MOTT MACDONALD

Renewed hope for energy

Contents

Helping to spark change

Renewable energy capacity across the world is growing exponentially. According to IRENA, a further 167GW of renewable power was installed worldwide in 2017, up from 164GW in 2016 and 157GW in 2015 – the third consecutive year that more renewable than conventional energy capacity was added.

We have extensive experience in renewable power at Mott MacDonald. Globally, over the past 10 years we have provided engineering services for 30GW of hydropower, 80GW of wind, 17GW of solar PV, 6GW of concentrated solar power (CSP), and 12GW of geothermal capacity.

Our energy expertise goes back a long way. From Sir Murdoch MacDonald's work on the Aswan Dam in Egypt, our engineers have been working for more than 100 years to help deliver power to people and communities. We have worked on many landmark power projects across the world, covering a range of technologies, often with technical challenges requiring novel solutions as 'firsts' in the industry. It is a proud heritage and one we strive constantly to continue.

We maintain our sector-leading expertise in hydropower, providing technical, contract and financial advice on projects around the globe, including the award-winning US$1.2bn, 450MW Chaglla hydropower project in Peru, which includes construction of one of the largest concrete-faced rockfill dams in the world.

Our teams are also helping to marry pump storage hydro and solar as hybrid systems become more important to utilise the advantages of different generation technologies. The Kidston combined solar and pumped storage facility in Australia repurposes two 300m deep disused gold mine pits to create 500MW capacity. Our solar activities include bringing CSP and storage to South Africa and developing the 257.7MW Sakuto solar array in Japan. Onshore wind projects include the Penonomé wind farm in Panama, the largest in Central America, and Lake Turkana in Kenya, the largest in Africa. We worked on Princess Amalia, the world's first offshore wind farm to be project financed. We are also at the forefront of spreading offshore wind, working on Block Island, the first wind farm in US waters and one of the first outside of Europe.

We are a connected business, meaning we are joined up across sectors and geographies. This gives clients access to exceptional breadth and depth of expertise. Often input from specialists in supporting infrastructure is as important as energy expertise and financial acumen in delivering a successful project. The 50MW Salkhit or Windy Mountain wind farm in Mongolia is more than 75km from the capital, Ulaanbaatar. The hot summers and very cold winters made construction difficult and required technical expertise and experience from multiple disciplines in the business.

Meanwhile, our extensive capability in transmission and distribution, including in high voltage direct current (HVDC) and undersea cabling, ensures the power from renewables is moved from where it is generated to where it is needed, and that operators everywhere can meet the challenge of balancing a grid reliant on renewables and meeting peak demand.

Over the last 10 years we have helped deliver:

80GW
wind

30GW
hydropower

23GW
solar

Our focus on collaboration across disciplines enables us to take a holistic view of a project and identify risks, opportunities and synergies, ensuring learning and solutions delivered elsewhere can be applied to reduce costs and drive better outcomes. And, as a global company, it's a way of working that combines our best local and international expertise. We are also a digital business, employing the latest technologies, such as business information modelling (BIM), to reduce delivery costs and add value for clients. BIM is also a key part of our asset management capability, helping clients to future-proof their assets and gain efficiencies.

All our thinking considers the impact of sustainability, which drives the development of renewable generation. Our environment and social specialists ensure renewable projects meet international standards, limiting the effects on their surroundings.

Over the following pages, you can read how we are helping clients around the world to bring about the renewables revolution.

Phil Napier-Moore, global practice leader, renewable generation

A brave, new world

National clean energy goals to meet climate targets and reduce air pollution are increasingly common across the world, and a growing number of countries are abandoning fossil fuels for generating electricity.

Lower subsidy and continuing expansion are signs of maturity of renewables technology and increased investor confidence.

Two events in 2017 from the UK illustrate this shift. In April, transmission company National Grid reported that the country had its first coal-free power generation weekday since 1882, when the world's first coal-fired power plant started generating electricity in London. Two months later, on 7 June, it announced that renewable sources of energy generated more electricity than coal and gas combined for the first time.

