MOTT MACDONALD

Hydroelectric solutions

Turning the power of water into energy

The promise of pumped storage and hydroelectric power

Three-quarters of the renewable energy on earth comes from hydroelectric power. As governments face mandates to decarbonize their operations, the need for hydropower and pumped storage will grow even more.

Pumped storage permits an increasing reliance on intermittant renewable power by converting off-peak surplus generating capacity into hydraulic potential energy that can be turned quickly back into dispatchable electrical power during periods of peak demand.

The flexible reserve capacity offered by pumped storage hydropower works in synergy with the increasing development of wind and solar power plants that offer additional energy but irregular output. Pumped storage brings stability, regulation, and security to an integrated power generation system.

A worldwide leader in dams and hydropower

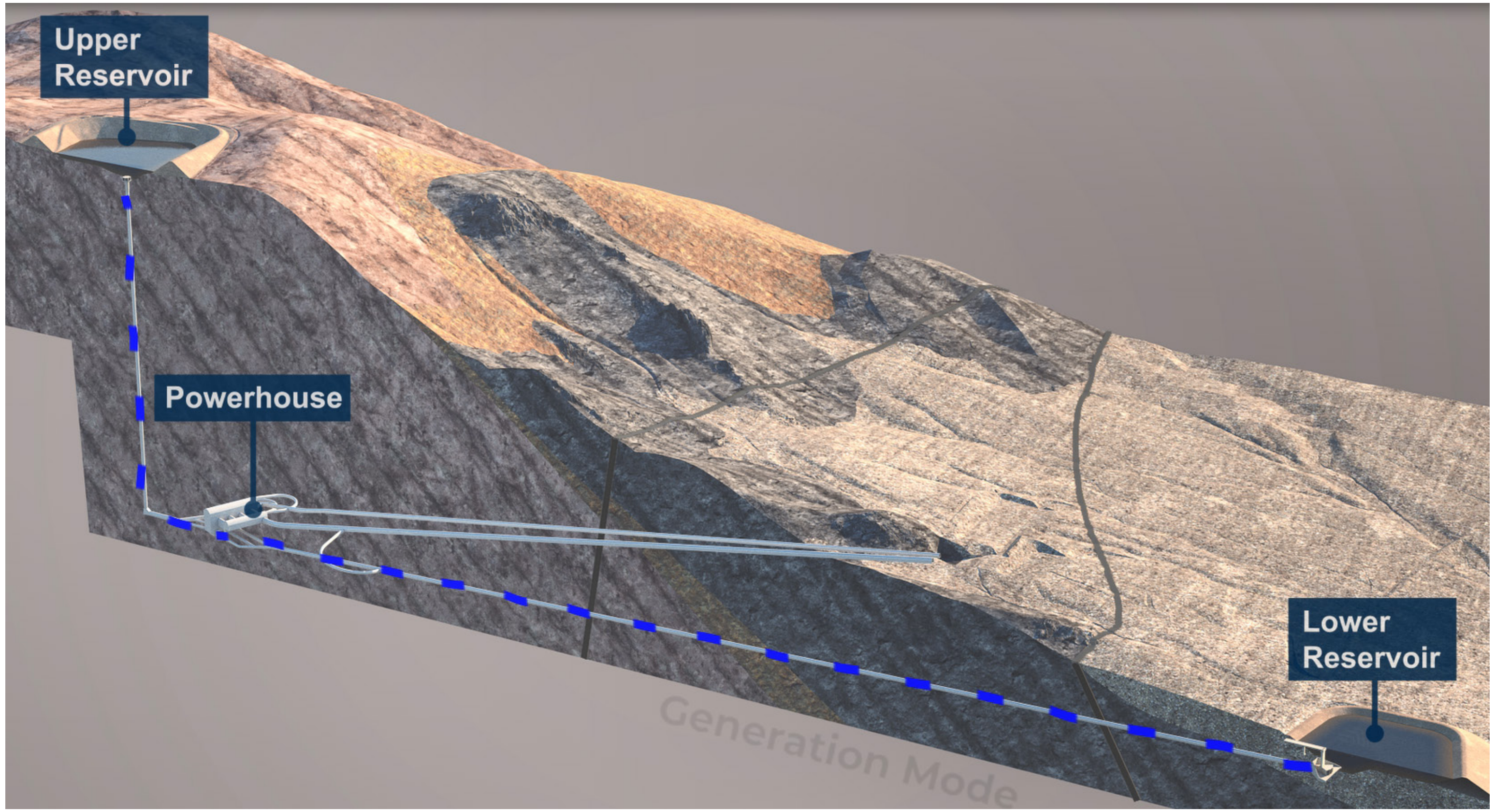
Mott MacDonald has been a leader in the development of dams and hydropower, including pumped storage, for almost a century. We have helped develop hydropower projects in 45 countries — more than 30,000 megawatts of hydroelectric capacity over the last 15 years.

