

Water and pumped storage hydro

A sustainable approach for pumped storage hydroelectricity

Energy storage has a vital role to play enabling the energy transition

There is a critical need for long-duration storage and grid services.

The energy transition is not just about new ways of making carbon-free fossil-fuel-generated energy. It also requires a massive expansion in our ability to store this energy.

Energy storage at utility-scale enables renewable energy, harvested intermittently, to be used when required.

The combination of renewable energy harvesting with high-capacity, long-duration energy storage can eventually eliminate the need for fossil-fuel generated electricity

Worley is busy helping our clients build massive batteries and battery factories. And we are also working on a different and far bigger battery concept – Pumped Storage Hydro.



Pumped storage hydro: the biggest battery

Pumped Storage Hydro (PSH) makes it possible to store thousands of megawatt hours of electricity, for days, even weeks, if needed.

Although battery installations are growing rapidly, these are generally comparatively small. PSH provides 97% of energy storage in the United States and more than 90% worldwide.

Many large PSH projects are currently being planned that will provide dispatchable electricity storage in the 10 – 100 GWh scale. This GW-scale technology is available NOW!

PSH is not the only storage technology required for the energy transition, there is a major role for many types of storage, including chemical batteries, but PSH provides THE bulk long-term storage technology

The two largest PSH projects in the USA will store approximately 22 GWh and 26.5 GWh daily, but much larger systems are feasible. For instance, a PSH project underway in Australia will have a daily capacity of 48 GWh, and a total energy storage capacity of 350 GWh, enough energy to power a major city for two weeks!

Worley is helping clients around the world develop both new hydropower projects and PSH projects that will provide vital utility scale, grid-stabilizing storage and boost energy security

Additionally, studies in several countries (e.g.: USA, UK, and Norway) show that PSH can save significant costs for the electric grid, through ancillary services, reducing curtailment, and providing balanced, quality power to the grid

What does a PSH project look like?

Hydropower relies on gravity-driven water flow through closed tubes (penstocks) feeding water into a turbine-generator.

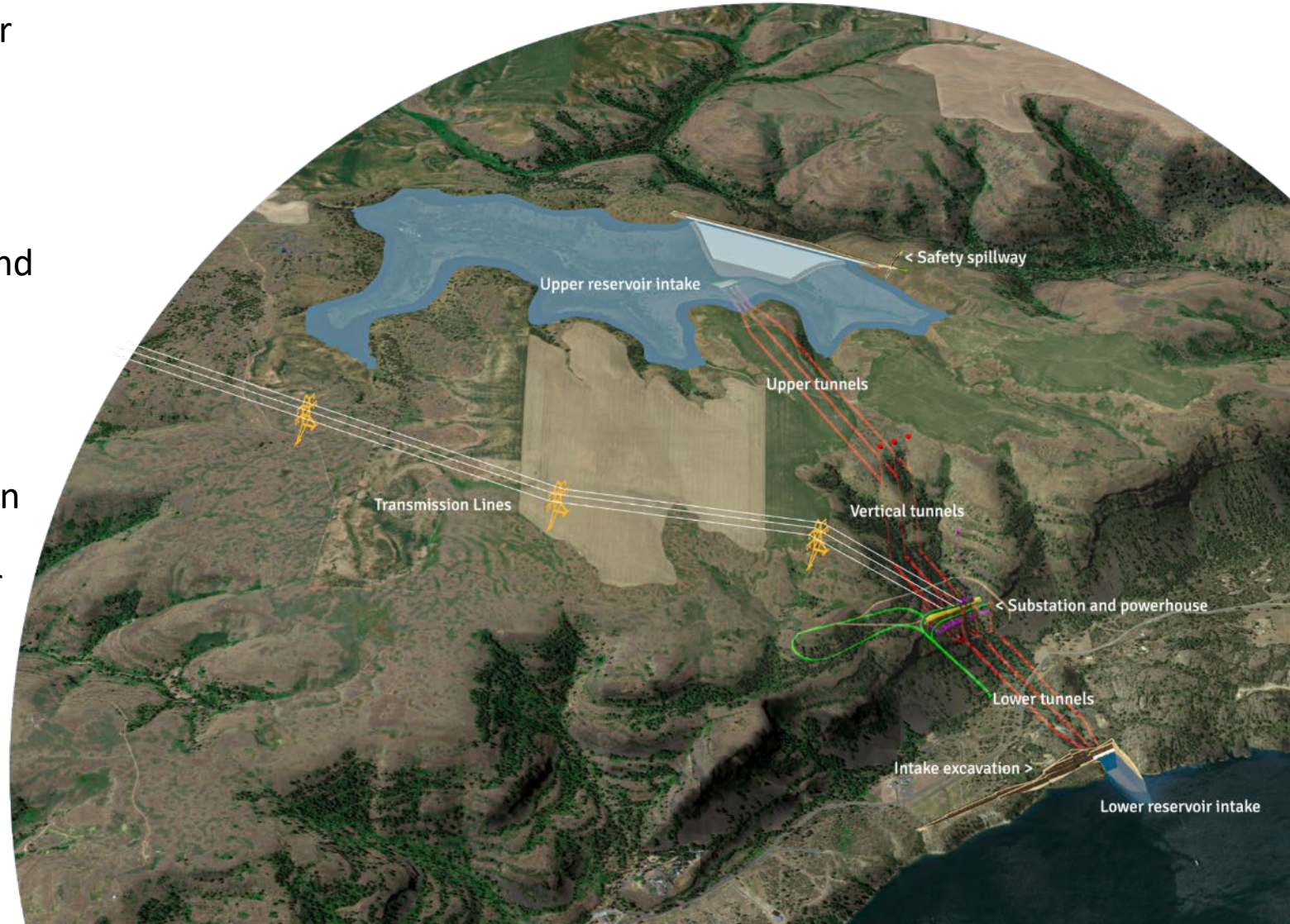
The flow of water turns the turbine driving a generator, making electricity.