It is a similar picture worldwide. The International Energy Agency (IEA) reports that in 2016, global coal production fell significantly, while several countries, including Germany, Canada, France and the UK, have pledged to phase-out coal-fired generation – the latter two by 2023 and 2025 respectively. Meanwhile, China plans to invest 2.5trn yuan into renewable power generation between 2017 and 2020 as it continues to shift away from coal power. Globally, the IEA predicts that renewable energy capacity will increase 43% by 2022, to more than 920GW. Hydropower will remain the largest source of renewable energy in 2022, followed by wind, although much of the forecast growth will be driven by solar photovoltaics (PV), which is benefiting from continuous technology cost reductions. Other renewables technologies such as marine, geothermal, bioenergy and concentrated solar power are emerging, albeit more slowly than hydro, wind and solar PV.

The policy framework supporting the different renewables technologies is shifting. The feed-in tariffs that many countries adopted to accelerate investment in renewables by paying a premium above the retail and commercial electricity price are increasingly being replaced. To cap expenditure and drive down industry costs, financial incentives are now more likely to be funnelled through competitive auctions, with generators bidding to supply electricity to the grid over a fixed period for a fixed price. Auctions are helping to make electricity generated by renewable sources cheaper. According to the IEA, solar power was contracted at a global average price of US$50/MWh in 2016, compared with almost US$250/MWh in 2010. It is a similar picture for wind energy. The winning bid for phases one and two of the Borssele offshore wind farm off the coast of the Netherlands averaged €0.727/kWh. This fell to €0.545/kWh for phases three and four.

Lower subsidy and continuing expansion are signs of maturity of renewables technology and increased investor confidence.

43%

increase in global renewables capacity, 2017-2022

920GW

global renewables capacity in 2022

Independent advocate

The successful delivery of a renewable energy project is a process – from analysing the market and assessing feasibility to finalising the detailed design and effectively managing procurement and construction, and decommissioning at the end of life. Our energy teams consist of technical engineers, as well as environment and social scientists, economic and financial specialists and project and programme managers, and our services cover a project throughout its lifecycle. We also provide support for different clients, including acting as owner's engineer, supporting public authorities and advising investors and lenders.

As owner's engineer we act in the interests of power plant owners, operating as their independent advocate through the project delivery and onwards to operation. We have teams of engineers experienced in front-end and detailed engineering design, preparation of tender documentation and undertaking bids reviews, and providing site supervision.

We provided multidisciplinary services for Fishermen's Energy to assist it in developing a 25MW pilot project for offshore wind off the coast of New Jersey. Our work helped to structure the project and reduce costs. In South Africa, we were owner's engineer during construction on behalf of the Cape Town-based owner and developer, Umoya Energy, on the 66MW Hopefield wind farm, the first to become operational under the Department of Energy's Renewable Energy Independent Power Producer Procurement (REIPPP) programme.

Combining renewables with emerging technologies to create hybrid arrangements to meet grid requirements is beginning to emerge. We were owner's engineer for four solar PV projects in a national park in South Africa. Our work included the site assessment, optimum solution investigation and technical inputs to the procurement phase as well as supervising construction and commissioning.

Energy advisor

Our energy advisory services include analysis of markets, policy and regulation, system studies, investment appraisals, capacity building, transaction advice and support for innovative technologies and methods. We employ a range of modelling tools, such as PLEXOS, the electrical power market simulation software.

In Jordan, we are assessing energy storage options for the country on behalf of the European Bank for Reconstruction and Development (EBRD). Our overall aim is to help the EBRD to put together a detailed energy storage roadmap for the country, with a particular focus on enabling regulation.

Another example is our ongoing work helping a Japanese solar business investigate investment opportunities in eight countries across Europe, the Middle East and Africa. The assessment of policy, market and regulatory landscapes is supported by technical and geographical information systems (GIS) studies to identify and evaluate preferred areas for deploying solar PV.

