Offshore wind

Local knowledge, global expertise
Developers of offshore wind projects need to build a dedicated team of collaborative and creative consultants who can identify all potential opportunities to increase the performance of their asset.

Acceptable consents and grid connections are the first step in the process. Looking forward, reducing the levelised cost of energy from its current level will be central to achieving economically viable projects. It will be achieved by challenging and innovating at all stages of project design and procurement. In the delivery phase projects must produce power on programme, with no cost overruns. During operation on-going maintenance must be minimised.

Arup’s technical, financial, business planning and project management support helps clients realise viable offshore wind schemes.

Arup works on projects from feasibility through to a sale of an operating wind farm. At each stage of a project we listen and respond to our client’s requirements, proactively reducing project risks and costs. We use our experience gained since 2001 in the offshore wind industry to provide a coordinated, team-working approach to deliver projects.

Future wind farms will need to innovate to reduce costs, whilst managing the overall risk of bringing an improved or new concept into the industry. We have a proven track record of developing viable innovative ideas with our clients from the ‘lightbulb’ moment to an installed product. This includes our award-winning steel-jacket substation platform concept and our work developing concrete gravity foundations as a viable solution for UK Round 3 offshore wind farms.

We are flexible in our approach to projects and can provide a team that is tailored to each project’s needs, at any stage of the development cycle.
UK Offshore wind farm zones

Working with our clients to reduce costs of UK offshore wind.

Indicative only: Refer to © Crown Estate for the status and layout of all windfarms
Offshore wind capability

Programme Management

We work with our clients to turn their vision and strategy into operational reality. We identify logical delineation of project boundaries and outputs, define inter-project dependencies, and outline clear understanding of programme expectations against responsibilities.

From planning to execution to the close of the programme, we drive and manage all project stakeholders to remain aligned with the project strategy. We revisit the project vision and strategy throughout the programme to ensure it produces the best project outcome. Arup is experienced in both multi-projects and standalone projects for local and international clients.

Marine Operations

To achieve the lowest overall cost potential installation methods must be an integral part of the project development. Our work with traditional offshore steel structures, concrete gravity structures and our innovative self-installing platforms has enabled us to have a unique and thorough understanding of the drivers on projects during transportation and installation phases. Our naval architects develop installation programmes to minimise weather downtime and develop efficient tow and installation methodologies backed up by scaled modelling in wave tanks. We have worked in partnership with marine contractors and installers to develop different methods of working that can reduce costs and risks.

Marine Geoengineering

We have developed a local, highly skilled and experienced team of engineering supervisors who not only ensure the clients technical requirements are achieved, but who are also commercially aware and act as the vital expert link between the client and the contractor. As a result, overall site productivity and the quality of the information obtained is maximised and unproductive ‘down time’ is minimised by working closely with contractors in a non-adversarial and collaborative manner. We offer a full range of geotechnical, geophysical and geoenvironmental design and interpretative reporting services which aim to provide maximum value to the client, to inform and guide the design development process. The key to our success in this field is our relationship management with clients, stakeholders, licensing authorities and specialist contractors. We have a strong team of people who are qualified to work offshore with the investigation team to represent our clients and provide sound practical advice and decisions in the field.

Risk Management

Safety is of paramount concern in all our work, prominent in our management of all types of risk. Arup project managers are fully experienced in project risk management integrated with project management and engineering capabilities. We encourage stakeholder participation in the risk management process and consequently improve the reliability and admissibility of its output. By engaging stakeholders, consultants and contractors at an early stage and throughout the project lifecycle, we are able to achieve optimum safety and value without jeopardising performance targets. We provide fully traceable, auditable and transparent risk reporting, risk registers and risk response planning depending on project size, complexity and duration. Skilled risk management workshops, facilitated by our qualified and experienced project managers, ensure comprehensive lists of risks and the best responses are identified with defined actions.
Management Systems
Organisations performing at their best are swift to respond to opportunities and challenges. To make the right decisions, they require sharp insight into trends. To be ready, they must see their resources and risks clearly. At Arup, we help businesses improve performance by giving them the complete picture. To do so we combine strategic commercial thinking with precise, hands-on experience of processes, assets and people. We connect and decipher the information businesses need to thrive. For a client exploring opportunities in the energy sector, for instance, we deliver practical advice by integrating world-class transactions advice and corporate finance consultancy and energy strategy. Behind our strategic advice is the technical depth of Arup specialists who have delivered major projects for the offshore energy industry.