In PSH, the turbine-generators are reversible and can be operated as pumps driven by motors.

Energy is stored by filling an upper reservoir dedicated to storing water.

When energy is needed, water is released down through the penstocks, turning the turbine-generator, producing electricity from the water stored in the upper reservoir.

The amount of electricity generated (MWh) is limited only by the storage volume available in the upper and lower reservoirs.



What are the challenges in developing a PSH project?

- Market stability and broadening the value of ancillary services to the grid.
- Development capital availability from government agencies, such as the US Dept of Energy, private investment groups, and non-government organizations interested in promoting renewable energy.
- Deep grid interactions, power marketing, transmission wheeling, and market trading.
- Licensing duration and complexity.
- High upfront capital costs, even though lifetime costs may be very competitive with batteries, nuclear etc., PSH can deliver 10 hours per day with 50-year life of project.
- Long development times, environmental mitigation, and large capital investment.
- Water availability, and acquisition of water rights can be a challenge in some locations.



How do we decide what to build?

1. Obtain clarity on energy storage requirements, total required energy storage, maximum capacity, number of hours to produce power, ability to be scalable over time, required ancillary services and required flexibility in operation.
2. Identify suitable sites that meet these requirements, topography, geology, water availability, connectivity to the grid and to infrastructure and with acceptable social and environmental impacts.

Normally a multitude of sites can be identified, including:

- open and close loop systems;
- existing dams/reservoirs;
- decommissioned mine pits; and
- the ocean or large lake as a reservoir.

The identified schemes are then assessed and compared to identify the most sustainable and attractive solution, considering technical, social, environmental, economical and financial aspects.

Finally, the preferred project will be further developed, to finalize the overall the solution, including operating modes and flexibility requirements, selection of the pump-turbine + generator/motor technology unit capacity and the number of units to be installed, as well as defining possible upscaling plans



Why Worley?

- Our experience spans the gamut, from site selection and preliminary studies to detail engineering, procurement, fabrication, construction management, commissioning to decommissioning, operation & maintenance, and remediation.
- Our in-house power marketing experts assist clients with sizing and operating the PSH project to optimize the fit to the Balancing Area Authority's power market
- Our expertise goes well beyond the boundaries of technical compliance, and includes socioeconomic, geopolitical, financial and environmental aspects.
- We understand the complete project life-cycle and what is needed to deliver successful projects.
- Worley understands the challenges of developing PSH projects, with over 50 years of experience in the development of hydropower projects.
- The great majority of the hydropower projects we have supported through development are now in operation or progressing to implementation.



