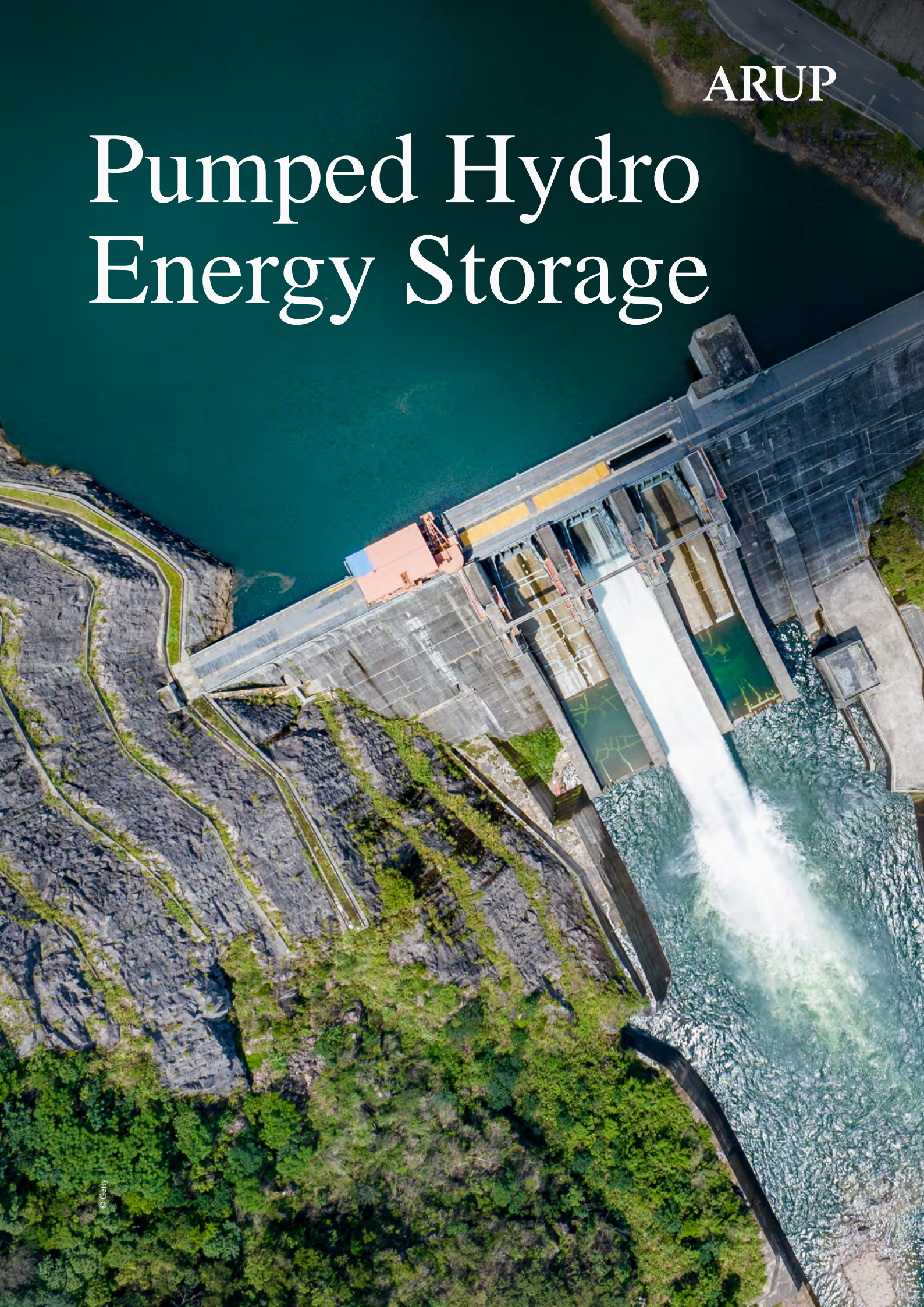


ARUP

# Pumped Hydro Energy Storage



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© Cratly

# Pumped Hydro Energy Storage

In today's dynamic and competitive landscape, selecting the right partner for your project is crucial.

At Arup, we understand the challenges in developing robust and fundable pumped storage schemes that are safe and sustainable to construct and operate. We have an unwavering commitment to excellence and delivery, committing the right resources to each client and to each of their projects.

Sustainability is at the core of what Arup deliver and we recognise the vital importance of implementing successful PHES schemes in the UK, as part of the wider energy transition. This pivotal role for Pumped Storage is reinvigorating existing schemes and prompting an increasing number of new-build projects. To deliver these schemes efficiently in a modern regulatory and planning environment, hydropower skills must be combined with major project delivery expertise. This combination is what makes Arup's approach different and is why we have focused on assembling a team of experts to work with clients to deliver these critical projects.

We take immense pride in our ability to draw on technical, commercial and planning skills from across Arup to deliver services of the highest standard, consistently meeting deadlines and budgets at any stage of scheme development and delivery. Our teams operate as cohesive units, blending diverse expertise and knowledge from

our technical and advisory specialists. This collaborative approach ensures that we offer comprehensive solutions tailored to the unique requirements of each project.

We recognise the importance of synergy and collaboration. Our teams integrate with clients bringing extensive experience in multi-disciplinary hydropower schemes, offering invaluable insights and innovative solutions across the market, from early pre-feasibility, through energy companies and other scheme developers, to project delivery and commissioning with contractors.

As you peruse this document, we invite you to envision the possibilities of partnership with Arup. Together, we can transform ideas into reality, setting new standards of excellence in project delivery. Thank you for considering us as a trusted partner.



**Matt Sykes**  
Director

*Civil structural, bridges and tunnelling team leader*

# Pumped hydro energy storage

Capability: **Technical**

## Dams, water, and hydropower

Arup has a proven track record of successful involvement in water resources, storage, treatment and distribution including dams and reservoirs projects. The multidisciplinary approach adopted by Arup ensures that reservoir studies can be carried out in house with a team formed largely from our own staff with local knowledge and specialist disciplines as required.

Arup is actively involved in the design of multiple pumped storage hydro projects in the UK, ranging in scale from 200MW to 1500MW. We thrive on working with both developer and constructor clients to bring innovative solutions to projects, accelerating them from the planning stage through to operation.

Recognising the complexity of these projects, we regularly collaborate with trusted partners to ensure the right level of expertise is brought to each project, ensuring efficient delivery.