Mott MacDonald opens opportunities through connected thinking. We provide innovative solutions to challenging problems. Working in collaboration with our partners and stakeholders, we design optimized, cost-effective, sustainable infrastructure that enhances grid stability and energy security.

A full range of capabilities

Mott MacDonald's expertise spans all stages of project development for owners and developers.

- Initial due diligence and reconnaissance
- Feasibility and environmental impact studies
- Permitting
- Dam safety evaluations under FERC and state regulations
- Cost estimating and scheduling
- Civil and structural engineering
- Hydraulics and hydrology
- Geology and geotechnical services
- Mechanical engineering
- Electrical and control systems engineering
- Value engineering
- Contract administration
- Construction management
- Inspection and quality assurance
- Startup and commissioning services



Designing alternatives for a flagship hydropower project

Project
White Pine Pumped Storage Feasibility Study

Location
Ely, Nevada

Client
rPlus Energies, Inc.

Expertise
Feasibility engineering and assessment services, value planning, cost estimating, risk assessment

Opportunity

The White Pine Closed Cycle Pumped Storage project will include a rockfill dam 165 feet (50 meters) high, impounding an upper reservoir of 4,100 acre-feet (5 million cubic meters) and a lower reservoir of equal capacity impounded by an earthfill dam. Both dams and reservoirs are lined with an impermeable membrane. Initial fill and annual makeup water is pumped into the lower reservoir through a pipeline connected to a well field.

This flagship hydropower project will produce 1,000 megawatts and will store 8,000 megawatt hours of power, transmitted to the NV Energy transmission system through a high-voltage transmission line 25 miles (40 kilometers) long.

The project is located almost entirely on federal land. Challenges include sensitive habitat, a historic railroad, difficult access to the upper reservoir site, and complex geological conditions.

Solution

Mott MacDonald was engaged as prime consultant to complete a feasibility study and prepare an AACE Class 3 cost estimate for this project. Twenty-nine of our experts from the US, Canada, Costa Rica, UK, France, Germany, Singapore, Malaysia, Australia, and New Zealand took part in a Value Planning Workshop where 386 ideas in 10 categories were developed, screened, and combined into six alternatives.

Using 3D AutoCAD and LeapFrog software, we rapidly developed 3D models that included geological conditions and detailed representations of each key element. Our work included supervising a detailed LIDAR survey of the site. We are coordinating with the client's environmental and geotechnical consultants to advise on permitting and site investigation.

Outcome

Working with the client, we selected a preferred alternative and developed it to 30% design maturity. The project will store excess energy for up to eight hours from intermittent renewable sources like wind and solar. The energy can then be dispatched when needed.

With proper maintenance, this project can have a lifetime of 100 years or more without major rehabilitation. The project will stabilize the grid in Nevada, provide direct employment and secondary jobs to improve the White Pine County economy, and help Nevada meet its goals for a carbon-free energy future.

The Kidston project is the first in Australia to combine solar energy and pumped hydroelectric storage.

Turning a ghost town and an abandoned mine into clean power and new jobs

Emissions reductions equal

33,000

cars taken off the road

Project
Kidston pumped storage

Location
Queensland, Australia

Client
Queensland, Australia

Expertise
Owner's engineering services, feasibility study

Opportunity

Kidston in northern Queensland was once the home of Australia's biggest and richest gold mine. The mine closed in 2001, leaving Kidston a ghost town.