Collaboration
Collaboration can save money and time for everyone on the project. Offshore wind projects have been largely carried out using a multi-lot contracting approach. This places a significant interface and schedule management burden on the developer who inevitably attracts higher costs when marine works cannot follow the intended sequence. The wind industry has acknowledged that a more collaborative approach would reap cost and schedule benefits. Arup is well-versed in assembling teams with complementary skills or contributing in collaborative working arrangements such as alliancing or forming a joint venture across a wide range of infrastructure projects.

Transmission & Distribution
At Arup we recognise the complexities and variations surrounding the engineering of offshore wind projects including offshore structures and subsea power cabling. We offer clients a range of technical services to deliver robust and cost effective solutions. Being at the forefront of high-end offshore technical consultancy services we provide expertise and analysis on all aspects including array optimisation and design, cable selection and installation, offshore AC and DC platform design, grid-code compliance studies, and technical due-diligence. We are engaged at all stages of the project lifecycle of offshore projects from design, installation, commissioning, operation and maintenance, and decommissioning.

Transaction Advice
Arup provides an unrivalled, integrated advisory service to our clients in the offshore wind sector, using the combination of our established technical and operational expertise with our financial, economic and commercial skills. Our insight into the technical and operating issues within the sector enable our teams to provide focused advice, using a combination of industry-leading skills. We advise investors, regulators, governments and major corporations. Our offering includes; Strategy development; Energy modelling; Market reviews; Economic impact; Commercial due diligence; Policy and regulatory analysis; Financial advisory services; Financial modelling; Business case development; Commercial structuring; Fundraising; Bid evaluation and support; Technical & operational advice; Equity technical and operational; Vendor due diligence; Lenders technical advisor; Environmental due diligence; Health & safety due diligence; Post-deal support.
The offshore wind industry has developed from small beginnings at the start of the 21st century to a larger but still rapidly evolving sector. Methods of financing, procurement and engineering are continually updated as each project learns from the lessons of earlier wind farms. As with all major infrastructure projects a developer needs a team with a wide range of skills and knowledge to deliver their project on time and to budget. Each company working with the developer needs to understand the overall project and the drivers of all stakeholders, to ensure that they act in the best interest of the project.

One of Arup’s strengths is our openness to communicate with each other and our project teams between physical and technological regions. We can draw on the knowledge of our renowned experts through our established global skills network. We have an extensive range of skills that enable us to understand most facets of wind farm development. We can provide large work packages covering many disciplines or can also provide focussed, specialised advice to help our client decrease the levelised cost of energy.
Wind Farms
OFTO Infrastructure
Grid

Management Systems

Procurement

Contracts

Programme Management

Steel Foundation

Transmission & Distribution

Self-installing Platforms

Self-buoyant Foundations

Marine Operations

Asset Management

Retrofit

Expert Opinion

Ports & Harbours

Due Diligence

Asset Transfer

Operation & Maintenance

Construction

Installation

Delivery

Governance

Funding

Business Case

Financial Solution

Commercial Structure

OFTO

Due Diligence
A selection of Arup’s Wind Projects

Greenwire HV AC and HVDC Cable Project, Ireland
Our environmental, planning and technical expertise enables us to deliver this complex infrastructure project involving multiple jurisdictions. Arup manages planning, environmental and engineering disciplines as well as offshore partners to input to a single deliverable or team, in order to present to the consenting authority. We are managing the following services for the planning and consenting of the cable network: Project management; Route design and selection (Corridor studies, Detailed routing and Landowner liaison); Onshore environmental impact statements; Planning consents and permits; and Civil/Structural engineering.