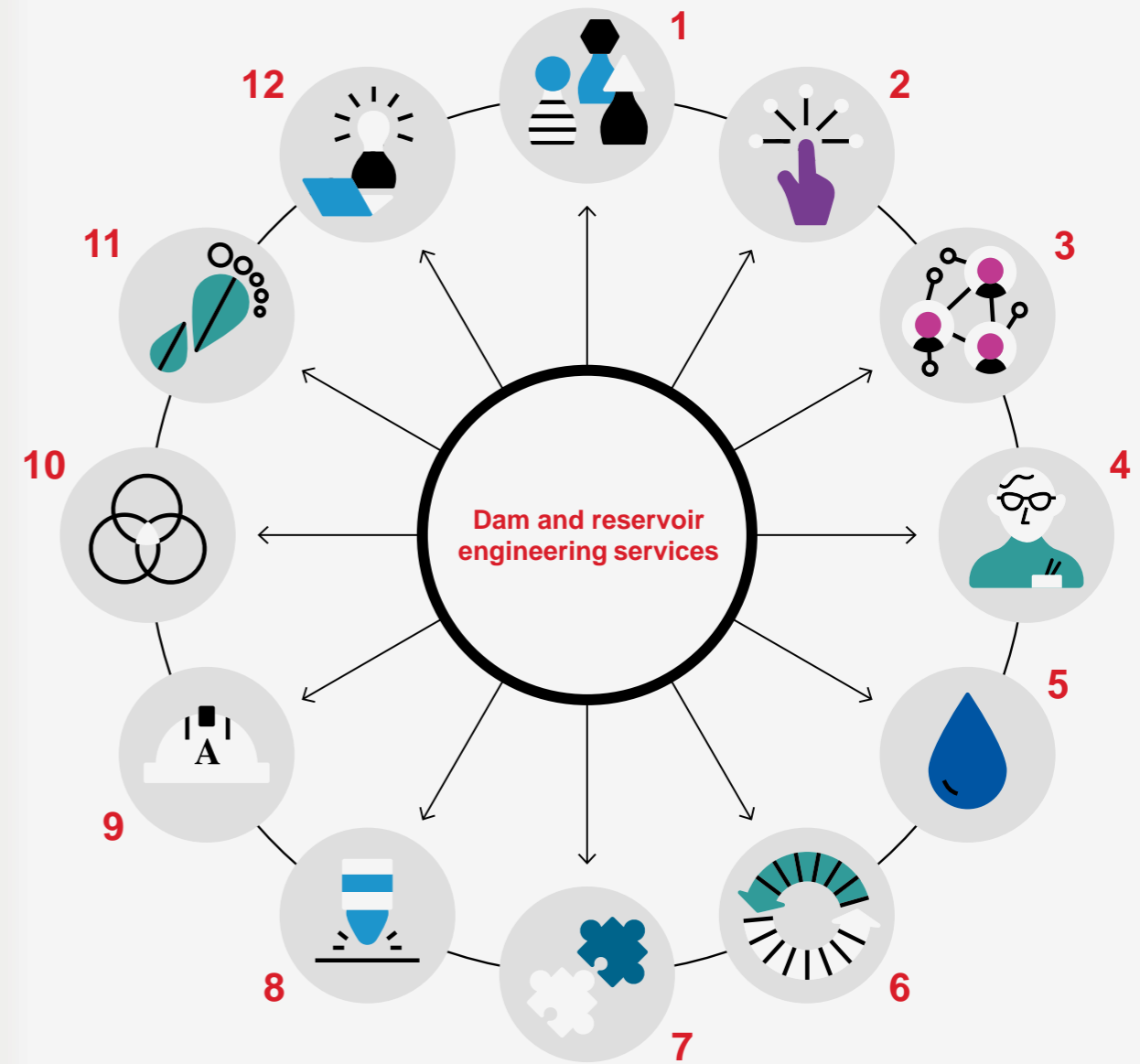
Dedicated to sustainable development, Arup is a collective of 18,500 people in 95 offices across 34 countries. Founded to strive for humanity and excellence in everything that we do, we collaborate with our clients and partners, using imagination, technology, and rigour to shape a better world.

# Pumped hydro energy storage

Capability: **Technical**

Our services in dam and reservoir engineering include the following:

1. Planning and promotion of proposed developments
2. Feasibility and detailed design
3. Construction supervision and project management
4. Supervision and inspection of existing dams and reservoirs
5. Reservoir safety studies
6. Design of remedial works
7. Decommissioning of existing assets
8. Seismic and dam break analysis
9. Hydropower assessment and implementation
10. Preparation of Operation & Maintenance manuals and Emergency Preparedness Plans
11. Sustainability appraisal
12. Technical research



# Pumped hydro energy storage

Capability: Environmental and social governance

Arup provides a range of economic advisory and strategy services on energy market forecast modelling, policy design, regulatory change, strategy development and impact assessment across the world. Arup Energy Economics team is a market leading economics team with senior experts that have a background and experience in energy policy, network price controls, energy demand forecasting, regulatory tariff modelling, energy market design and cost benefit analysis.

We can help you address risks and challenges and support the growth of your business through our deep understanding of energy policy and regulatory issues, our industry networks and economic expertise. We bring strong market and policy knowledge, drawing on our sector experts and specialists from across the firm to deliver integrated, evidence-based advice to our clients.

Our offering includes:

### Strategy and business case

Assessing projects or policies feasibility and developing the business case.

#### 1. Economic impact analysis

Quantifying and assessing the economic impact of policies and investments.

#### 2. Policy and regulatory analysis

Advising clients on key policy issues and development of new regulatory and tariff designs.

#### 3. Energy modelling

Developing economic and energy models across a spectrum of sectors and geographies.

#### 4. Market review

Providing advice on market trends, market entry and exit strategies and future scenarios.

#### 5. Commercial due diligence

Providing commercial and regulatory advice to public and private sector clients on infrastructure transactions.