Located in Australia's "red zone" of maximum solar irradiation, the Kidston area offered great potential for renewable energy. A 270-megawatt solar photovoltaic plant was built to take advantage of that.

In addition, two abandoned mining pits could be used for a pumped storage project. The Wises pit is 984 feet (300 meters) higher than the Eldridge pit, making the two well suited for power generation.

Solution

As owner's engineer for a project to optimize the design of the pumped storage project, we saw the potential to use the Wises pit as the upper reservoir rather than build a new reservoir. This would help avoid the need for excess water management during construction.

We identified an alternative waterway and cost-cutting measures for the powerhouse, and explored the feasibility of variable-speed technology.

Outcome

The pumped storage project will be able to power about 280,000 homes. The emissions avoided are equivalent to taking 33,000 cars off the road.

In 2018, a government infrastructure fund awarded more than $370 million (500 million Australian dollars) to the project, the first in Australia to combine solar energy and pumped hydroelectric storage.

This combination also shows potential for sites in North America.

Simon Kidston, executive director of Genex and a descendant of the Queensland Premier for whom the town was named, said, "Pumped storage hydro is the most efficient mature technology to store energy, and integrating this with solar and potentially wind over time, we can deliver the holy grail of renewable, which is dispatchable reliable energy."

Innovative energy solutions in the world's driest desert

A photovoltaic plant and a pumped storage facility will work together to deliver constant power to the grid.

2,133 feet

(650 meters) above sea level in the Atacama Desert, Chile

Opportunity

In northern Chile's Atacama Desert, a photovoltaic plant known as Cielos de Tarapacá (Skies of Tarapacá) is being developed alongside a pumped storage facility called Espejo de Tarapacá (Mirror of Tarapacá).

The photovoltaic plant, 37 miles (60 kilometers) south of Iquique, will cover 4,077 acres (1,650 hectares) and generate 600 megawatts of electricity. The pumped storage facility, 62 miles (100 kilometers) south of Iquique, will have a capacity of 300 megawatts of power.

Solution

From 2016 to 2017, Mott MacDonald undertook a technical and business case review of this innovative energy project. The two plants are designed to operate in conjunction and deliver constant electrical power to the grid.

Outcome

During hours of sunlight, half the power production from the photovoltaic plant can be used to pump seawater up to the upper reservoir of the pumped storage facility. When the sun is down, the pumped storage facility will generate electricity and deliver it to the grid.

Project
Valhalla photovoltaic/pumped seawater storage

Location
Chile

Client
Confidential

Expertise
Due diligence assessment

Powering Vietnam with hydropower

Opportunity

Vietnam has experienced increases in electricity demand of over 15% per year. Song Bung 4, the first major hydropower project in Vietnam funded by the Asian Development Bank, was intended to meet increasing power demands while reducing reliance on fossil fuels.

The project involved the construction of a roller-compacted concrete dam 361 feet (110 meters) high, an intake structure, a headrace tunnel 2 miles (3.2 kilometers) long and 24 feet (7.2 meters) in diameter, a surge shaft 52 feet (16 meters) in diameter, and a powerhouse.

The steep and rugged terrain, isolated location, and a work site spread over a large area make this a particularly challenging construction site logistically. A tight timescale was constrained by rainy-season flooding. Clear communication was challenging in the languages used on site: Vietnamese, Chinese and English.

Solution

We were the lead firm responsible for construction supervision and contract administration duties. We also provided design review, assistance with procurement, resettlement advice and monitoring, and environmental management and monitoring.

Poor rock conditions on the left abutment required significant investigation, redesign, and a revised construction methodology.

Challenges were met by the development of good, open working relationships between the client, contractors, designer, and our site supervision team, and a proactive approach to problem solving.

Outcome

Our collaborative approach to solving the geotechnical problems at the left abutment contributed to significant savings in schedule and expense.

By working 24 hours a day on site, the team was able to place concrete at a rate of 2.6 million cubic feet (75,000 cubic meters) per month.

We helped transfer knowledge of international practices and standards in the areas of engineering, procurement, resettlement, and contract management to the client, our local counterpart staff, and the contractor.