Relevant project experience

Worley's experience across hydropower sector

Worley has delivered over 260 projects for hydro facilities. Ranging in size from >1 MW up to 20GW covering all aspects of project development and execution.

Our experience includes all stages of hydroelectric development and operation start from initial resource assessment and scanning, to option studies, selection of preferred configurations, design, procurement, construction, and commissioning, and continuing to maintenance, operation, and refurbishment phases, including:

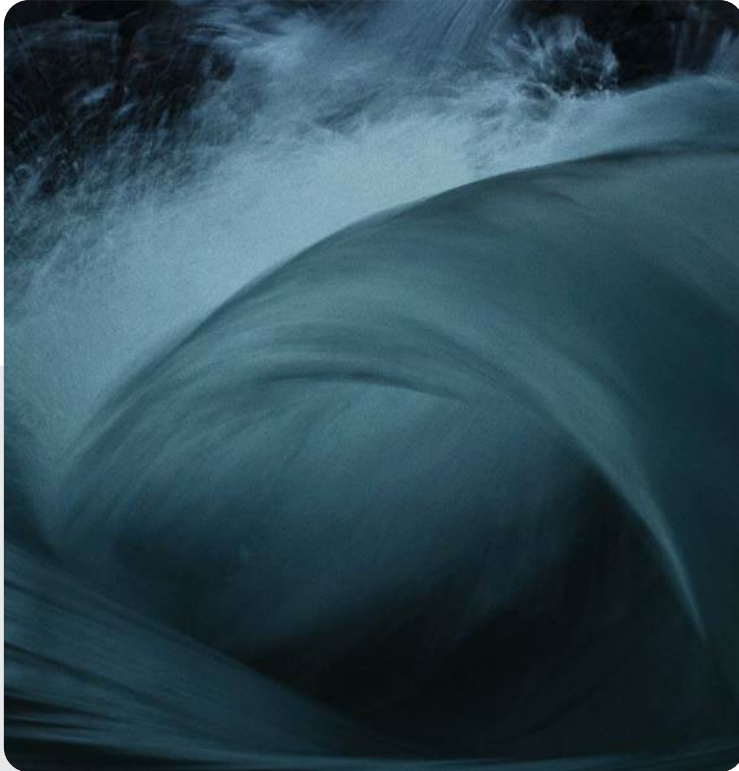
- Resource assessment
- Inventory studies
- Feasibility studies
- Basic design
- Detail design
- Owner's engineering
- Hydraulic structures design
- Hydropower/FERC licensing and relicensing
- Identification of multiple-use benefits
- New hydro at non-power, existing dams
- Small hydro, in-conduit hydro
- Refurbishment and rehabilitation
- Transmission and substation
- Environmental and social impact studies
- Optimization of projects
- Operation
- Support to investors
- Power marketing – dispatchable energy for off-takers
- Development of ancillary services for the grid operator
- Power system optimization to improve ROI of existing renewables



Across 7 states, USA

Tennessee Valley Authority Plant Modification & Maintenance

Performed **construction management, modification, maintenance and capital improvement work** on 29 hydroelectric power generation stations, 1 pumped storage power generation station; 113 generation units with a capacity of 5170 MWe, over a seven-state region. We also provide the same services for 31 river level control and navigation dam facilities.



USA

Confidential Pumped Storage Hydro Facility Seismic Analysis Project

This Confidential Power Plant is a multi-unit pumped-storage hydroelectric plant operated by a confidential utility that provides peak load power from the falling water of a large nearby supply.

Worley performed a seismic analysis, calculation for structural steel members, concrete structures and foundations including design of all steel connections, model, how structures will perform during high seismic event, and determine the weakest link. The scope of work to support the customer with updating the seismic analysis of the hard structures at the Power Plant consisted of the following structures the main powerhouse, the unit 7 Powerhouse, penstocks, the outlet tower and access bridge, industrial tank, and the emergency spillway.

Worley also provided training to the customer's personnel during the above tasks.