We were also advisor on the €2.8bn Gemini wind farm off the coast of the Netherlands, which in 2014 was the largest power deal to ever reach financial close. We delivered due diligence and helped to achieve a successful financial close; and, during construction, advised on progress and mitigating risks associated with health and safety, design, manufacturing and environment. The shift away from direct subsidies for renewables has implications for operators and we have supported the onshore wind industry in the UK by developing a financial model to help it understand the impact of moving to auctions under the Contracts for Difference (CfD) regime.

In the Caribbean, we devised a regulatory framework to help the region meet its ambitious renewable and energy efficiency targets, while the government of South Africa appointed us as lead consultant for the design and delivery of a procurement process to introduce renewable energy projects across the country (p14). The success of the South African programme has made it an exemplar model for renewables in countries worldwide.

Sustainability goals

Environment and social outcomes

Energy projects have the capacity to do harm to the environment and local communities if not managed properly. All projects must be assessed for their environment and social impacts, at development, construction and operational phases. Assessment includes risks to the ecology, biodiversity and people as well as the likelihood of causing pollution.

Environmental and social impact assessment (ESIA) is a process for systematically identifying and assessing likely impacts of a project on the natural and human environments. Determining significant effects and ensuring these are minimised in the design is crucial to safeguarding people and other living organisms as well as habitats, and ensuring projects are sustainable, comply with regulatory conditions and can attract international investment.

The bankability of projects is dependent on completing an effective ESIA process, and our environment and social specialists work with their technical colleagues to help clients identify optimal solutions that maximise low-carbon innovation with minimum impact on natural and human environments.

For the 1.8GW Benban solar complex in Egypt, we are undertaking due diligence and construction monitoring activities in accordance with guidelines from the International Finance Corporation and EBRD. Our work covers 29 solar PV projects to ensure the environment, communities and workers are safeguarded from risks.

We also assisted developers with an ESIA, followed by environmental management to international standards, during the construction of the Shuakevi hydropower project in Georgia, a 400MW hydropower cascade on the Adjaristsqali River. This service complemented our technical role as owner's engineer on the scheme.

In the marine environment, our services cover monitoring and management of coastal and offshore infrastructure, as well as coastal management practices for nearshore and offshore power generation and transmission; for example, our geotechnical and coastal engineers are advising on all aspects of the construction stage of the landfall cable for the East Anglia array in the UK North Sea, 48km off the coast, bringing power to shore.

Powering the future

Innovation in energy

Innovation lies at the heart of the renewable energy revolution, making the different sources cheaper and more efficient. Technology is changing all the time. The wind sector illustrates this. Turbines are getting bigger, particularly offshore, as well as more aerodynamic. Over the past 20 years, rotors have increased from about 46m in diameter to 122m, while towers are often 90m above sea level. The larger the diameter, the greater the area that can be swept, and taller towers catch the faster-blowing winds at higher altitudes.

More powerful and efficient turbines are helping to bring down the price and this is expected to continue. In 2017, Bloomberg New Energy forecast that the levelised cost of offshore wind – the unit cost of electricity over the lifetime of a generating asset – will decline 71% by 2040, while the cost of onshore wind will fall over the same period by 47% – on top of the 30% drop of the past eight years.

Innovation is key to reducing the cost of renewables and ensuring grid resiliency as the conventional centralised system of generation disappears. We have worked on innovative projects to incorporate energy storage to maximise energy yield, provide energy security, limit variably of output to the grid and provide ancillary services to the network operator.

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This includes supporting the UK government's Energy Entrepreneurs Fund, which provides capital grants to support the development and demonstration of innovative technologies and/or processes in the areas of energy efficiency, power generation and energy storage. We are acting as incubation advisors for the scheme, helping companies increase the chance of successfully bringing their innovation to market.

Example projects under the fund include: a tidal turbine platform to speed up installation, optimise energy yield from turbines and reduce maintenance burden; a solar PV-T panel to provide increased electrical production and meet thermal demands from a single panel; and vertical axis wind turbines – suitable for installation in thin corridors of land such as railway tracks.