Mott MacDonald is the owner's engineer and technical advisor for Song Bung 4, the first major hydroelectric project in Vietnam to be financed by the Asian Development Bank.

Project
Song Bung 4

Location
Quang Nam Province, Vietnam

Client
Electricity Vietnam

Expertise
Construction supervision, contract administration, design review, environmental management and monitoring

The new John Hart Generating Station will supply electricity to about 80,000 homes in British Columbia. Photo courtesy of BC Hydro.

Protecting salmon while generating power

Project
John Hart Generating Station

Location
Vancouver Island, British Columbia

Client
SNC-Lavalin Capital

Expertise
Lender's technical advisor, specialist review of design-build works

Opportunity

Built in 1947, the John Hart Generating Station is located in Elk Falls Provincial Park on Vancouver Island in British Columbia. About 95% of the Campbell River, a popular destination for recreational fishermen, passes through the aging infrastructure of the hydropower plant. The area has been dubbed the "Salmon Capital of the World."

The station's generating units are in poor condition, and their capacity has declined over time. The original woodstave surface penstocks are seismically vulnerable and are considered unlikely to withstand a low to moderate earthquake. An interruption in the flow of water could be devastating for the salmon population and the clean, reliable power supply to Vancouver Island.

Solution

As part of a design-build-finance-maintain project, Mott MacDonald was retained as the lender's technical advisor to provide due-diligence review of the bid and design process, construction monitoring, and commissioning. We also provided specialist review services for the design-build works, and continue to undertake regular site inspections to monitor progress.

Outcome

A new underground generating station, almost invisible to park visitors, improves access to trails and the river and was completed in 2019. New tunnels and a new powerhouse ensure more reliable water flows and clean power generation, improve public safety, reduce the environmental footprint, and safeguard the salmon habitat downstream of the project.

Forty-five miles (72 kilometers) of tunnels carry water from glacial rivers to the Kárahnjúkar Hydropower Plant.

Glacial rivers power growth in Iceland

Opportunity

Beginning in 2003, three dams were constructed to create the Hálslón Reservoir. With a surface area about the same as Manhattan, the reservoir provides seasonal storage of 555 billion gallons of water (2.1 billion cubic meters). Water from Hálslón and two smaller reservoirs passes through 45 miles (72 kilometers) of underground water tunnels and down a 1,380-foot (421-meter) vertical penstock.

Solution

As lead consultant for a joint venture, Mott MacDonald directed an integrated team of 50 people providing expertise in engineering and construction supervision. A challenging combination of volcanic and glacial geology required daily mapping by tunnel engineers. Mott MacDonald developed an advanced database to manage the large amount of data generated by up to seven simultaneous tunnel boring and drill-and-blast drives.

About 31 miles (50 kilometers) of tunnel were drilled by three tunnel boring machines, a method never used before in Iceland. The remaining 14 miles (22 kilometers) were completed with conventional drilling and blasting.

Outcome

Geologic faults more than 30 feet (9 meters) wide were handled with stabilizing measures including grout injections, foam, and concrete in front of the cutterhead, and steel support ribs behind the head. The Kárahnjúkar Hydropower Plant now supplies 690 megawatts of power to a single customer, an aluminum smelting plant on the eastern coast of Iceland.

Project
Kárahnjúkar Hydropower Plant

Location
Iceland

Client
Landsvirkjun

Expertise
Lead consultant, project management, construction supervision

Meeting the challenge

Developing hydropower in the Himalayan Mountains involves substantial risks. A broad range of technical skills is required to unlock the thousands of megawatts of renewable energy potential in the world's highest range. These are some of the selected projects we have undertaken in the Himalayan region.

Pakistan

Suki Kinari.
870 megawatts capacity.
Feasibility study, owner's engineering.
Currently under construction.

Patrind.
150 megawatts capacity.

Gulpar.
102 megawatts capacity.

Diamer Basha.
4,500 megawatts capacity.

India

Luhri.
700 megawatts capacity. Feasibility study, detailed project report, preparation of tender documents.

Bhutan

Pre-feasibility study, site investigations, optimization, environmental and social studies for multiple projects:

Shongachhu.
107 megawatts capacity.

