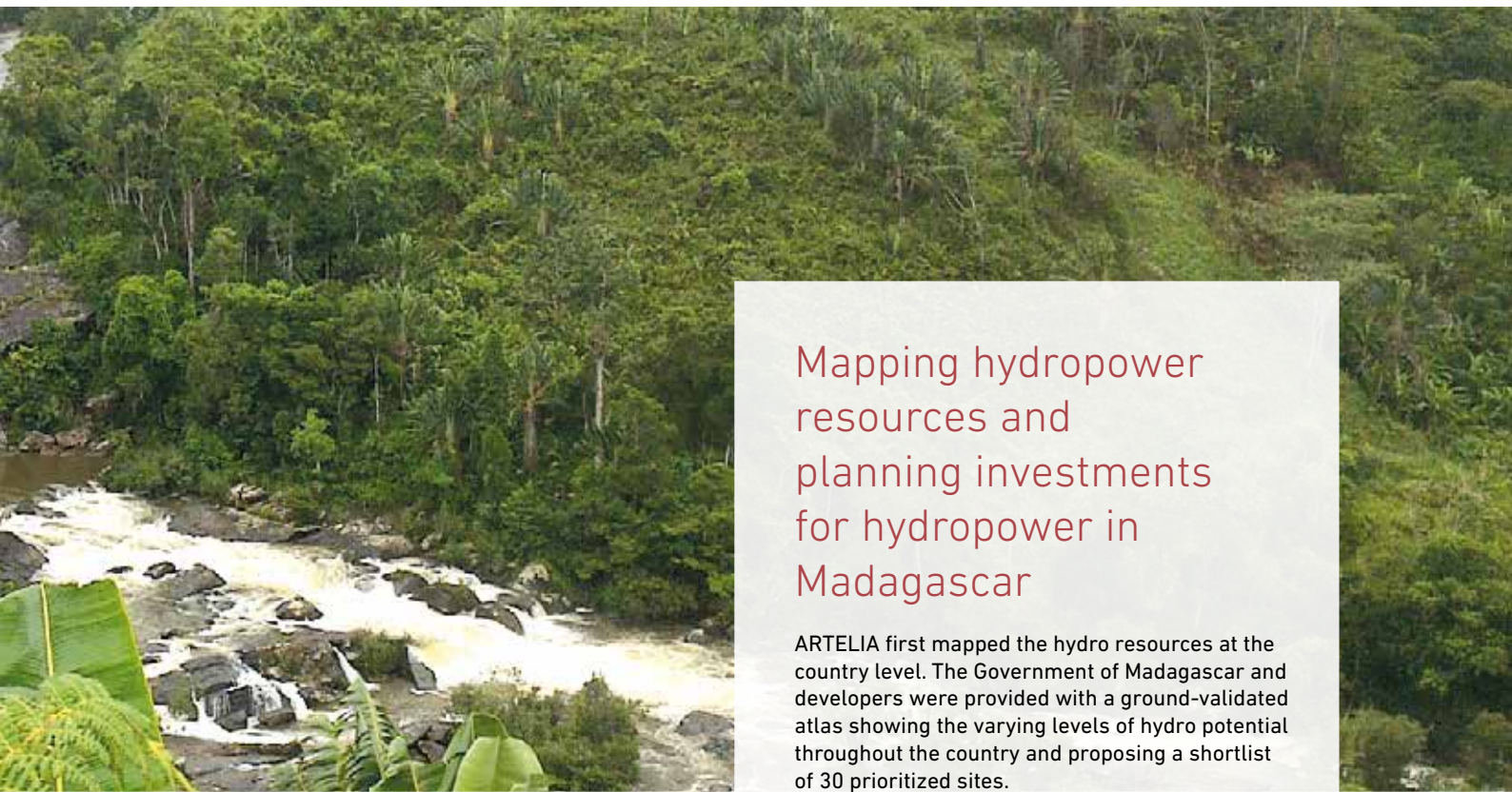
From national master planning to site selection and economic studies, our advisory services encompass a wide range of solutions.