Our engineering expertise is supporting the development of innovation technologies. We applied the skills and knowledge gained from working for more than 100 years in hydropower to the Swansea Bay tidal lagoon project, playing a key role in the development of a variable speed turbine solution that will pump and generate in two directions to harness maximum electrical energy from the tidal cycles. When complete, the proposed 320MW plant will provide, on average, 14 hours of reliable renewable electricity generation every day, powering more than 155,000 homes.

South Africa

Procuring renewable energy projects

6GW
of renewable energy

100+
projects

Renewable energy plants are regarded as a way of boosting energy security in South Africa, a country prone to power cuts. In 2010, the government appointed us as lead consultant for the design and delivery of a process to introduce renewable energy projects across the country.

Working for the National Treasury and Department of Energy, our role included managing government stakeholders and acting as legal, financial and technical advisors on the Renewable Energy Independent Power Producers Procurement (REIPPP) programme. We provided technical and commercial advice for documentation, including the request for proposal and power purchase agreement between the utility and network operator, and evaluating all submitted bids for technical compliance.

Designing the process was the most challenging aspect. The support mechanism had to be value for money, which pushed us away from a simple tariff system. However, we were aware of flaws in the design of auction systems in other countries, with bids sometimes so low that contract winners later realised that they could not deliver the project.

We opted for a blended approach consisting of an auction system, which incorporated minimum requirements for the bidders to provide confidence the proposed projects were viable. The programme also had to comply with national employment and training policy, and the government's ambition to manufacture some of the renewable energy generating equipment domestically. Collaboration was key to completing the project on time. We worked with the government rather than for them. We exchanged ideas and talked about what would work in South Africa.

With the auction programme ongoing, we have been able to tweak each round to incorporate lessons learned from previous rounds.

Five auction rounds have been completed under the REIPPP programme since it was introduced in 2011, with more than 6GW of renewable energy capacity procured from more than 100 projects. By February 2018, 3.7GW across 61 projects was in operation. Wind and solar PV have proved the most popular with developers, but concentrated solar power (CSP), landfill gas, biomass and small hydro projects have also been contracted.

The South African model is now seen as an exemplary programme for renewables worldwide and has been used as a starting point by other developing countries.

James Dodds, project manager and renewable energy engineer

Japan

Large-scale PV on a retired salt field

Setouchi Kirei is the largest alternating current solar PV project in Japan. The US$1.1bn project is located on a retired salt field near the city of Setouchi in southern Okayama Prefecture.

900,000
PV modules

235MW
capacity

We acted as owner's engineer during the development phase of the project for developer Setouchi Kirei Future Creations. The role involved assessing plant performance and drafting plant test procedures, supporting contract negotiations and advising on procurement.

One of the challenges was the lack of adequate forecasts for irradiance at the site. We introduced a new way of improving the accuracy of estimates and got the backing from investors for our approach. This involved using data from the local weather station to correct satellite information to estimate long-term irradiance. The lack of weather stations and the high spatial variability in irradiance throughout the Japanese archipelago means our approach can be replicated across the country to accurately represent irradiance differences.

There is a nature conservation area within the Setouchi Kirei site, so environmental concerns were to the fore when designing and scheduling construction work. This included scheduling construction around the visits of the rare Eastern Marsh Harrier, which comes there to breed between February and August.

The team used international standards in drafting the contracts for the engineering, procurement and construction, as well as for contractors' handling operations and maintenance. These were different from those typically used in Japan, since utility-scale solar PV plants were not common in the country at the time. Persuading the client and contractors to accept international standards involved discussions and negotiations on PV module testing procedures, contracts and procurement. We had to demonstrate an in-depth understanding of the subject matter and knowledge of the Japanese context.

Our multidisciplinary team is currently managing the construction schedule and supervising building quality at the PV plant as well as for the 16km transmission line and a reinforced seawall embankment on the coastal side of the site, which is designed to prevent flooding. The plant will comprise more than 900,000 PV modules and is expected to begin operations in 2018.