# Pumped hydro energy storage

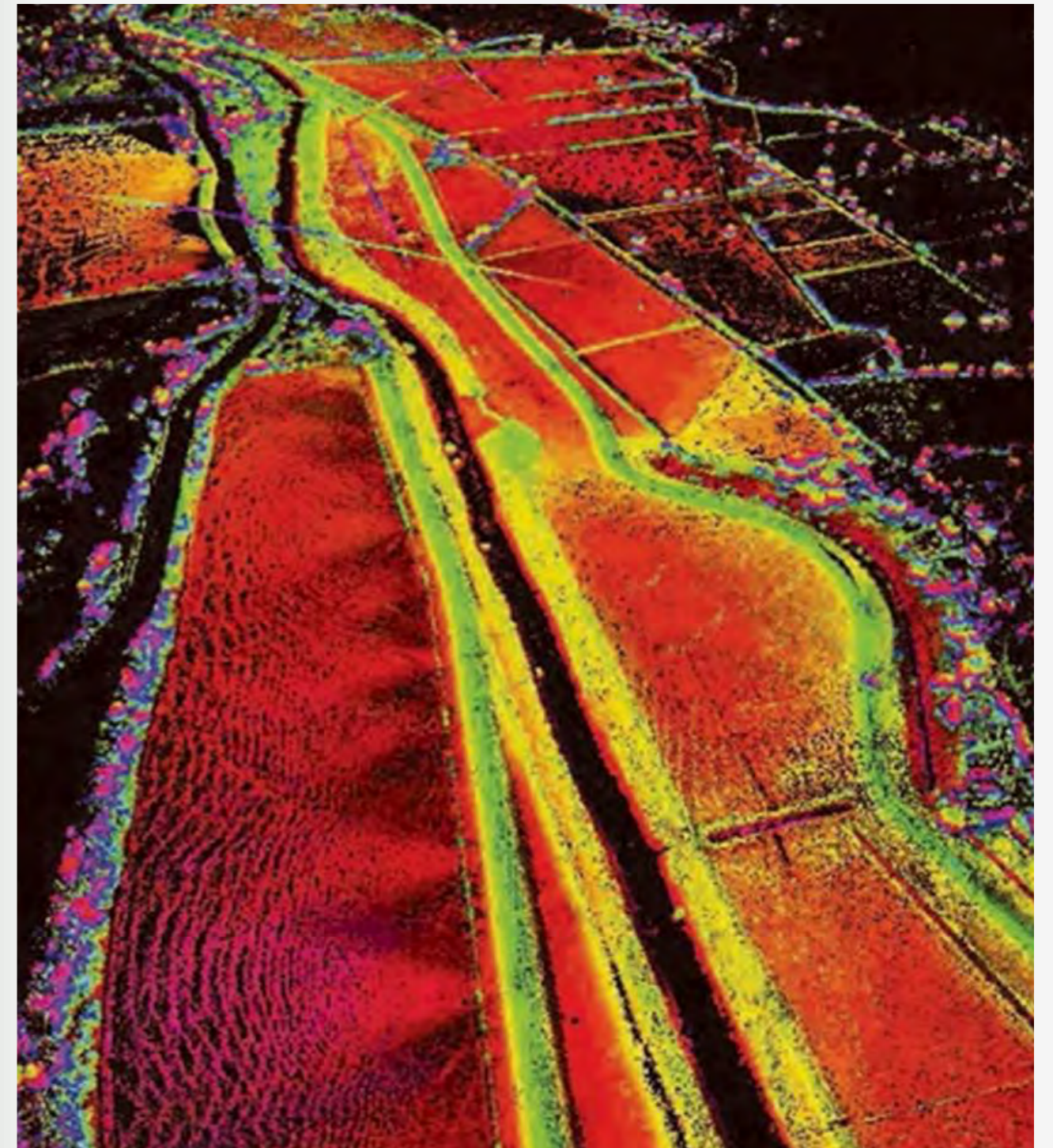
Capability: Digital

Arup are committed to being the digital leader in the built environment. Digital technology and connectivity have already transformed many aspects of our lives. And we are excited and inspired by the possibilities of valuable data, increased computing power, digital technology, user-centred design and new analytical techniques to unlock greater value.

Harnessing digital amplifies our expertise, reinforces best practice, delivers consistency, helps us to improve outcomes, while releasing more time to be creative. Data and digital fundamentally change how we interact with the physical world and unlock greater value for our clients, across the lifetime of their operations and generates new and exciting sources of revenue. Digital and data are also key to our pursuit of sustainable development.

Through this we focus on providing better outcomes for our clients through improved design, analysis, and insight, enabled by data and computational power.

We use geographic information systems (GIS) technology and tools like Leapfrog and PowerBI to visualise, manage, analyse and collate data based on any location. Our data management solutions make it simpler and quicker for you to manage your assets geographically, identify opportunities, reduce risk and adapt to better face the future. We have tools to utilise this data to provide site selection support decision tools, enabling you to assess based on your own criteria which sites to prioritize for future development.



GIS model indicating the areas at risk from flooding from a river

# Pumped hydro energy storage

Case studies: **Loch Kemp**

Loch Kemp is a pumped storage power plant with a potential capacity of up to 600 MW. It comprises a large lower reservoir (Loch Ness) and an extension of an existing natural upper reservoir, Loch Kemp, with the reservoirs connected by tunnels.

The powerhouse shaft and building will be constructed on the banks of Loch Ness. The complex project entails the construction of eight new dams, utilising a mixture of embankment and Roller Compacted Concrete (RCC), aimed at augmenting the capacity of the upper reservoir to meet the energy production requirements of the scheme.

Arup Services: Arup and ILF have established a design joint venture to undertake the reference design role for Statera, the scheme developer. Our responsibility encompasses developing a robust Front-End Engineering Design (FEED) and reference design that aligns with the requirements of planning and Environmental Impact Assessment (EIA) assessments, serving as the foundation for a competitive tender process.

This complex multi-disciplinary project located in an environmentally sensitive area of Scotland offers several unique engineering design challenges which draw on the experience and skills of the Arup ILF team.

The services Arup ILF are providing as part of the reference design process are summarised below:

- Dam and Reservoir Engineering (including panel engineer review)
- Geology and geotechnics
- Building design – structures and MEP
- Fire Design
- Site wide infrastructure (access roads and utilities)
- Maritime engineering
- Tunnel engineering
- Hydro design and OEM functional requirements
- Waterway lining design
- Substation and grid connection interface
- Production of employers' requirements
- Tender document preparation



# Pumped hydro energy storage

Case studies: **Glenmuckloch Energy Park, Scotland**

Glenmuckloch Energy Park involves the conversion of an old coal mine into a mixed-use energy generation plant consisting of 8 wind turbines and a 210 MW pumped storage plant.

Initially the focus of the services provided was on undertaking an Environmental Impact Assessment, specialist expertise throughout the scoping and environment statement phases and helping the client (then Bucleugh Estates) through the stakeholder consultation process leading up to submission of the application for and obtaining consent.

The project was then sold to Foresight Group and Arup were engaged as Owners Engineer (with ILF as a subconsultant). Arup and ILF are therefore responsible for the development of a reference design for all elements of the project, provision of procurement advice and then preparation of tender documents, tender support and evaluation and support during construction.