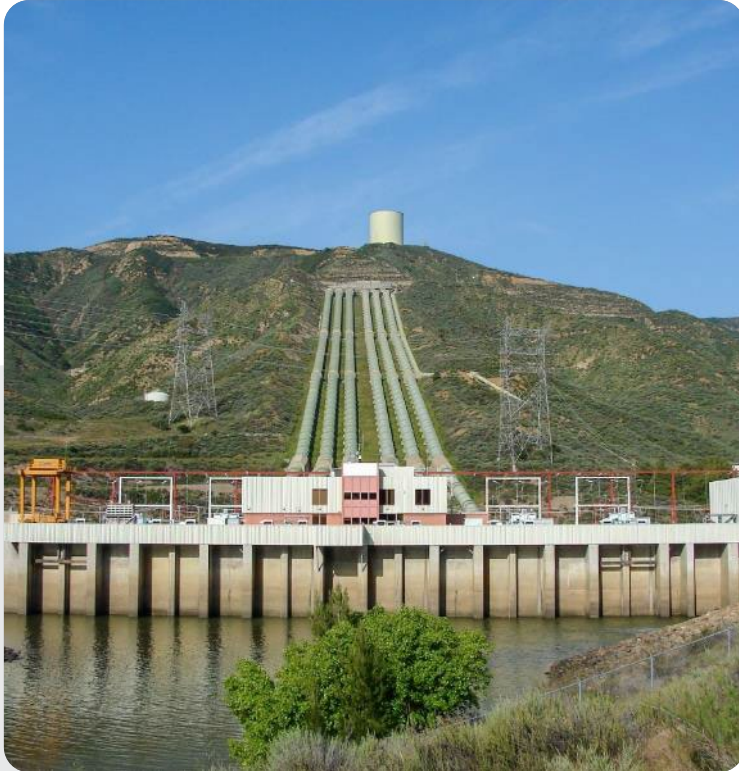
USA

Ludington Pumped Storage Electrical Design Services

The Ludington Pumped Storage Plant is a 1875 MW hydroelectric plant and reservoir in Michigan.

We are delivering Electrical Design Services to support Ludington pumped storage hydroelectric facility's balance of plant equipment overhaul of Units 1 & 3, which encompasses motor generator controls integration.

Modifications are being made to electrical schematic, loop, and wiring diagrams, conduit and layout drawings, creation of circuit and raceway routing schedules, and review of as-built plant conditions.



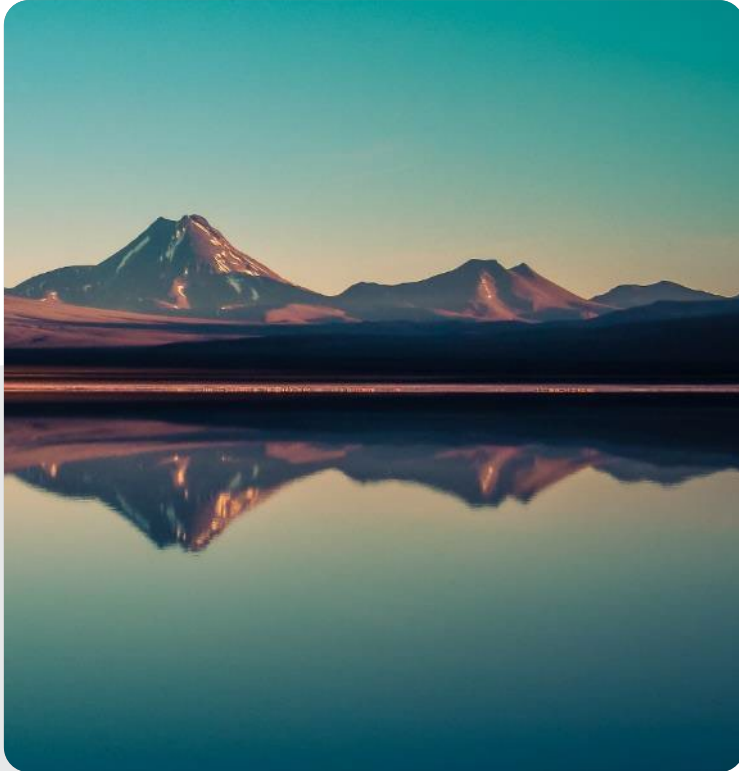
California, USA

Operating procedure training at the Castaic Pumped Storage Hydro Plant

Castaic PSH in Southern California, near L.A. produces 1,247 MW for up to 10 hours in generating mode.