Tatsu Kikuchi, project manager and renewable energy engineer

Latin America

Milestone onshore wind projects

Over the past decade, we have been involved in about 50 onshore wind projects across Latin America. Our work has been mostly as advisor for investors, which involves a holistic review of project documents from a technical, environmental and commercial perspective. We have also acted as owner's engineer to support the development of wind farms in the region.

550MW
onshore wind plans in Argentina

442MW
Reynosa wind farm in Mexico

270MW
Penonomé plant, Panama's first wind farm

Currently, the largest markets are Argentina, Brazil, Chile and Mexico. Restructuring of the energy market in Mexico is an incentive for energy companies to invest, and the government has plans for significant wind and solar generation. Meanwhile, Argentina recently launched a tender for 550MW of onshore wind as part of its programme to lift the proportion of electricity generated by renewable sources to 20% by 2025.

Our work across Latin America is predominantly as lenders' engineer, which involves assessing a scheme against technical, environmental and safety criteria, and producing a report for investors to inform their decision-making. We work as owner's engineer on around 20% of projects.

We have a specialised team to serve the Latin American wind market based in Houston, US, as well as offices in Colombia and Brazil. Having a dedicated presence enables our team to better understand the needs of clients and stakeholders, and to provide advice about electrical grid and environmental aspects of power projects first-hand. It has also strengthened our relationship with commercial and development banks and export credit agencies in the region and globally. Since 2010, we have worked on projects in the region worth about US$10bn. These include the 50MW Orosi wind farm in Costa Rica, which in 2013 won Project Finance magazine's award for best Latin America wind deal. We worked as lenders' engineer for the 270MW Penonomé plant, Panama's first wind farm. We also have a strong presence in Uruguay, working as technical advisor on the financing of 10 projects.

Two projects in the Latin American portfolio stand out as particular milestones. Cerro de Hula in Honduras was one of the first large wind projects in Latin America. The wind farm helps tackle energy shortages and supports the national government's plans to promote the use of renewable energy technology. We acted as lenders' engineer for the US$290M, 102MW plant, carrying out a comprehensive review of the project, including designs, energy yield, contracts, construction and operational methodology, environmental and social assessment, as well as technical inputs to the financial model.

The 442MW Parque Eólico Reynosa wind farm is another important project we are working on. The US$600M project consists of 123 wind turbine generators and is Mexico's largest wind farm to date and one of the biggest in Latin America. It will provide energy to approximately 900,000 people and avoid the emission of 739,000t of carbon each year. The wind farm will also help Mexico reach its overall target of generating half its electricity from clean energy sources by 2050.

Carlos Riano, project manager and renewable energy engineer

UK

Tidal turbines with multiple added benefits

1.5M
homes with power

A tidal energy project in north west England could transform the region's energy profile, improve transport links and flood defences, and boost job creation. The project's proponent, Northern Tidal Power Gateways, has appointed us to advise on the scheme, which it is proposing to build in Morecambe Bay and the Duddon Estuary.

It involves the construction of tidal gateways. These will incorporate tidal turbines with a dual carriageway on top, linking the M6 in the south to Millom in the north. The Morecombe Bay gateway has the potential to produce 7000GWh of electricity a year, enough to power around 1.8M homes, while the scheme across the Duddon Estuary could generate about 700GWh, the equivalent of powering around 180,000 homes. Meanwhile, the dual carriageway could cut journey times across the industrial hub of Barrow-in-Furness from two hours to 25 minutes. Estimates indicate that the £10bn project will generate more than 7000 building jobs, and more than £300M gross value added (GVA) a year to the region's economy during construction.

Combined benefits from increased employment, improved connectivity, economic growth, flood control and protection, and an enhanced environment, have been estimated at more than £1bn a year.

The project is in scoping stage, and we have undertaken multiple studies across a myriad of disciplines to assess potential energy generation, road users, revenue, and environmental constraints and benefits.

6500GWh
of electricity

The sheer scale of the Northern Tidal Power Gateway is demanding. Based on current capacity, it would take the entire world's hydro turbine manufacturing resources to produce the 132 machines required. There are also technical challenges in terms of connecting a large number of intermittent machines to the grid.