The services Arup and ILF are now providing as part of the reference design process are summarised below:

- Dam and Reservoir Engineering (including panel engineer review)
- Geology and geotechnics, including mineral stability assessments
- Building design – structures and MEP
- Fire Design
- Site wide infrastructure (access roads and utilities)
- Wind turbine foundation design
- Hydro design and OEM functional requirements
- Waterway lining design
- Substation and grid connection interface
- Production of employers' requirements
- Tender document preparation



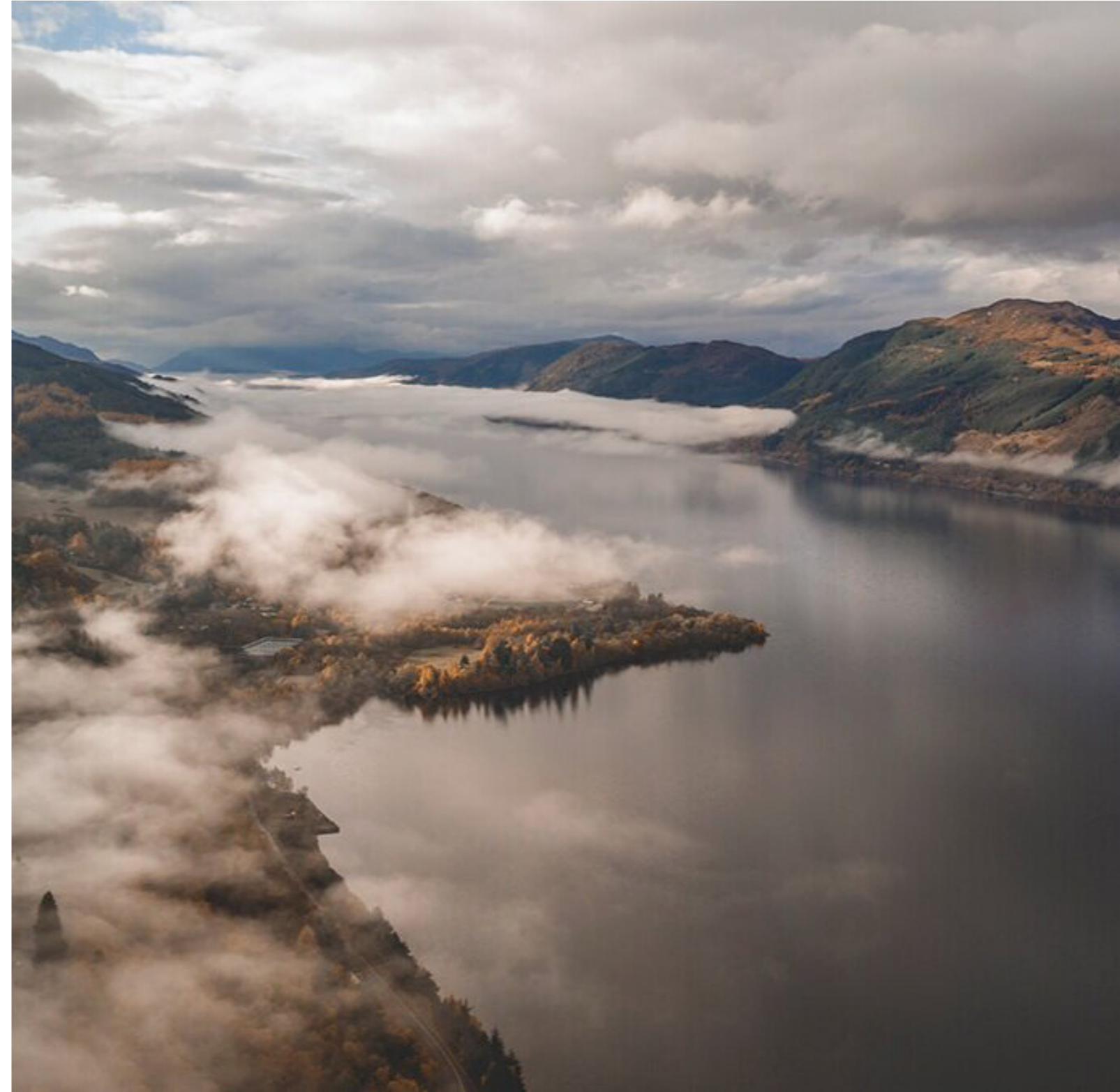


# Pumped hydro energy storage

Case studies: Coire Glas PHES, Scotland

Coire Glas is a pumped storage power plant with a potential capacity of up to 1,500 MW. It consists of a large lower reservoir (Loch Lochy) and the new upper reservoir (formed by constructing a 90m high dam) which are connected by an upstream and downstream tunnel and a penstock (3000 m, Ø 9.5 m). Furthermore, a large underground powerhouse cavern will be constructed, along with multiple access tunnels.

Scope of Work: Arup and ILF have been working together to assist Strabag through multiple phases of the project. Following successful prequalification, the JV have developed a Stage 1 tender including optimisation of the existing concept design, reviewing geometry of the hydro scheme and spoil management options. In addition, Arup is currently Engineers to Strabag on the exploratory works contract (1.2km long, 5m high and 4.5m wide tunnel, with a horseshoe profile and flat floor), with services including the design of the spoil storage areas to deal with materials arising from the tunnel and enable them to be safely stored on the sloping site and avoid offsite transportation.



# Pumped hydro energy storage

Project experience: **Design, EIA, due diligence**



## Cultana

*Confidential*

Arup has gleaned extensive knowledge from our experience in developing the Cultana PHES. The lessons learned and practical insights bring value to increasing the effectiveness of saltwater PHES grant schemes, and include:

- Water source: it is vital to consider water source due to evaporation, potable water expensive and not sustainable, natural replacement desired (Cultana used de-salinated seawater).
- Civil Works: the biggest expense of the project is civil works. Advantages from naturally occurring reservoirs or infrastructure that can be re-used such as existing dams.
- Ground Conditions: uncertainty on ground conditions led to high-risk pricing from EPC contractors, even though a reasonably comprehensive ground investigation was conducted.
- Ecology: particularly due to seawater use, led to ecological difficulties with marine life.
- Capacity: bigger capacity means more cost but needs to be balanced with the market power price forecasting. 6 to 8 hours found to be best for Cultana but this will vary depending on market factors.
- Elevation: suitable elevation and gradient required to operate the turbines economically.
- Stakeholder engagement: was good but onerous, with many groups to consider.
- Planning (state vs federal): due to placement on both state and federal land, Cultana had to undertake parallel EIS processes increasing cost.
- Electricity Connection: expensive network studies required to receive grid connection offer. This is unavoidable due to the existing requirements from AEMO and network operators. Early engagement with the network operator is critical to evaluate feasibility for a pumped storage scheme.
- Land access and ownership: secured land ownership, lease agreement and ongoing access for the life of the projects are essential prior to any significant investment being made by the developer



## Snowy 2.0

*Confidential*

Arup provided tender design services to a joint venture to achieve preferred bidder status for the Snowy 2.0 project. The project, comprising a 2,000MW generation capacity pumped hydro facility with over 17,000MWh of storage, links two existing hydroelectric reservoirs via 27km of waterway tunnel.