Our teams of engineers are complemented by economists, scientists and planners to investigate, plan, optimize and design hydropower and multipurpose schemes.

These services are typically required at the early stage of hydropower and dams developments but they can also support decision for further investment, refurbishment and divestment.

Our services include:

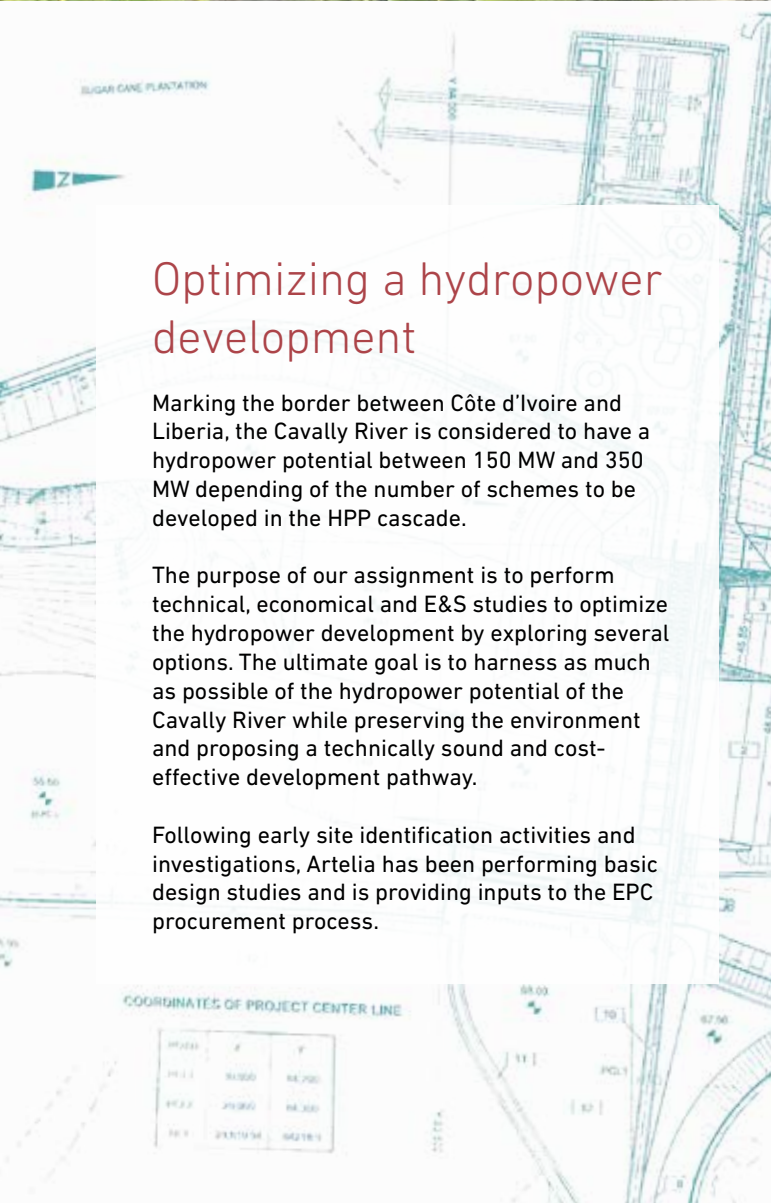
- National and regional master plan and Least Cost Development Plans (including consideration of E&S constraints and opportunities)
- Hydropower potential mapping and Hydropower Atlas
- Lenders Technical Advisor and Lenders Environmental and Social Management Consultant
- Pre-Feasibility Studies and Bankable Feasibility Studies (including grid connection studies)
- Energy production assessment and economic studies
- Due diligence on existing or proposed schemes
- Condition assessment and decision support for rehabilitation and/or divestment
- Risk analysis including dam break analysis
- Dam monitoring and assistance to powerplant operation
- O&M Strategy
- General support to developers, contractors and lenders at all stage of the development
- Capacity building and training



Mapping hydropower resources and planning investments for hydropower in Madagascar

ARTELIA first mapped the hydro resources at the country level. The Government of Madagascar and developers were provided with a ground-validated atlas showing the varying levels of hydro potential throughout the country and proposing a shortlist of 30 prioritized sites.