The location is environmentally sensitive, with the bay and estuary jointly designated as a Special Protection Area (SPA). When you look at long-standing tidal projects, such as in San Malo in France, the big concern has always been the mudflats that are exposed at each turn of the tidal cycle. Past projects have always changed the range of the inter-tidal zone, which is a crucial to maintaining these unique ecosystems. However, a recent technological breakthrough enables turbines to replicate the natural tidal cycle of the area. Variable speed turbines can generate energy and pump in two directions, maintaining the amplitude of the inter-tidal zone. This brings further potential benefit in reducing flood risk and mitigating sea level rise.

The aim is for construction to begin in 2024, with Duddon Estuary producing power by 2027, and full completion in 2031.

Shaun Benzon, project manager and hydropower engineer

Cyprus

A strategy for a new electricity market

16%

renewable energy target for Cyprus

The Electricity Authority of Cyprus (EAC) has appointed us to advise on optimising its resource utilisation for generation development and expansion. The utility is currently the sole provider of electricity in Cyprus, but the government is opening up the market to new participants to comply with EU rules.

Our energy advisory team is supporting the EAC with decisions about existing and new energy plants by exploring various scenarios using the modelling tool PLEXOS. The business strategies being developed need to take account of several complexities. First, Cyprus plans to move away from its reliance on imported heavy fuel oil and invest in infrastructure that will allow the introduction of natural gas. The island must also achieve its EU target for 16% of its energy to be from renewable sources by 2020.

To remain competitive when the energy market opens, the EAC must become even more cost effective. PLEXOS was used to develop a set of strategies for the company based on the availability of natural gas and timing of electricity market reform.

Our energy model is sufficiently flexible to deal with the uncertainties around fuel availability, market conditions and varying levels of renewable generation. Cyprus has significant solar resource, but we had to consider the impact of intermittency, how much reserve capacity was needed to ensure smooth system operation and whether installing battery storage was necessary. PLEXOS was also used to optimise maintenance scheduling, and estimate fuel consumption and carbon emissions. We created many future scenarios, modelled and analysed them, and compared the results. This enabled us to develop investment strategies for the EAC. Our combined expertise in engineering and modelling enabled us to demonstrate what was technically and economically feasible.

Daniel Cook, project manager and energy economist

South Africa

Innovation in concentrated solar power

A typical dilemma faced by solar power developers is that demand tends to peak at sunset when the sun's energy is fading. But advances in technology have enabled concentrated solar power (CSP) projects in South Africa to add energy storage, extending power availability hours into the night.

Our first scheme was the 100MW KaXu plant in Northern Cape Province, which uses parabolic trough CSP technology. This involves the installation of parabolic-shaped mirrors to focus the sun's energy and heat fluid in tubes. The fluid passes through heat exchangers where it generates steam, which turns a turbine to generate power. To store the energy, the fluid heats a reservoir of molten salt to 385°C. The salt gradually releases the energy to keep power production going after sunset.

Investor support for innovative technology such as CSP was not immediately forthcoming, however. Unlike solar PV, there was little experience of CSP globally and in South Africa, where the technology is bespoke to the developer. Lenders were initially apprehensive, and with no precedent it was hard to conduct due diligence. Investors had different concerns and key performance indicators, so it was a long process.

As the lenders' technical advisor, we were directly involved in contract negotiations on a daily basis. We accompanied the lenders to Spain to see how the developer's pilot plant worked and provided examples of where equipment used in these projects is already in operation in thermal plants to demonstrate that the technology works.

100MW

KaXu Solar One

The KaXu Solar One project began operation in 2015 and is the first large-scale CSP plant with storage developed by the private sector in an emerging market. The project has stimulated local economic growth and created jobs in the Northern Cape, an impoverished province with one of the highest youth unemployment rates in the world.

KaXu Solar One has also brought social benefits. The local community has a minority shareholding in the project, so it directly supports long-term education and economic development initiatives in the area. The project has also contributed to the creation of a local supply chain, generating both skilled and unskilled jobs.