Met Mast foundation, Hong Kong
Arup designed innovative suction caissons to mitigate the specific site risks. We obtained government consent for the development, and then produced the detailed design of the foundation. The foundation was installed in 30m of water over soft marine clays and dense alluvial sands, presenting a technical challenge for the foundations which was overcome through the use of suction caissons supporting a tripod substructure. Arup specified centrifuge modelling and field trials of the suction caissons to verify their performance under both static and cyclic load conditions to demonstrate their suitability for use.

Round 1 Offshore Wind Farms, Remedial Works Design, UK
Arup examined various remedial works to ensure the long-term integrity of the foundations and guarantee the long term return on investment from the wind farm. We undertook a concept screening exercise to identify remedial works solutions that met the client’s requirements. We then examined a range of remedial works concepts for ease of fabrication and installation before detailing the preferred arrangement. Working in partnership with the client we ranked design concepts against a range of criteria. This included the ease of handling the components, health and safety, and anticipated future maintenance. To confirm adequate strength and fatigue performance, we analysed the designs in detail.

Greenwire HVAC and HVDC Cable Project, Ireland
Our environmental, planning and technical expertise enables us to deliver this complex infrastructure project involving multiple jurisdictions. Arup manages planning, environmental and engineering disciplines as well as offshore partners to input to a single deliverable or team, in order to present to the consenting authority. We are managing the following services for the planning and consenting of the cable network: Project management; Route design and selection (Corridor studies, Detailed routing and Landowner liaison); Onshore environmental impact statements; Planning consents and permits; and Civil/Structural engineering. We are also part of the public and stakeholder consultation.
Port of Leith Masterplan and Technical Feasibility Study, Edinburgh, UK

The Port of Leith is an impounded multi-functional port with industrial, cruise and residential developments located within the main port basin. In an effort to reinvigorate the port for the 21st century our client expressed an interest to attract new wind manufacturing businesses and larger cruise ships. Arup was initially engaged to provide technical engineering services to investigate the feasibility of providing marine access solutions for larger vessels to Leith. Subsequent services now being provided include the development of designs for new berths, strengthening of existing structures, and civil engineering services to enable the port to attract new businesses whilst retaining existing customers.

Floating Concrete Foundation Research & Development Programme, UK

We launched an in-house research and development programme into floating foundations for wind turbines. A conical floating foundation to support a wind turbine emerged from an evaluation of spar-type structures. The foundation was targeted at intermediate water depths of 60-100m that would be likely to feature in future UK licensing rounds. The foundation showed good motion characteristics and was configured for quayside mass-production to give an efficient cost-effective turbine support solution. The design was entered in the Carbon Trust’s Offshore Wind Accelerator competition and for the Energy Technology Institute’s floating wind demonstrator programme. Both the Carbon Trust and ETI considered the solution to have merit and that further development and scale model testing is the next step towards commercial application.

AC Substation Jacket

Our client needed a team to be quickly mobilised to address a concern that a jacket design from an EPCI contractor was not as efficient as expected. We were able, in a very short period of time, to review the incumbent design and compare it against our independent model of the jacket and piled foundations. Our review included key fatigue details and pile designs with cyclic loading, with state of the art design procedures from our academic partners. We were also able to review the design basis against our in-depth knowledge of other sites in the North Sea. Arup identified key areas of potential savings, enabling our client to have constructive talks with their EPCI contractor.

OFTO Offshore Transmission Due Diligence, Irish Sea

Key risks were identified including the availability, reliability, installation and on-going monitoring of submarine cables. In order to translate our technical findings into financial consequences we had to develop a full understanding of the OFTO licences and financial incentive mechanisms. Another key issue which was identified was that the wind farm and transmission assets were originally designed as one and splitting the transmission element out created a number of new technical and contractual interfaces on the offshore platforms. This required careful definition of asset split and responsibility, together with clarity where the OFTO provided secondary services to the windfarm and vice-versa.
Offshore Wind Foundations
Strengthening, Life Extension and Asset Management

Arup has a proven track record in realising minimum intervention monopile grouted connection strengthening solutions and the use of constant monitoring to accurately predict and extend the life of foundations.