In a second assignment, ARTELIA prepared a Least Cost Development Plan for renewable energy generation and proposed an investment plan to guide future developments.



Optimizing a hydropower development

Marking the border between Côte d'Ivoire and Liberia, the Cavally River is considered to have a hydropower potential between 150 MW and 350 MW depending of the number of schemes to be developed in the HPP cascade.

The purpose of our assignment is to perform technical, economical and E&S studies to optimize the hydropower development by exploring several options. The ultimate goal is to harness as much as possible of the hydropower potential of the Cavally River while preserving the environment and proposing a technically sound and cost-effective development pathway.

Following early site identification activities and investigations, Artelia has been performing basic design studies and is providing inputs to the EPC procurement process.

Hydrological studies

Water from reservoirs is used for different purposes: irrigation, fisheries, energy production, water supply, flood protection, flow regulations, navigation, recreational use, etc. Our hydrologists plan schemes ensuring water resources are articulated efficiently across multiple usages.

From site identification, our teams are analyzing the basic parameters and hydrological data to optimize the scheme (in terms of power generation, flood events, minimum flows, etc.).

A safe base for a sound project

Understanding the key constraints associated with geotechnical and geological conditions is one of the critical steps in the development of an hydropower and dam/reservoir project.

Our engineers have gained strong experience working in most type of conditions and adapting the design and construction methods to most type of geological and geotechnical constraints. This includes not only services for dam and different structures foundations but also for underground structures such as tunnels and underground power plants.

From defining and managing investigations to performing 3D modelling of geotechnical conditions and managing excavations, we have helped our clients overcoming the challenges on their projects.

Our expertise includes:

- Scoping and managing field investigations with local drillers
- Analyzing material properties, soil and rock profiles
- Analysis and numerical modelling of key constraints
- Evaluation and supervision of tunneling (tunneling, TBM, boring...), excavations techniques, earthfill and rockfill compaction activities
- Foundation treatment, grouting, cut-off walls, drainage solutions to inform design and improve stability of the dams and auxiliary structures



BAGATELLE - MAURITIUS ISLAND

Dealing with tropical residual soils

Built in a volcanic context, Bagatelle is a 40 m high and 2 km long earthfill and rockfill dam with a clay core. The foundation and earthfill are made of tropical residual soils characterized by alternating rock and soil layers at depth. Advanced numerical modelling was used to estimate the stresses and deformations along the cut-off-wall and a foundation treatment consisting of a plastic cut-off-wall was used to reduce seepage and piping risks.

DELSITANISAGUA HPP - ECUADOR

Challenging dam foundation & landscape

The Delsitanisagua hydropower project (180 MW – EPC contract) required the construction of a 35 m high concrete dam in a valley with very steep and unstable slopes. During supervision of works, ARTELIA developed deep geotechnical analysis and up-to-date numerical modelling to deal with adverse geological conditions. High capacity tendons (200 tons each) and shear galleries filled with concrete have been installed to stabilize a major landslide of more than 600,000 m³ of rock and soil.



BALAA - LEBANON

Designing and building a reservoir on karstic foundations

Balaa is a 45 m high bituminous concrete faced rockfill dam with foundation consisting of very karstified limestone covered by ancient lava flows with over thirty sinkholes. The sinkholes were over excavated in a cone shape and filled with porous concrete (within the reservoir) and conventional concrete (underneath the dam); the reservoir was fully lined with bituminous concrete.