Project developer Abengoa set up a socio-economic and enterprise development programme to promote micro-, small- and medium-sized enterprise development in four communities near the site. The programme provides access to education, infrastructure and funding, business training and promotion of local businesses.

100MW

Xina Solar One

Confidence in the technology has soared through this project, paving the way for development of another parabolic CSP plant. The more-advanced 100MW Xina Solar One plant uses molten salt to provide a five-hour thermal energy storage system. The plant features the largest parabolic trough collector used in a commercial CSP project to date. It has also been developed by Abengoa, which was awarded the US$880M contract in the third round of renewable energy auctions (REIPPP programme) organised by South Africa's Department of Energy. It was the first CSP project to benefit from the country's 'time of day' payment structure, which incentivises generation during peak demand hours.

50MW

Khi Solar One

We also worked on the 50MW Khi Solar One plant, which has been operational since the beginning of 2016, and are currently involved in all seven CSP projects awarded under South Africa's renewables programme.

Shilpee Sinha, project manager and renewable energy engineer

The Netherlands

Reaching financial close on a 600MW offshore wind farm

600MW
capacity

1.25Mt
carbon savings a year

The €2.8bn Gemini project was the largest offshore wind scheme to reach financial close when backing was secured in 2014. It was also one of the largest such projects in the world to be project financed. Comprising 150 Siemens turbines, each with 4MW capacity, it was completed in 2017. The project features two offshore high voltage substations and a pair of 220kV high voltage cables, which transport the energy more than 85km to the coast at Eemshaven.

As lenders' engineer, our role was to advise banks on the technical risks of the project, and what sort of mitigation could be put in place in terms of health and safety, design, manufacturing and the environment. Financiers' main concern was that long-term production would be lower than forecast or, in a worse-case scenario, the project would not go ahead. So we also had to confirm that the developer was suitably managing risk.

Sixteen banks and financial institutions were involved. Organisation, communication and a consistent approach to managing information were key to keeping track of the large number of queries and responses flowing between us and the investors. The developer, Canadian energy company Northland Power, understood the value of being open and providing the information sought by the lenders.

After financial close, our role moved to monitoring construction, providing monthly progress reports to the financial backers. The project team developed objectives, processes and strategies to deliver Gemini over the two-year construction period. We scrutinised these closely as part of our pre-financial close review, and were part of ongoing discussions during the construction phase. For example, the last 15km of the twin 85km export cables could only be installed when the tide was out due to a high tidal range, which prevented the use of boats and barges. Instead, a vehicle ploughed a channel in the sea bed, while laying the cable from a reel mounted on its roof. Assessing these strategies, and monitoring their progress, was key to the lenders remaining confident throughout the construction period that the project would be completed on schedule.

Environmental concerns, such as protecting sea mammals from the noise of driving monopile foundations into the seabed, was another challenge. Spotters on boats ensured the area was clear of whales and dolphins before work started. After the 'all clear' was sounded, a technique known as 'soft starting', where pile driving begins gently and then increases to the required force, was employed.

The wind farm was completed ahead of schedule and under budget in April 2017. It provides energy to approximately 785,000 households and is helping the Netherlands meet its target of 14% renewable energy generation by 2020. It will also cut carbon emissions by 1.25Mt each year.

Will Lamond, project manager and renewable energy engineer

Tanzania

Capacity building of safeguards for geothermal energy

Tanzania's location in Africa's Rift Valley gives it rich potential for geothermal energy. Successful development of plants exploiting this renewable resource in neighbouring Kenya has spurred Tanzania to explore its own opportunities. Development of geothermal plants has the potential to alleviate the frequent blackouts suffered in the country, while also aiding sustainable development and reducing poverty.

The government has established the Tanzania Geothermal Development Company (TGDC) to spearhead new geothermal projects. TGDC already has technical approval to undertake exploratory drilling in Ngozi, in the south west of the country, and initial studies have shown the site has the potential to produce 200MW of energy.