The extensive underground powerhouse complex represents a significant proportion of the capital cost, and Arup provided value engineering input to the design, construction and operational assumptions that realised significant time and cost benefits to the contractor, in addition to operational benefits associated with fire and life safety and ventilation requirements.



## Hydropower Due Diligence, Spain

*Repsol*

Arup provided a Vendor's due diligence review of a 700MW hydro power asset portfolio in Spain including storage and run of river plants and a 300MW pumped storage hydro facility, Scope included technical M&E, safety and dams engineering and a review of the outline design and investment plan for a further 1GW pumped storage hydro plant to be incorporated into the existing reservoir system resulting in a successful investment of ~\$900m.

# Pumped hydro energy storage

Project experience: **Hydropower design, feasibility, and due diligence**



## **Glendoe Hydropower 100MW, UK**

*Confidential*

The Glendoe facility includes 6km of 5m diameter circular machine excavated tunnel connecting the upstream reservoir to the 100MW hydropower plant.

A section of the headrace tunnel was thought to have collapsed over a 270m length, Arup provided expert advice following the collapse. This included several site inspections, geological and geotechnical interpretation, as well as sampling and testing. The team's extensive geotechnical and geological experience combined with a thorough investigation enabled them to provide the client with robust advice.



## **Viesgo Hydro Power Portfolio (Acquisition and Refinancing)**

*Macquarie and Wren House*

Arup advised Macquarie on their successful acquisition of E.ON's portfolio of energy asset in Spain which include 12 hydro plants with a total capacity of nearly 700MW. All the hydro plants are located in the north of the Iberian Peninsula within the Autonomous Communities of Asturias, Cantabria, Palencia and Leon. The portfolio includes a mix of run of river and pumped storage plants.

In 2013, the plants' net generation was around 1,262 GWh of electricity, operating into the merchant market in Spain. E.ON has around 4% of the market share of hydropower in Spain, with Iberdrola and Endesa holding approximately 75% of the total.



## **Dinorwig Pumped Storage Scheme, North Wales**

*Confidential*

The Dinorwig Pumped Storage Scheme includes 6 x 300MW 535 Reversible Francis turbines.

Our team's involvement in the scheme spans from the original detailed design through to ongoing present-day inputs. At various points in the project this has included simulation of transient flow scenarios, assessment and inspection of hydro mechanical equipment and design of construction methods for some of the underground works.



## **Green Highland Renewables**

*Ancala Partners*

Arup advised Ancala Partners on their successful investment in a portfolio of operational and development projects in Scotland, with a total installed capacity of 22 MWe.

The hydro portfolio is located around the Scottish Highlands. The portfolio comprises two operational schemes, seven schemes that are under construction, and eight schemes that are at various stages of development.

Arup provided a range of technical advisory services, including commentary on the design features of the new facilities, their likely ongoing O&M and lifecycle costs; O&M strategy and assessment of energy yield from each scheme.

# Pumped hydro energy storage

Project experience: **Hydropower design, feasibility, and due diligence**



## Hydropower Due Diligence, Italy, 2020-21

*ERG*

Arup delivered the Vendor's due diligence study for the successful sale of a ~500MW hydro turbine portfolio including storage, run of river and proposed pumped storage hydro power plants utilising the existing reservoirs combined with new storage capacity. The technical elements of the review included M&E, dams engineering and hydrology in addition to operation and maintenance, performance and reliability assessments.



## Hydropower Due Diligence, 2023-24

*Confidential*

Arup undertook a Vendor's due diligence study for a mixed renewable portfolio of wind and hydro assets. The scope included a detailed assessment of a 600MW+ pumped storage hydro power plant under construction and covered technical, contractual and commercial reviews.



## Hydropower Due Diligence, 2023-24

*Confidential*

Arup delivered a Vendor's due diligence study for a portfolio of over 150 hydro power plants and 7GW of operational pumped storage hydro power plants. Technical activities included review of asset performance, mechanical and electrical design, condition and investment planning, dams and reservoirs design, inspection and operation and maintenance strategies.



## Hydropower Due Diligence, West Africa (Various)

*Ancala Partners*

Technical due diligence of proposed hydropower dam designs for a mixture of earthfill and RCC dams in Gabon, Mali and Madagascar. Technical due diligence of existing hydropower dams in Ivory Coast including dam inspection.

# Pumped hydro energy storage

Project experience: E&S Monitoring for dams and hydropower



## Hydropower Modelling and Feasibility, UK

*Yorkshire Water Services*

A feasibility review of 26 hydro-electric sites up to 1MW covering a range of installation locations around the Yorkshire region including run-of-river, reservoir discharge and pipeline outfalls.

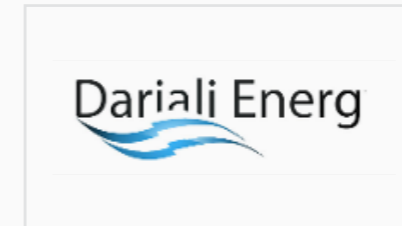
Three schemes have initially been selected for development. Arup provided expertise in the following areas: feasibility regarding the installation of hydropower plants; development of turbine selection and economic modelling spreadsheets; mechanical, electrical and civil design; consideration to the complete range of turbine types; economic analysis; G59 protection issues; liaising with the Distribution Network Operator.



## Confidential Pumped Storage Schemes, UK

*Confidential*

Arup provided technical consultancy services to a client wishing to develop a portfolio of pumped storage hydropower schemes in the UK. The scope included notional scheme design to support the client in discussions with the planning authorities and environmental consultants and provision of cost data to allow high level comparison of potential sites to prioritise investment.