Understanding the flows from the water intake to the restitution channel

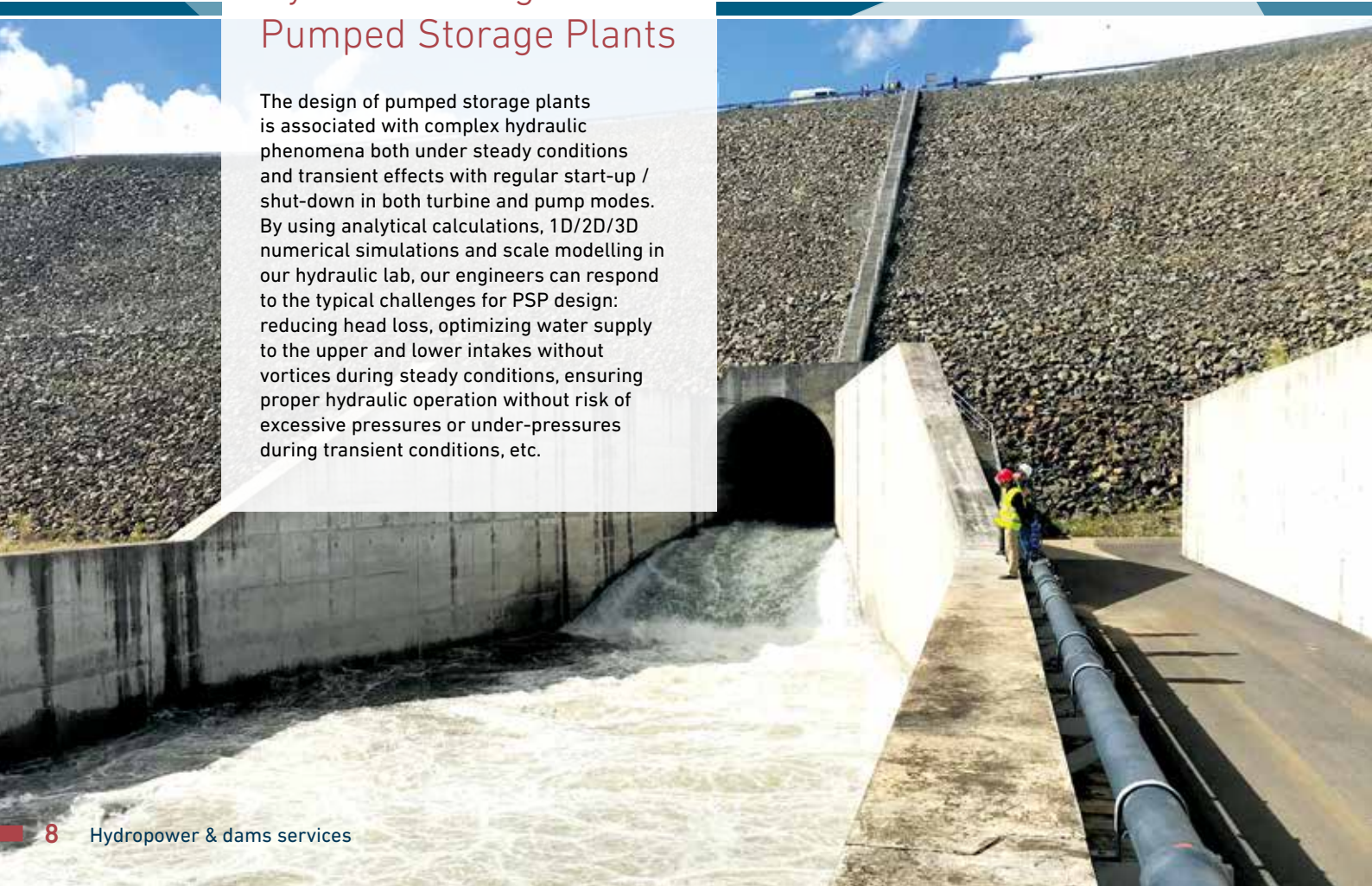
Hydraulic engineering is an integral part of ARTELIA history; our former name as SOGREAH (Société Grenobloise d'Etudes et d'Applications Hydrauliques – Grenoble Company for Hydraulic Studies) is a testimony of this heritage.