Dagachhu-II.
70 megawatts capacity.

Manas.
1,100 megawatts capacity.

Hydropower in the Himalayas

Opportunity

With a capacity of 7,100 megawatts, the Bunji hydropower project will be the largest of its kind in Pakistan. The project is located on the Indus River near Gilgit, with a powerhouse and dam 348 and 380 miles (560 and 612 kilometers) from Islamabad, respectively.

Solution

For over 50 years, Mott MacDonald has helped drive development in Pakistan. In addition to land and water resource projects, we have contributed to 12 hydropower projects, including the award-winning Ghazi Barotha and Sukkur Barrage projects.

For the Bunji project, our team joined local companies and partners from France and Japan to conduct a feasibility study. The study identified the optimum approach within financial, economic, and environmental constraints, and provided detailed engineering design and tender documents.

Outcome

The Bunji project includes a powerhouse cavern, a roller-compacted concrete dam 656 feet (200 meters) high and five headrace tunnels each 36 feet (11 meters) in diameter.

Project
Bunji Hydropower

Location
Gilgit and Skardu districts, Pakistan

Client
Water and Power Development Authority

Expertise
Geotechnical feasibility study, detailed design, tender documents

Boosting energy capacity at Scotland's "Hollow Mountain"

Opportunity

First conceived in the 1930, the Cruachan Power Station is located in a cavern excavated inside Ben Cruachan, a granite mountain in the Scottish Highlands.

Mott MacDonald was the original engineer/designer for the project, which was constructed over six years by a team of 1,300 men known as the Tunnel Tigers. The first reversible pumped-storage hydropower system of this size in the world, the station was opened in 1965.

Solution

In 2001, ScottishPower appointed Mott MacDonald as Owner's Engineer to refurbish and upgrade two of the four turbines from 100 megawatts to 120 megawatts. We were responsible for project management, design review, factory inspections, construction monitoring, health and safety requirements, monthly progress reports, financial data, and site supervision.

We supervised repairs to the concrete-lined penstock, analyzed the turbine structure, and conducted fault level studies of the electrical system. We were also responsible for the blowdown system and fire safety system.

Outcome

The two upgraded units were returned to service in 2004, adding 40 megawatts of renewable energy to the plant's capacity.

In 2005, ScottishPower appointed Mott MacDonald as Owner's Engineer for the refurbishment of the remaining two turbines. In 2009, we became the Owner's Engineer for refurbishment work on Unit 4, which required further remedial works.

Project
Cruachan Power Station

Location
Scotland

Client
ScottishPower

Expertise
Owner's engineer, project management, design review, inspections, site supervision

“Positive Energy” for the Philippines

Opportunity
Citicore Power Inc. describes itself as “a Community-Focused Renewable Energy Company that responsibly harnesses nature’s resources to fuel long term value and empower Filipino communities through innovative renewable energy systems, delivering Positive Energy to all.”

For the Central Visayas region of the Philippines, Citicore proposed a 200-megawatt pumped-storage hydropower plant. Located on a brownfield site at an existing copper mine, the plant would include a new artificial upper reservoir and would use an existing lake as the lower reservoir.

Solution
Mott MacDonald was appointed as the owner’s engineer, providing conceptual design and a feasibility study for the project. A vertical shaft 1,300 feet (400 meters) deep leads to an underground powerhouse, a tailrace tunnel one mile (1.5 kilometers) long, and reversible Francis pump-turbines.

Package I of the project will consist of a high-level desktop review of the main risks, based on information provided by the client. A fatal flaws study and risk review will be followed by a site visit by our pumped storage specialists. Package II will include a more detailed review of the project information, culminating in a full-fledged feasibility study.

Outcome
Mott MacDonald will produce a conceptual design for the client, including a layout of key structures, power energy calculation, cost estimate, and risk analysis. The design will pave the way for a successful brownfield development that delivers reliable renewable energy to the people of the Philippines.

Project
Toledo City Pumped Storage Project

Location
Central Visayas, Philippines

Client
Citicore Power Inc.