LADWP installed a new Control System at the 7-unit pumped storage hydroelectric Castaic Power Plant as part of the Castaic Modernization Project. The purpose of Control System Upgrade was to replace and improve the existing plant controls with modern, state-of-the-art hardware and software. The project increased overall generating capacity, improved plant reliability, and increased plant availability.

Our scope of work included preparation of operating procedures for 14 modes of operation and training Plant Operators on the new procedures.



Chile

Pumped Storage Hydro Project Design Services

Our team executed civil, hydraulic & electromechanical and transmission system design for a pumped storage plant in Chile.

The plant design consists of an upper reservoir with CFRD dams, a 6m wide 1000m long pressure tunnel, pressure pipe, underground powerhouse with 4 reversible Francis units, four 180MW turbine/pumps, lower reservoir with filling dam, bottom drain, patio de alta and 2x220kV transmission line. Both reservoirs would have a useful volume of 5.6M m³, the upper one would consist of 5 dams of the CFRD type between 14 and 75m high, while the lower reservoir would be formed by a fill dam and geomembrane, between 8 and 22m high.



Australia

Muswellbrook Mine Pumped Storage Hydro project

Concept design for a new pumped storage hydro project using a decommissioned coal mine pit as the downstream reservoir.

Several upstream reservoir options and their consequent pump hydroelectric layouts were evaluated.