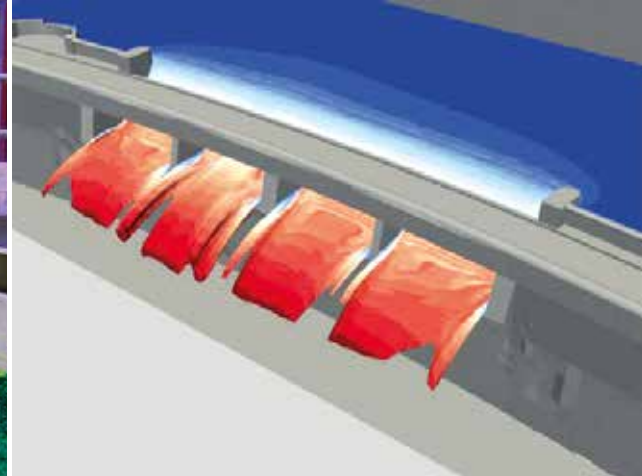
Since the 1960s, our hydraulic engineers have been key players in the development of numerical modelling with more than a dozen in-house modelling software (1D, 2D and 3D models, floods and dry weather flows, hydro sedimentary analysis, etc.).

ARTELIA plans and design all hydraulic components of major hydropower and dams developments including waterways, pressure tunnels, water intake, penstocks, gated weirs, radial gates, restitution channels, fish pass, locks, flood spillways, water transfer systems, etc. Our engineers use numerical modelling, CFD modelling and physical scale models in our in-house laboratory to design and test hydropower developments with flow rates of up to 25,000 m³/s (Jirau HPP in Brazil) and hydraulic heads over 1,000 m.

Hydraulic Design for Pumped Storage Plants

The design of pumped storage plants is associated with complex hydraulic phenomena both under steady conditions and transient effects with regular start-up / shut-down in both turbine and pump modes. By using analytical calculations, 1D/2D/3D numerical simulations and scale modelling in our hydraulic lab, our engineers can respond to the typical challenges for PSP design: reducing head loss, optimizing water supply to the upper and lower intakes without vortices during steady conditions, ensuring proper hydraulic operation without risk of excessive pressures or under-pressures during transient conditions, etc.





A UNIQUE FEATURE

ARTELIA hydraulic laboratory

Since 1917, ARTELIA and its predecessors have performed over 2,500 studies using physical scale model in our Hydraulics Laboratory.

Our facilities include:

- More than 11,000 m² of testing halls and 3,200 m² of outdoor facilities
- 800 m² of workshops (models, electronic equipment, etc.)
- An in-house team of technicians and engineers to build run and analyse the models
- Expertise and experience in measuring complex phenomena (head loss, vortex, cavitation risk, air entrainment, sedimentation and erosion, pressure fluctuations, ...)
- Hybrid modelling mixing physical scale modelling and numerical modelling

Physical scale models are a formidable resource to help hydraulics engineers analysing, validating and communicating key components of complex developments. They help understanding key phenomena and designing optimum solutions and provide project owners with a complete 3D overview of the project and its integration on site. Scale models are also used to develop dimensional designs that fit projects as closely as possible, thereby achieving significant savings during construction.

Balancing strength and cost effectiveness to optimize structures



JANNEH - LEBANON

Design and construction supervision of a high RCC arch-gravity dam

The Janneh dam is part of a multi-purpose scheme intended to provide Beirut with potable water and to generate hydropower with an installed capacity of 100 MW. The dam is built in the vicinity of an active fault with very high seismic loads. By using numerical analyses, the design team proposed an arched layout for the 157 m high RCC dam; this reduced the concrete volume by about 30% compared to a straight gravity dam design and resulted in significant costs savings. ARTELIA is providing all engineering services from design to construction supervision.