Our engineers have gained extensive experience through the assessment, monitoring, analysis and strengthening of wind turbine foundations on eight offshore wind farms. We offer the following services individually or in combination.

Assessment and strengthening of monopile to transition piece grouted connections

- Development of minimum intervention schemes for axial and torsional strengthening of grouted connections
- Detailed non-linear finite element analysis to optimise strengthening design to minimise offshore work
- Liaison with certification authority to gain acceptance of strengthening designs

Fatigue and fracture assessment

- Conventional S-N based fatigue assessment
- Non-destructive testing expertise to determine existence and size of existing flaws
- Fracture mechanics assessments to determine future life of pre-damaged details, inspection intervals and repair strategies

Life extension

- Constant monitoring of foundation loads (strain gauges) to predict actual fatigue damage
- Development of method for coupling monitored loads, monitored wind data and original design loads to predict future life without over-conservatism. Demonstrated to more than double predicted life for certain foundations

Materials advice

- Fatigue assessment of concrete and grouted connections
- Material selection to enable robust realisation of novel strengthening solutions
- Review and development of onshore and offshore welding methods
- Corrosion protection advice including coating selection and internal and external cathodic protection design

Review of non-standard/novel strengthening methods and cable configurations

- Material and geometrically non-linear finite element simulation of complex cable configurations of strength and durability
- Dynamic non-linear finite element analysis to predict driving stresses in flanged monopiles
- Detailed non-linear finite element analysis to predict performance of non-conventional grouted connections e.g. tapered conical

Computational fluid dynamics assessments

- Detailed simulation of flow around foundations to optimise scour protection
- Simulation of highly non-linear wave loading effects including wave slam and ringing

Technical project management

- Acting as owners engineer to manage foundation assessment and/or strengthening design works
- Develop industry best practice using in-house expertise, research and management of bespoke test programmes

Expert advice

- Provide independent advice to investors
- Provide technical input into court cases and/or arbitrations
- Act as expert witnesses
Selected Projects

**Round 1 Offshore Wind Farm, UK**
Completing a detailed design of foundation strengthening, we increased both axial and torsional capacity of grouted connections and designed a vibration suppression system for J-tubes for more than 50 monopiles. Work included detailed non-linear finite element analysis and fatigue and fracture mechanics assessment of components to develop a minimum intervention design. All modifications were designed to be implementable offshore and successfully installed in 2012.

In addition to strengthening works Arup was responsible for developing a fatigue assessment methodology for the existing structure which combined monitored data, strains on a sample of the foundations, and wind information across the wind farm with design information to determine more realistic/less conservative fatigue life predictions, which in this case led to more than a twofold life extension.

**Round 2 Offshore Wind Farm, UK**
Working as owner’s engineers we developed a strategy for dealing with the transition piece to monopile interface slip, including a detailed engineering assessment of the consequences of the slip. We also developed an extensive campaign of offshore inspection to baseline the condition of more than 100 offshore wind turbine foundations.

We provided expert witness in an arbitration case on behalf of our client, on the subjects of vibration and fatigue in offshore

**nkt Cable Reburial, Germany**
Through use of in-depth non-linear finite element modelling, validation against trial lifts and controlled factory tests our engineers were able to quantify the risks associated with excavating and re-burying an in-situ wind farm export cable.

Taking into account the sea-bed environment, the influences of factors including lay-tension alignment, lift height, cable length, burial depth, lift rate, backfill properties and cable to soil friction were all considered.

We quantified cable tension, lift contact forces and cable bend radius for a number of scenarios, demonstrating the risk factor to cable integrity for the client.

**Nordsee 1 Pile Driving Assessment, Germany**
Our structural experts assessed the dynamic performance and fatigue strength of flange connections between large diameter monopiles and transition pieces for offshore wind turbine generator foundations. We took into consideration the stress, fatigue and permanent deformation factors associated with driving flanged monopiles, and used a combination of explicit non-linear finite element analysis and implicit linear finite element analysis to assess structural integrity.