To investigate the full potential of geothermal energy, TGDC requires financial support from institutions such as the World Bank and African Development Bank. Each bank has its own environmental and social guidelines that must be followed to obtain funding.

The World Bank appointed us to assess and build capacity within TGDC to enable it to meet the environmental and social impact assessment (ESIA) standards demanded by international lenders. We also trained staff from state-owned electricity supplier TANESCO, the Ministry of Energy and Minerals and the National Environment Management Council, which are responsible for granting certificates for the environmental process. The aim was for us to help develop the in-house skills needed to undertake ESIAs for Ngozi and for other potential projects over the coming years.

We assessed TGDC's ability to undertake an ESIA to international standards and then prepared a bespoke training programme to plug the gaps. This covered all environmental and social aspects of a geothermal project, from air quality and biodiversity to indigenous people and cultural heritage. We explained how all these issues should be reflected in project design, and how Tanzania's impact assessment processes differed from the international ESIA approach.

For example, when it came to stakeholder engagement, TGDC had organised public meetings to discuss geothermal technology in Ngozi but had not addressed its potential impacts, something that is required by international standards. We gave a presentation on stakeholder engagement addressing objectives, strategies and activities as well as what materials are required to stage a consultation event.

Our team briefed trainees on how to respond to questions and possible audience behaviour. Trainees prepared responses to questions likely to be raised, and they took part in a role-play exercise, acting as representatives of the local government, a small business owner, farmers and environmental campaigners. A lot of information had to be communicated to take trainees from limited knowledge of international ESIAs to being able to produce one for a geothermal energy project, which involves complex technology and multifaceted environmental and social issues.

Excellent feedback was received from participants, particularly on how topics were taught and the interactive nature of the training. Our work contributed significantly to TGDC's capability to assess, address and manage environmental and social risks and impacts, and helped to identify appropriate, project-specific mitigation and opportunities for enhancing environmental and social benefits in line with international good practice.

The increased capacity will go beyond benefiting the Ngozi project and contribute to the sustainable development of similar future projects in TGDC's pipeline.

Shalini Arora, project manager and environmental specialist

Pakistan

Hydropower high in the Himalayas

Located in the Kaghan Valley, high in the Himalayan mountains, the Suki Kinari hydroprower plant faces challenges in terms of extreme cold and complex geology. It will be powered by the Kunhar River, which traverses the length of Pakistan.

870MW
installed capacity

3050GWh
annual energy generation

The plant has a run-of-river design and enough active reservoir volume to generate four hours of peak power. This lowers the capital cost and minimises environmental impacts. There will be a height difference of more than 900m between the head of the dam and the powerhouse, enabling the plant to produce 870MW.

We have been involved in the project since 2008, conducting an initial feasibility study. We are now working as owner's engineer for developer SK Hydro Consortium, a role that involves reviewing the design, construction supervision and project management. The project achieved financial close in 2016. The engineering, procurement and construction contract is for six years and was awarded to the China Gezhouba Group Corporation (CGGC).

The project is now in the detailed design and construction phase. Both of these processes are being carried out in tandem, allowing design changes to be made when necessary. For example, the dam was originally designed with an asphalt face to make it watertight. This was amended so that the asphalt was inside the core of the dam, significantly improving its ability to deal with extreme temperatures at the location, which can go as low as -20°C. The location of the underground powerhouse was moved closer to the river. This now requires only a 700m access tunnel rather than the 4km tunnel in the original design.

The complex geology of the area is the biggest challenge. It is a seismic area with active faults, and seismic specialists have advised on expected movement in the faults over the next 100 years, with the structures being designed accordingly.

Scheduling of construction has to take account of very low winter temperatures. Snow and poor road conditions halt construction of the dam during winter months, but work on the powerhouse can continue because it is underground.

The plant is urgently needed as Pakistan suffers frequent power cuts. Suki Kinari will provide peak power, so it can be mobilised when needed to help stabilise the grid. It is scheduled to start generating power at the end of 2022.

Eric Guilleminot, project manager and hydropower technical director

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power@mottmac.com

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