Designing all types of dams and structures

Combining internally developed tools and experience gained while managing the construction of civil works, our teams have an extensive track record with most type of structures and materials:

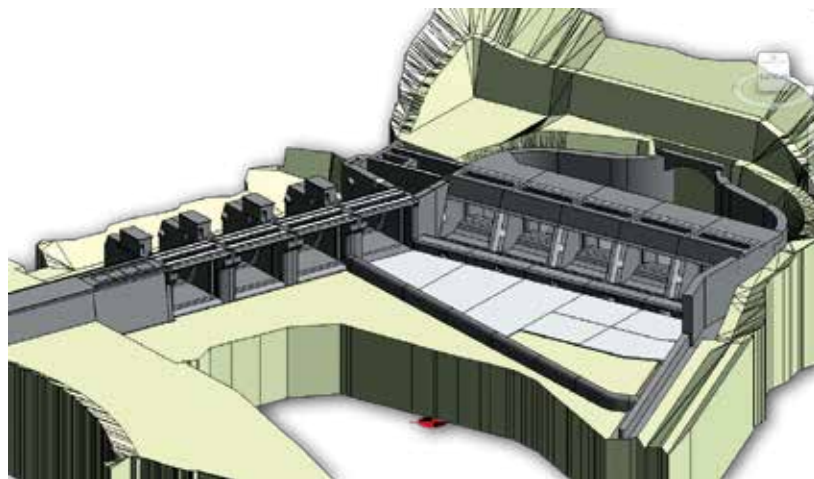
- Arch dams
- Concrete gravity and Roller Compacted Concrete (RCC) dams
- Concrete Face Rockfill Dams (CFRD)
- Earthfill and rockfill dams
- Saddle and buttress dams
- Ancillary infrastructures, flood spillways, water intake, open channels, tunnels and shafts concrete lining, ...
- Rehabilitation of old structures such as masonry dams

Complex calculations and computational modelling

Numerical analyses validate the feasibility of new projects and significantly optimize their design. On existing facilities, they are useful long-term support for monitoring and safety reviews. They provide physical explanations to complex behaviors and can help avoiding costly strengthening works.

Our main skills:

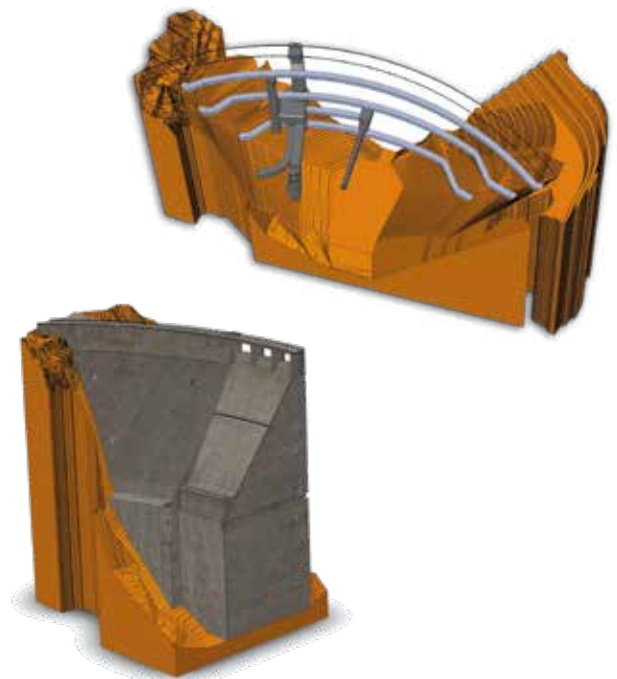
- Modelling of strong non-linearities (contact opening, cracking, sliding, poro-plastic analyses)
- Advanced approaches for seismic analyses
- Innovative time-dependent analyses (calibrated to monitoring data): concrete thermo-mechanical, creep, concrete swelling, ...