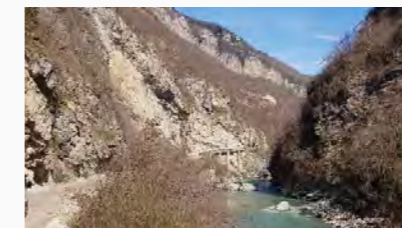
## Dariali Hydropower, 108MW, Georgia

*EBRD*

The Project comprises of a run of the river hydropower scheme on the river Tergi. The installed capacity will be 108 MW and expected electricity output 510 GWh.

Arup undertook a study outlining an appropriate environmental flow regime through a proposed Hydroelectric Power Plant (HPP) scheme in northern Georgia.

Arup provided advice relating to the specific components of the Project that relate to the EBRD's Performance Requirement 6 and the IFC's Performance Standard 6, Biodiversity Conservation, and provide recommendations for sustainable solutions and further monitoring, analysis, assessment and adaptive mitigation measures required.



## Namakhvani Hydropower Cascade, 480MW, Georgia

*EBRD & IFC*

The proposed Namakhvani hydropower cascade comprises two dams on the Rioni region of central Georgia with electricity supply to the Georgian grid. Arup is appointed as Lenders Environmental and Social Consultant to advise the lenders (IFC and EBRD) prior to loan signing (due diligence) and throughout construction and the initial years of operation.

Arup's role is to assess and assure the implementation of the Bank's environmental and social requirements associated with the loan agreement. Due diligence began in 2018. Key issues in this Category A Project include resettlement, water use rights, geohazards, dam safety and cumulative effects.

# Pumped hydro energy storage

Project experience: Environmental and social due diligence



**Paravani Hydropower Plant, 86MW, Georgia**

*EBRD*

EBRD appointed Arup to undertake Environmental and Social monitoring to assess the implementation of the Bank's environmental and social requirements associated with the loan agreement.

This Category A project includes new dam on the Paravani River, a diversion tunnel to carry water from the dam to an 86-megawatt hydropower plant near the Mtkvari River, and a 30km transmission line to carry power to a substation near Akhaltsikhe.

Construction involved environmentally sensitive activities. Recommendations for improvement was made because of the visit.

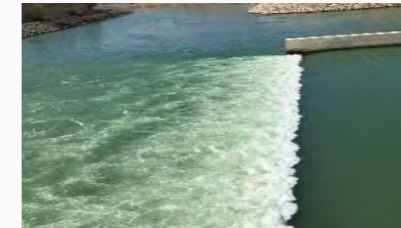


**Adjaristqali (Shuakhevi) hydropower project (180 MW), Georgia**

*EBRD*

Arup is Lenders' Environmental and Social Advisor (for IFC, EBRD and ADB) for the construction and operation of this run-of-river project. The Project comprises 2 dams and a weir with 2 powerhouses and extensive tunnelling.

Arup initially undertook the Environmental and Social Due Diligence, including gap analysis of the ESIA documentation in 2014. Based on the findings an integrated Compliance Matrix Table and an ESAP were prepared. Since 2015, Arup has undertaken quarterly monitoring of the Environmental and Social performance of the project through its construction and commissioning phases. The Project anticipates commercial operation in third quarter of 2017; Arup continues its role in conducting semi-annual monitoring into operation.



**Project Bal, Turkey**

*EBRD*

Arup were engaged by the European Bank for Reconstruction and Development (EBRD) to undertake a Corporate Environmental and Social Due Diligence of a Renewable Energy Company in Turkey which the EBRD is considering investing in.

The Company currently has an investment portfolio of 10 hydropower projects across the country and has ambitions to expand into wind power and other renewable investments.

Arup undertook a corporate-level ESDD of the company, and delivered an Environmental and Social Assessment, Environmental and Social Action Plan (ESAP), Non-Technical Summary and Stakeholder Engagement Plan for public disclosure, and an E&S due diligence procedure for the company to use for future investments.

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# Pumped hydro energy storage

Key staff

© Getty



**Matt Sykes**

*Director, Civil Structural, Bridges and Tunnelling Team Leader*

Matt Sykes, a key member of our Energy Water and Resources team, spearheads the development of Water and Hydro Projects within the UK. With a wealth of experience spanning projects in the UK, Hong Kong, Greece, South Africa, Spain, Jordan, Australia, Denmark, USA, and Abu Dhabi, Matt brings a global perspective to his role.

Renowned as a project leader, Matt specializes in complex projects, particularly in underground works. Heading Arup's Tunnelling team across the UK, he offers expert counsel to clients and contractors, ensuring the success of major underground projects. Additionally, as a hands-on project director, Matt drives projects forward, working closely with clients to align planning, reference and detailed design development while safeguarding project expectations.

With a deep understanding of Pumped Storage Hydro, Matt leads Arup's portfolio relationship development, advising on project risks, investment strategies, and bidding tactics. His expertise extends to delivering bids and providing design guidance for international pumped storage schemes, showcasing his proficiency in this domain.

Matt's adeptness in developing reference designs and navigating tender processes is exemplified by his recent leadership on the Mineral Transfer tunnel project for the Woodsmith Mine. His intimate knowledge of ground risk and mitigation strategies, has been honed through his work for the insurers on the Glendoe project tunnel collapse, further underscoring his ability to identify and minimise project risk effectively.

Moreover, Matt's appreciation of the complexities of design development within sensitive planning environments ensures successful project outcomes. His instrumental role in the rapid progression of critical projects, such as the Mineral Transport tunnel for the Woodsmith Mine which enabled the new mine to gain planning permission within a National Park, attests to his ability to innovate and deliver positive project outcomes within compressed timelines.

With a track record of success and a commitment to excellence, Matt Sykes continues to play a pivotal role in driving forward impactful infrastructure projects with Arup.

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### Colin McCreath

*Director | Energy Water & Resources North Group Leader*

Colin McCreath stands at the forefront of Arup's Energy, Water, and Resources (EWR) division, leading the charge for the "North" region, particularly focusing on hydropower projects across Scotland. With a rich background spanning over 28 years in ground engineering globally, Colin brings a wealth of experience to the table.

As Arup's Group Leader for EWR North, Colin has been instrumental in delivering diverse projects, ranging from pumped storage and wind farms to power stations, railways, bridges, highways, and tunnels. His extensive portfolio includes projects in various environments, demonstrating his adaptability and expertise.

Colin's leadership in pumped storage projects is evident through his management of key initiatives, including serving as the project director for the exploratory works at the Coire Glas Pumped Storage project and the Glenmuckloch project, where his team is transforming a 210MW scheme from concept to a reference design which can be implemented.