Australia

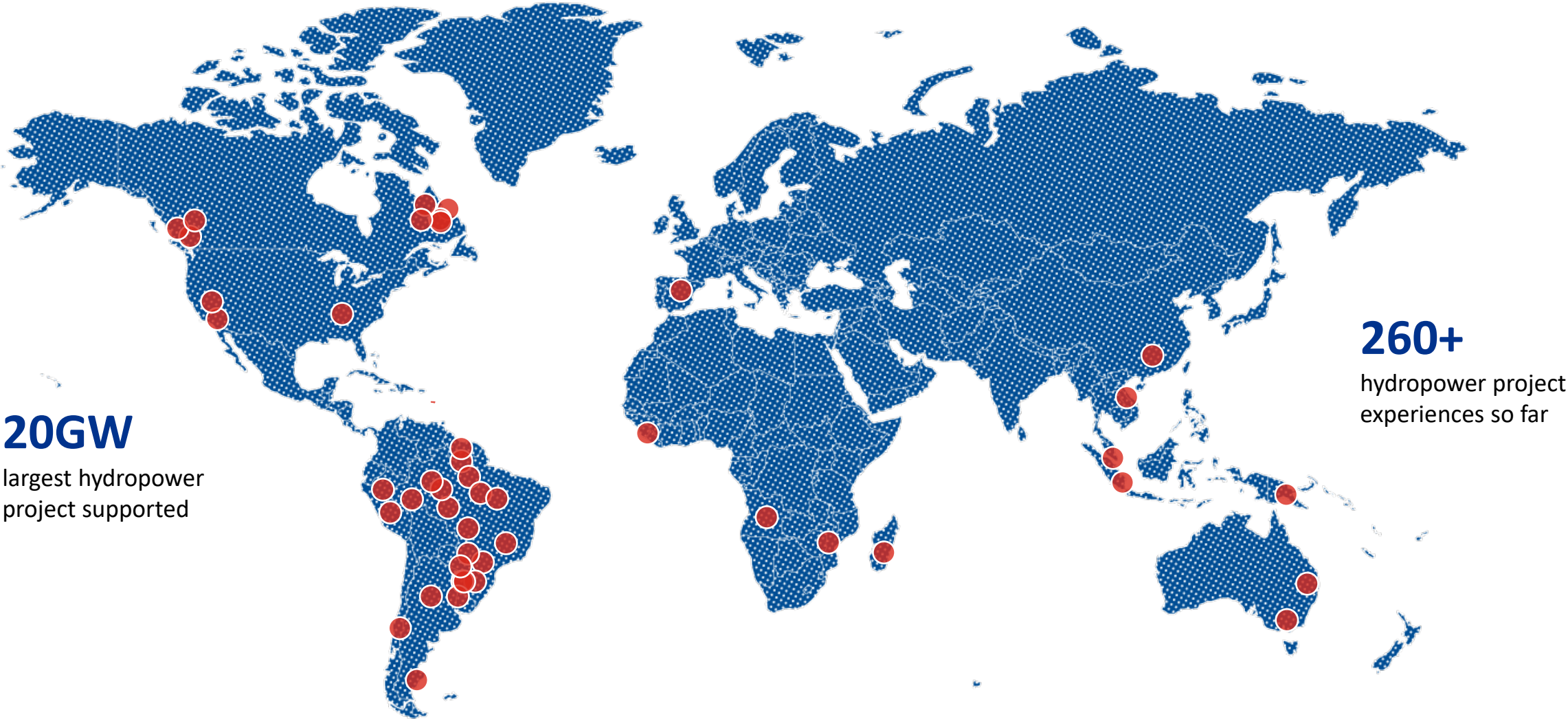
South Australia Energy Storage Options

We were commissioned to study alternatives to enhance a new transmission system with energy storage options that balance the generation of renewable energy with network requirements.

As part of the scope, the potential for pumped storage schemes was considered. This included defining the scales of projects, identifying potential sites at new or existing reservoirs, identifying the main characteristics of the projects through preliminary design, and estimating capital and operational costs.

Global hydropower project experience

Showcasing some recent hydropower projects we've supported across the globe.