RWANDA TANZANIA

Rusumo falls hydropower project

'The Rusumo Falls Hydropower Project is currently being built at the border between Rwanda and Tanzania and includes a dam fitted with a gated spillway able to route a total discharge over 1,600 m³/s and a power plant housing 3 Kaplan units totaling 80 MW. From the beginning of its involvement for Preliminary Design and up to Detailed Design stage, Artelia investigated several alternatives and determined the optimum concept for both temporary (diversion) and permanent (power intake & headrace tunnel) waterways. This optimization allowed reducing the project construction budget for civil works by about 10% and the expected construction schedule by 15%. Following the technical and E&S detailed studies, Artelia (in JV) is providing supervision services as Employer's Representative.'



Generating and transmitting power

From early technology selection to detailed design, factory testing, installation and commissioning, our team of mechanical and electrical engineer are involved at all stages of a hydropower project.

We support our clients with the power generation equipment, control and monitoring systems and infrastructure associated with power evacuation from the HPP. With turbine, hydro-mechanical, electro-mechanical, SCADA and HV electrical engineers, ARTELIA cover all type of equipment and specifications. Our teams have built experience on developments ranging from a few MV to over 7,000 MW.

We provide services in relation to:

- Analysis of energy generation potential, optimization of hydropower developments (including economic and financial studies) and network/connection studies
- Turbine design, installation, commissioning, testing and refurbishment
- All hydro-mechanical equipment including steel liner and penstock, valves hydraulic and radial gates, pumps, navigation locks, ...
- All electrical equipment including transmission lines, power house design, generators and transformers, substations, switchgear of various voltages from LV to HV. This also includes ancillary and control/command systems
- Complete design and construction supervision services of Pumped Storage Schemes
- Asset condition assessment and rehabilitation programs (needs assessment, design, construction supervision, testing and commissioning)
- Assist plant and equipment owners to optimize or rehabilitate hydropower plants, locks, dams. Theoretical and applied training is also provided by ARTELIA

UGANDA

Taking over construction supervision on Isimba

Located about 90 km North-east of Kampala on the White Nile the design and construction of Isimba was started in 2013 under EPC arrangements and ARTELIA mobilized in late 2017 to take-over as Employer's Representative. Our supervision team managed all electro-mechanical and electrical aspects on the project including construction of the 41 km long 132 kV line and the installation of four Kaplan turbines totalling 183 MW.



FRANCE

Vives Eaux: Rebuilding a navigation dam on the Seine

A new regulating dam has been built on the Seine river to replace the old one built over 100 years ago. The new dam consists of three bays equipped with 30 m x 6 m gates regulated by a programmable logic controller, a fish pass with 12 successive pools, a control room and a footbridge open to the public. ARTELIA provided the full suite of services from preliminary studies to construction supervision and assistance with acceptance operations.



MALI

Complete rehabilitation of Sélingué & Sotuba

The hydropower plants of Sélingué and Sotuba in Mali were over 40 years and 30 years respectively. The aim of the rehabilitation project was to provide an additional 15 years to the running life of the equipment and hydropower plant. ARTELIA electro-mechanical team provided the full suite of services from expert's appraisal of the existing equipment to works supervisions and commissioning.



EGYPT

Replacing New Assiut dam and building a new power plant

The New Assiut dam on the Nile river in Egypt replaces the old Assiut barrage with the addition of a 43 MW low head hydropower plant equipped with 4 bulb units, a gated spillway and two navigation locks. ARTELIA provided full services for electrical, instrumentation and control equipment for the hydropower plant from feasibility studies to works supervision and commissioning.

Ensuring responsible and sustainable hydropower developments



Increasingly, Environmental & Social (E&S) aspects are key issues for hydropower developments; a good E&S management has become a critical success factor for any responsible hydropower project.