Moreover, Colin's understanding of the Scottish business environment and his ability to navigate the challenges of construction in sensitive areas make him an invaluable asset. His familiarity with stakeholders such as SEPA and other Scottish Government agencies ensures realistic timelines and streamlined project delivery.

Drawing on his background in Design and Build projects, Colin excels in developing attractive tender packages while mitigating risks for clients. His expertise in managing third-party relationships and his track record in creating competitive environments drive value and innovation throughout the tender process. The successful delivery of future pumped hydro schemes in the UK will require strong collaborative relationships between clients and contractors, something Colin is ideally placed to help facilitate.



### Ljiljana Spasic-Gril

*Associate Director*

Ljiljana is a dam & hydropower specialist with over 40 years' experience in dam engineering and dam safety; she is the Lead Dam Specialist at Arup, across all the regions, and has worked on over 400 dam projects spread in 57 countries in Europe, Asia, Africa, North and South America, Australia and New Zealand.

She is a Fellow of Institution of Civil Engineers (FICE), UK, the UK representative to the Seismic Technical Committee of International Committee for Large Dams (ICOLD), Member of British Dam Society and, since 2012, a Permanent Visiting Professor at South Bank University, London (Dam Engineering).

Ljiljana has worked on International Dam Safety Panels for 13 dam construction projects, including the Rogun Hydropower dam in Tajikistan, Central Asia. Once completed, the 335m high Rogun dam will be the tallest dam in the world. She is currently the Chair of the International Dam Safety Panels for over 10 dam projects, most of them under construction. She is also the Chair of the Panel for the Nurek hydropower dam - the Nurek dam is 300m tall and is the second tallest dam in the world.

She has been appointed the UNESCO's World Heritage Dam Expert.

Ljiljana published 23 papers related to dams, she has written a book: Dams Safety and Society, published in September 2022 by publisher Taylor and Francis Group. Ljiljana is also an author of a book chapter on dam engineering, published in the book: Engineering Geology and Geomorphology of Glaciated and Periglaciated Terrains, published 2017.

She has also been appointed as the World Bank advisor for "A Global Analysis of Regulatory Frameworks for the Safety of Dams and Downstream Communities" published by the World Bank, 2020.

She has worked as an Expert Witness on a dam in New Zealand that almost overtopped and breached and is currently working as an Expert on Root cause analysis of a dam failure in East Asia.



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**Debbie Harper**  
*Director*

Debbie is a Director and currently Arup's UK Energy Consents Lead. She leads Arup's Glasgow office and planning, consenting and economics work across Scotland, Northern Ireland, the North-East of England and beyond. Debbie has over 20 years' experience in the energy industry, having worked on major onshore, offshore and innovative energy projects.

She has provided planning advice across the UK on complex major infrastructure energy projects, overseeing and leading the work of multidisciplinary teams and advising on consenting strategy. Debbie was the Project Director for the EIA, consultation strategy and consenting of the proposed pump storage hydro scheme for 2020 Renewables in 2016. More recently, Debbie managed the Section 36c application and EIA for Buccleuch to vary conditions of the original consent. Glenmuckloch PSH was consented under the Electricity Act.



**Fraser Maxwell**  
*Associate Director*

Fraser is the Nature Team Leader for Arup across their Scotland, Northern Ireland and northern England offices, leading on all ecology, biodiversity and nature-related issues, based in Edinburgh. He's also a highly experienced Environmental Impact Assessment (EIA) practitioner, which recently included achieving consent for the Glenmuckloch Pumped Storage Hydro (PSH) scheme in Dumfries and Galloway. He has had previous involvement in the SSE Coire Glas scheme, and is currently the ecology lead on the Loch Kemp PSH scheme.

He has 24 years of consultancy experience, which includes a significant proportion of energy consenting work. This has included innovative energy projects such as the H100, a world-first green hydrogen-to-homes heating network in Fife, and the current H2NE hydrogen production scheme in Teesside. Fraser is currently the EIA lead for the revised wind farm application at Glenmuckloch. Most recently, Fraser has been managing the biodiversity elements for a Scottish offshore wind project.



**Stephanie Dye**  
*Associate Director*

Stephanie is a chartered mechanical engineer and project manager, with 17 years' experience of industrial mechanical systems and plants. Her work incorporates all phases of multidisciplinary design and construction projects involving MEICA assets for water, energy and infrastructure. As a qualified and experienced Hazard Study / Hazop leader, Stephanie provides a focus on the safety and operability of energy systems as a top priority.

As a designer, project manager and MEICA leader she brings her technical, commercial and coordination capabilities to a wide range of clients. Previous projects have included hydro power feasibility studies from micro hydro to medium scale plants, run of river and reservoir systems in the UK and overseas, tidal range energy assessments and optioneering. Additional roles have included providing specialist guidance on hydro power installations in heritage contexts and supporting developers in bid submissions for international hydro power plants.

Supporting worldwide energy transactions, Stephanie has delivered technical due diligence assessments of 15 pumped storage hydro power plants and over 100 conventional hydro generation systems, considering performance, availability, maintenance and asset condition. Her understanding of the long-term operation and maintenance associated with hydro power plants supports and informs investors and vendors and contributes to effective hydro power designs.



**Anthea Peters**  
*Associate Director*

Anthea Peters is a seasoned dam engineer with a specialization in hydrological and hydraulic performance, serving as the UK lead for dams and reservoirs. Renowned for her expertise, she holds the distinguished role of All Reservoir Panel Engineer under the Reservoirs Act (1975) and Reservoirs (Scotland) Act, 2011.

With extensive experience in reservoir safety, Anthea has led numerous safety schemes, encompassing new dam designs, spillway replacements, major remedial works, and structural stability investigations. She is adept at enhancing overflow and emergency drawoff provisions, ensuring optimal safety standards.

Anthea's technical acumen extends to leading specialist studies, including dam safety assessments, portfolio risk evaluations, drawdown studies, and predictive breach analyses. Her expertise has been instrumental in the successful execution of large-scale raised reservoir schemes such as Pickering, Mill Beck, Skipton, and Toddbrook.

Moreover, Anthea has served as the technical design manager for various flood alleviation schemes in both the UK and Ireland, including design and build initiatives. With a proven track record of delivering complex projects to the highest standards, Anthea Peters continues to be a respected leader in the field of dam engineering and reservoir safety management.