20GW

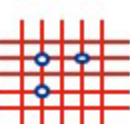
largest hydropower
project supported

260+

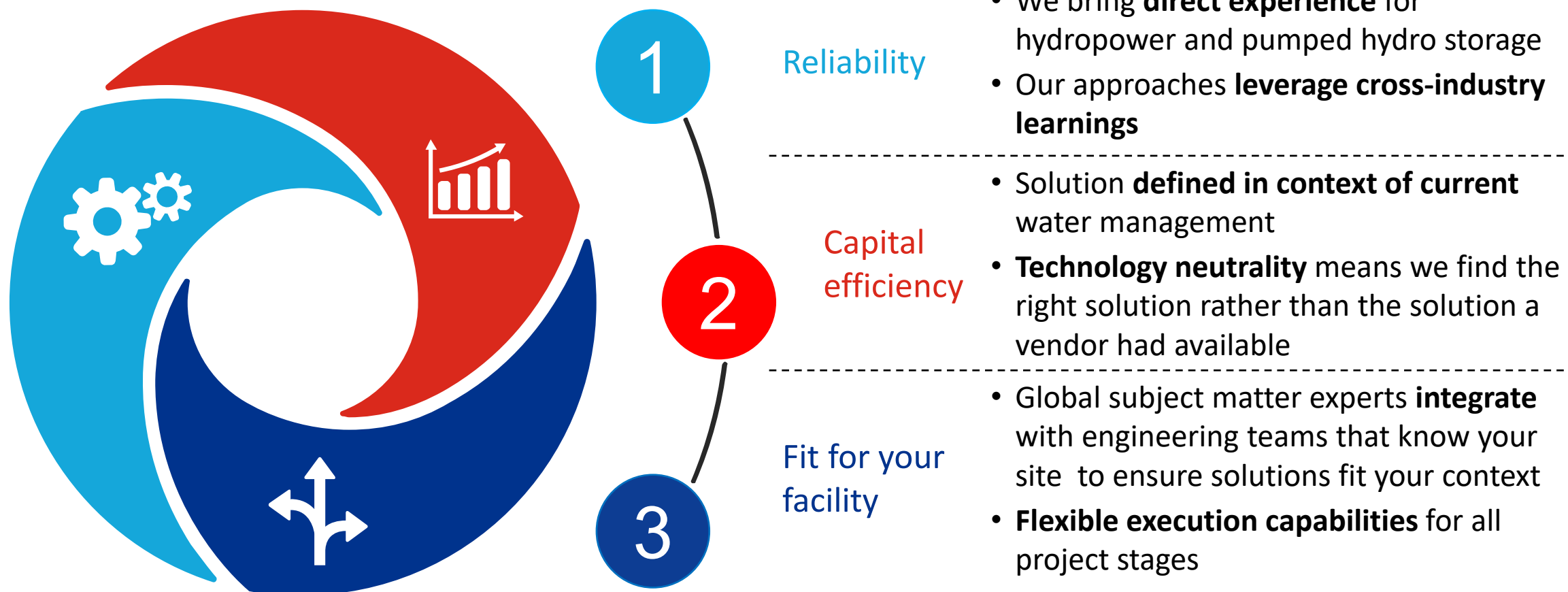
hydropower project
experiences so far

Energy transition: Worley is the leader

3019+ Project experiences

										
Solar power	Wind power	Geothermal, hydro & ocean power	Nuclear power	Liquid renewable fuels, renewable natural gas, waste-to-energy	Hydrogen	Distributed energy, EV & storage	Electrification, energy efficiency & grid transformation	Carbon capture utilization & storage	Energy Transition in mining, minerals and metals	Energy Transition materials
365+ Solar power projects	782+ Wind power projects	320+ Geothermal, hydro and ocean power projects	229+ Nuclear power projects	248+ Liquid renewable fuels, renewable natural gas, and waste-to-energy projects	105+ Hydrogen projects	248+ Distributed energy, EV & storage projects	231+ Electrification, energy efficiency and grid transformation projects	214+ Carbon capture utilization and storage projects	56+ Energy Transition projects in mining, minerals and metals	221+ Energy Transition materials projects (excluding copper)
950 MW World's largest CSP/PV hybrid project	310 MW Largest onshore wind farm (and largest in Africa) 2600 MW Largest offshore wind farm (1218 / 1386 MW)	20 GW Largest hydropower project	30+ GW Nuclear projects in 60+ years, 27 countries, 5 continents	\$211m Savings in a single project through licensor design optimization	36 GW Largest green hydrogen electrolyzer studied, combined with offshore wind	200 MW EPC for PV solar project including grid interconnection	\$20m/yr Savings achieved through energy efficiency and electrification for a single industry client	100 MT Million tons of CO ₂ expected to be captured and stored on world's largest CCS project	70% Diesel reduction through electrification at world's largest iron ore mine	25+ Lithium projects in brine concentrates 25+ yrs Lithium experience globally

Worley has the right people and experience to provide reliable, cost-effective water solutions for pumped storage hydro projects



A Global Team

We bring decades of water sourcing, treatment, resources, storage and hydroelectric experience.

We have hundreds of experts in all major geographies, combining perspectives as consultants, EPC, project developers, OEMs, and operators to deliver solutions that produce lifetime performance and value.



Andrew Hodgkinson, Global Technical Leader - Water

- 35 years of water and wastewater treatment experience
- Water technical lead for recent study for North Sea wind to hydrogen project
- Water technical lead for European green hydrogen project
- Technical lead for confidential Belgium desalination/ demineralization study
- Significant wastewater reuse experience across multiple industries
- Worley's Global Technology Director for Water and Wastewater Treatment



Stuart Atkinson APAC Leader – Hydrologist

- Water security studies & strategy development and implementation
- Hydrogeological assessments, Flood modelling, mitigation design
- Mine site water management and design, dewatering and supply
- Impact assessments regulatory approvals, closure planning and design



Len Marino – Hydropower & Dams, North America Lead

- 40+ years experience in operation & maintenance of dams and hydroelectric systems
- Expert in power marketing and optimization of hydro for the local power market
- Condition assessment of dams, hydropower, and water delivery systems
- Design of conduit hydro “bolt-ons” to add a revenue to existing water systems
- Licensing studies, right-of-way, and water rights acquisitions



Earl Hamil – Senior Consultant, Power

- 40+ years capital projects experience in power, resources, water.
- Experienced Consultant (Worley, Enercon), Owner (Dominion Energy), OEM Equipment Supplier (GE) and EPC (Bechtel, S&W, Benham, Daniel Const, Fluor)
- Developing 5,000 MW pumped storage portfolio with Daybreak.
- Lawrence Hydro 18 MW bulb turbine project (first ever in US)



Gabriel Rocha - Global Leader – Hydropower

- 22 years of hydropower and pumped storage experience
- Hydropower Global Lead for Worley
- Project Manager for large hydropower contracts, such as Itaipu (14GW)
- Significant experience with due diligence, studies, development and execution of greenfield and brownfield hydropower and pumped storage plants.
- Worley representative at the International Hydropower Association (IHA)



Looking for support on pumped storage hydro?

Get in touch with a local expert today:

Earl.Hamil@worley.com

Maxwell.Pitts@worley.com

David.Williams@worley.com

WET@advisian.com