We provide comprehensive E&S services to identify and mitigate impacts, to facilitate the construction and operation of hydropower projects while sustaining the environment. Our team of scientists, planners, sociologists, ecologists and engineers work collaboratively with local partners to provide a range of E&S Services:

- Environmental and Social Impact Assessments (ESIA): determining comprehensively the baseline conditions (including field investigations) and evaluating the project's potential impacts.
- Environmental and Social Management Plans (ESMP): anticipating and managing the potential E&S impacts during the construction and operations phases
- Resettlement Action Frameworks/Plans (RAPs): identifying the Project Affected Persons (PAPs), proposing the eligibility and compensation framework and working with the developer to facilitate the evaluation of the needs and costs in a participatory manner.
- E&S Due Diligence: determining environmental liabilities or anticipating risks before investing or financing a hydropower development.
- E&S monitoring during construction: checking that the E&S conditions of approvals, commitments and the ESIA/ESMP are correctly implemented during the construction phase.



NENSKRA HPP - GEORGIA

Giving confidence to Lenders on E&S management

The Nenskra HPP in northern Georgia is a large project (140 m high AFRD with 280 MW, a water transfer from an adjacent valley, two tunnels etc.) in a sensitive region. ARTELIA has been providing Lender's E&S services to a consortium of development banks. This required the development of an E&S monitoring framework aligning each Lender's E&S Performance standard, regular site visits and documentation review across all aspects (from livelihood restoration to natural hazards) to provide an independent and robust opinion to the Lenders on the E&S performance of the Project.



KÉNIÉ HPP - MALI

Developing a project in a heavily inhabited area

Kénié HPP is a run of river development on the Niger River in Mali developed by a private company according to IFC standards. Up to 200 persons could be resettled as a result of the project which also requires careful consideration of water use and livelihoods depending on the river and its resources (e.g. sand quarries and adjacent irrigated agricultural perimeter). In addition to the ESIA and the RAP, ARTELIA also proposed tailored mitigation measures for the fish population (about 120 species including 60 migratory species) and a manatee population located upstream.



A trusted representative to manage the construction of your project



In recognition of the unique challenges brought by construction supervision, ARTELIA has a dedicated team focused only on construction related services for hydropower plants.

We can work within different contractual context (Construction Contracts, Design & Build, EPC/Turnkey). All our engineers involved in construction supervision have previous experience designing dams and hydropower projects and have developed tools to facilitate the day to day monitoring of construction activities such as a Construction Booklet documenting the supervision requirements for different work packages and regular fly-over using drones. To staff supervision assignments, ARTELIA maintains a team of in-house resident engineers complemented by associated freelancers.

We provide the following construction related services:

- Owner's Engineer (Engineer, Employer's Representative, Technical advisor) Services under various contractual arrangements and covering a wide range of requirements (including project management, work supervision, quality control management, construction drawings & design or validation of design and construction drawings, approval of As-built Plans, checking and validation of Quantities, training of counterpart staff, development of O&M manuals, etc.)
- Contract management (e.g. contract review, assistance during tendering and negotiations, management of contractual claims)
- Construction E&S monitoring and auditing.
- Independent due diligence and audits during construction
- Take-over of construction supervision including site and design assessment, transition planning and risk mitigation planning for project completion



NAM NGUM III - LAO PDR

Managing the construction of one of tallest CFRD in the World

With a height exceeding 215 m, the dam will be among the highest CFRD (Concrete Faced Rockfill Dam) in the world. An extensive analysis with a 3D numerical model was carried out to check the strain and stress in the dam body and in the concrete face. The project also includes a gated spillway with a 12 000 m³/s capacity, 11 km of underground works (headrace tunnels, pressure shafts and tunnels, surge shaft) with difficult geological conditions and water ingress in fault and karst areas, a 480 MW powerhouse (concrete structure) and a 130 km long 230 kV transmission line. ARTELIA provides the full suite of Employer's Representative services on this development including design review, construction supervision and E&S management.



ATTAQA MOUNTAIN PSP - EGYPT

More than 2000 MW of PSP under development

The Pumped Storage Power Plant (PSP) of Attaqa Mountain will be the largest PSP in the Middle East with a planned capacity of 2,400 MW. ARTELIA was awarded the contract from the Ministry of Electricity and Renewable Energy in Egypt to provide Owner's Engineer services during 7 years for the PSP including project management, engineering review, quality control, construction monitoring and commissioning services.



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