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**Steven McNeish**

*Associate*

As a Chartered Civil Engineer within Arup's Energy Water and Resources North team, Steven is dedicated to championing, supporting, and implementing the utilisation of information modelling and digital technology in infrastructure projects. His primary focus is on enhancing project efficiency, accuracy, and collaboration.

Steven is an experienced Design Manager, playing a key role in the ambitious Loch Kemp Pump Storage Hydro Scheme. His background in energy and water projects equips him with valuable design management skills. He collaborates closely with the Arup ILF team, leading the creation of a comprehensive Front-End Engineering Design (FEED). His meticulous approach aligns the project's design with safety standards, environmental considerations, and project goals. Loch Kemp Storage, with its 600MW capacity, is set to significantly impact the UK's energy landscape.

Collaborating closely with multidisciplinary teams, Steven leads the integration of Building Information Modelling (BIM) and advanced digital tools. His commitment to embracing technological advancements underscores his dedication to delivering infrastructure projects that exceed client expectations and adhere to industry best practices.

With a solid foundation in civil engineering and a passion for leveraging innovative solutions, Steven is instrumental in transforming infrastructure delivery. His efforts ensure projects are completed efficiently and excellently, contributing to the advancement of the infrastructure industry.



**Daniel Reader**

*Associate*

Daniel Reader is a widely recognised design leader, celebrated for his adept steering of multi-disciplinary teams through the intricate design and construction supervision phases of major hydropower and infrastructure projects. His extensive experience demands seamless coordination with clients, contractors, stakeholders, and fellow design teams, ensuring the smooth delivery of coordinated and efficient designs. Moreover, Daniel assumes responsibility for managing site supervision, further enhancing project efficiency.

Daniel's technical expertise is evidenced by his successful oversight of underground works for significant hydropower and infrastructure ventures worldwide. Whether navigating congested urban areas like London's High Speed 2 and the Elizabeth Line or tackling challenges in remote rural settings such as those in Georgia and Pakistan, Daniel skilfully manages diverse contractual settings and excavation techniques. His leadership blends office-based design prowess with on-site construction experience.

His proficiency extends from initial feasibility studies to detailed design phases. Notable projects include the Thame Water Ring Main Hampton Pump-Out Shaft in London, the Shuakhevi hydropower scheme in Georgia, and the Tarbela Fourth Extension hydropower project in Pakistan.

Daniel's adeptness in technical, risk, and commercial management further underscores his leadership. With a deep understanding of health, safety, and project risks, he chairs collaborative risk workshops and leads the preparation of supporting documentation to ensure effective risk communication throughout project development.



**Alasdair Mott**

*Associate, Energy Water & Resources*

Alasdair Mott is a highly skilled Civil Engineer with extensive experience spanning design consultancy and contracting roles. Specializing in leading the delivery of complex multi-disciplinary infrastructure projects, Alasdair draws upon his breadth of knowledge and collaborates closely with relevant specialists to ensure that client and project requirements are met with precision through an integrated design solution. He is adept at recognising where barriers to communication exist and works tirelessly to bring project teams together for successful delivery.

As Design Lead for the Glenmuckloch Pump Storage Hydro Scheme Alasdair has played a pivotal role in leading the multidisciplinary teams from both Arup and ILF in the delivery of the co-ordinated reference design and associated employer's requirements. With a focus on ensuring the viability of the scheme, Alasdair has used his considerable experience to guide the development of a fully integrated reference design, compatible with the emerging PSH requirements in the UK, which has investigated and better quantified risks, setting up the project for success. This will be utilised as part of the competitive tender process to obtain prices for detailed design and construction phases, enabling the project to progress through financial investment decision and into construction.

Known for his adeptness in managing the diverse and competing requirements of projects, Alasdair excels in delivering designs that are not only efficient and practical but also prioritizes safety throughout the construction process. While his background lies in civil engineering, Alasdair is naturally inquisitive and seeks to continuously expand his knowledge across the Energy Water and Resources (EWR) portfolio of projects, including Hydrogen, Power Systems and Onshore Wind, ensuring his expertise remains relevant and adaptable to fast evolving industry demands.

# Pumped hydro energy storage

Arup Management Systems

Arup operates a company-wide “Arup Management System” (AMS), which combines quality, health and safety and environmental management into a single, integrated system.

The AMS is routinely audited by independent auditors, and is certificated to ISO 9001:2015, ISO 45001:2018 and ISO 14001:2015 by Lloyds Register Quality Assurance (LRQA). We operate formal quality management systems, routinely reviewing and auditing our work. Project teams are structured to achieve clear lines of responsibility and communication with the client and other consultants.

By these measures, Arup adds value to their clients’ projects and achieve quality on which they can rely.

Arup International Projects Limited is a 100% subsidiary within the Arup Group of companies. Arup International Projects Limited will, in carrying out the projects for which it contracts, have at its disposal the appropriate resources, including being able to rely upon technical and professional experience within the Arup Group of companies.



# Pumped hydro energy storage

Our commitment to a sustainable future

Change is all around us.

Population growth and urbanisation, climate change and resource scarcity, the fourth industrial revolution and globalisation are all having an enormous impact on how we work and live. They also offer our firm clear opportunities. The Arup Strategy 2020 highlighted the global influences that make sustainable development an imperative. In October 2017 in Shenzhen, we made a commitment to contribute meaningfully to the UN Sustainable Development Goals (SDGs), creating shared value for our clients and our communities while safeguarding our planet.

With our expertise, diversity of thinking and independence we are well placed to become our client's partner of choice in the quest for a safe, sustainable, and resilient future – for all. Sustainable development is fundamentally about creating a balance between the needs of a growing world population and the finite resources and health of our planet – our life support system. The SDGs define what better looks like in 2030 and provide us with a lens through which we can challenge, frame, refine and expand the impact of our work. They facilitate shifting our focus from the outputs our clients demand to better outcomes for entire communities and the impact on our planet. This is how we will shape a better world.



**Top**  
Examples of how we address the SDGs through our projects.

**Bottom**  
The built environment plays a critical role in moderating the delicate balance that exists between satisfying the needs of a growing world population and the health of our planet.

**Contact:**

**Matt Sykes**

Director

t: +44 20 7755 3976

e: [matt.sykes@arup.com](mailto:matt.sykes@arup.com)

8 Fitzroy Street,  
London, W1T 4BJ

**Colin McCreath**

Director

t: +44 141 202 7604

e: [colin.mccreath@arup.com](mailto:colin.mccreath@arup.com)

1 West Regent Street,  
Glasgow, G2 1RW

[arup.com](http://arup.com)