Expertise
Owner’s engineering, design review, construction supervision, project management, commercial management

Five ways you can benefit from our pumped storage expertise

1
Current experience and integrated capabilities

Mott MacDonald has provided integrated pumped storage, hydropower, water, and tunneling projects for local and international clients. We are currently carrying out major pumped storage and hydropower assignments around the world.

2
Understanding of the issues

Clients appreciate our familiarity with major issues such as hydrology, sediment, geology, ground behavior, power, and energy modeling. We also understand the requirements for conjunctive operation and the role of the pumped storage plant, as well as the transmission and regulatory issues that can affect the timely development and construction of projects.

3
Value-added services

We are more than simply engineers. We also have a strong focus on commercial matters that helps us work with clients to better plan their long-term implementation strategies. We offer a flexible approach that finds solutions for all stakeholders.

4
Nontraditional services

Mott MacDonald can and does provide services beyond those of the traditional engineering consultant. Our services include market analysis, institutional strengthening, and the design and implementation of operational and strategic asset management techniques.

5
Local presence with a global perspective

As much as possible, we work and live in the markets we serve. This gives us a local presence with an excellent understanding of the local energy market. We bring first-hand knowledge of local conditions.

Worldwide experience with smarter energy storage

Project	Country	Capacity (MW)	Year
Coire Glas Pumped Hydro	Scotland	>1000	2022
Bunkers Hill Pumped Hydro Storage Facility	Australia	350	2021
Lake Onslow Pumped Hydro Storage Project	New Zealand	>1000	2021
White Pine Pumped Hydro Storage	USA	1000	2021
Oquirrh Pumped Hydro Energy Storage	USA	500	2021
Baroota Pumped Hydro Storage Facility	Australia	250	2020
Kidston Pumped Storage	Australia	250	2018
Toledo Pumped Storage Project	Philippines	200	2017
Seawater Pumped Storage	Chile	300	2016
Kanmantoo Pumped Storage	Australia	250	2016
Dinowig and Ffestiniog	United Kingdom	1,800 + 300	2016
Wawa PSP	Philippines	500	2015
Conjunctive PSP and Renewable Energy	South America	720	2015
Halkyn Mine Pumped Storage	Wales	5-300	2015
Matra Pumped Storage Scheme	Hungary	600	2012
Cruachan Pumped Storage	Scotland	400	2010
Waterford Pumped Storage	Ireland	300	2009
Camps Pumped Storage	Scotland	500	2007

Project	Country	Capacity (MW)	Year
Braamhoek /Ingula Pumped Storage	South Africa	1,333	2008
Kippagh Lough Northern	Ireland	6-150	2007
Foyers	Scotland	600	2002
Dinorwig and Ffestiniog	Wales	1,800, 360	2002
Cruachan Pumped Storage	Scotland	400	1999
Dinorwig Pumped Storage	Wales	1,800	1999
Pumped Storage Studies	England	230	1998
Dinorwig Pumped Storage	Wales	1,800	1996
Dinorwig and Ffestiniog	Wales	Various	1995
Summit UPS	Ohio, USA	1,500	1994
Underground Pumped Storage	England	800-1,000	1991
Pumped Storage Scheme	Middle East	500	1990
Guangzhou	China	1,200	1988
Craigroyston Pumped Storage	Scotland	1,320-3,200	1986
Loch Doon Pumped Storage	Scotland	230	1986
Palmiet Pumped Storage	South Africa	400	1986
Underground Pumped Storage	England	800-1,000	1985
Dinorwig Pumped Storage	Wales	1,800	1984
Estangento Sallente Pumped Storage	Spain	400	1982
Shenzhen Pumped Storage Scheme	China	800	1981
Steenbras Pumped Storage	South Africa	180	1979
Loch Sloy Pumped Storage	Scotland	1,200-1,800	1978
Ardvorlich Pumped Storage Scheme	Scotland	800-1,600	1976
Investigations into pumped storage sites	Wales	1,320-3,200	1971
Seawater Pumped Storage	Wales	1,600	1966
Cruachan Pumped Storage	Scotland	400	1965
Ffestiniog Pumped Storage	Wales	360	1963

Opening opportunities with connected thinking.

For more information, write to americas@mottmac.com or call 800.832.3272.