**GOAL, UK**
Leading this joint industry project in terms of technical management we have the objective of justifying guidelines for the design of grouted connections for jackets supporting offshore wind turbines.

To ensure the thoroughness of this investigation we are managing a variety of project tasks: ensuring coordination of input from industry experts and stakeholders; developing a specified test program; design of realistic test specimens; review of testing data; and interpretation of results. These tasks will allow us to verify suitable design guidance for our client.
Arup is the creative force at the heart of many of the world’s most prominent projects in the built environment and across industry.

We are an independent firm of designers, planners, engineers, consultants and technical specialists offering a broad range of professional services. Through our work, we make a positive difference in the world.

We are a global collective with a strong UK presence. Our 15 UK based offices comprise of approximately 4,000 people. From 100 offices in 38 countries our 11,000 consultants, designers, engineers and planners deliver innovative projects across the world with creativity and passion.

Founded in 1946 with an enduring set of values, our unique trust ownership fosters a distinctive culture and an intellectual independence that encourages collaborative working. This is reflected in everything we do, allowing us to develop meaningful ideas, help shape agendas and deliver results that frequently surpass the expectations of our clients.

The people at Arup are driven to find a better way and to deliver better solutions for our clients.

We shape a better world.

Arup office locations worldwide
People

Henrietta Ridgeon
Structural Design
Henrietta is an effective manager and designer on a variety of offshore wind infrastructure projects, including offshore gravity foundations and steel jacket substructures for offshore wind. Her skills lie in her ability to programme projects, to manage budgets and to advise clients on their risk management strategy, thereby saving costs and increasing project certainty.

Gordon Jackson
Offshore Structures
Gordon has specialised in the design, construction and installation of offshore structures, from concept to delivery stages of projects. The emphasis of his work has been the application of value engineering to problems and development of innovative construction and installation methods, with the aim of reducing capital expenditure or schedule. Gordon is the inventor of Arup’s self-installing ACE platform range.

Clare Lavelle
Offshore Development
Clare has extensive experience in the energy industry in the UK and Scotland at all phases of a project lifecycle, with a proven track record for successfully delivering ambitious projects. She supplies a variety of technical, environmental and policy services in generation and transmission and distribution projects. Her focus in recent years has been in offshore wind, wave and tidal renewables, including management of consents of 2.5GW worth of offshore wind projects in Scottish waters.

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Kamal Siriwardhana
Transmission & Distribution
Kamal is a chartered electrical engineer with an extensive track record of providing innovative design solutions and implementing them in UK and global power and transmission & distribution projects. He has been involved in the UK Round 1 and Round 2 OFTO licensing process by undertaking technical due diligence of offshore windfarm assets. His work includes High Voltage Direct Current (HVDC) transmission both for interconnectors and offshore wind.

Colin McCreath
Geo-engineering
Colin delivers to time and budget, for a variety of marine infrastructure geo-engineering services. Colin has managed projects in the offshore renewables sector for government organisations and numerous ports on the UK coast. His extensive knowledge in the area of offshore geo-engineering enables him to minimise project risks from the sea bed with efficient and effective site investigations.

Ben Francis
Transaction Advice
Ben has built up an experienced team providing transaction advice, business planning and due diligence advice to investors, developers and the public sector in the development of renewable energy projects. His experience covers a broad range of renewable energy sectors and projects with transaction values of over £1bn. He appraises project financial options and works with clients to reduce the levelised cost of energy on their projects.

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Borbala Trifunovics
Marine Engineering

Borbala manages multi-disciplinary design teams and gives specialist maritime engineering advice to clients throughout the UK, Europe, Asia and Oceania. Her areas of expertise include: ports, harbours and marinas; wave processes; navigation and channel design; scour and ship impact; mooring and fendering; coastal protection design (revetments and seawalls) and dredging and reclamation schemes.

Rob Davies
Risk Management

Rob leads our project risk management team. He draws on his considerable experience of applying risk management techniques in numerous industry sectors to help enable our clients to successfully manage their project risks including cost, revenue, programme and reputation. His key strengths are tailoring risk classification schemes to suit our clients’ predisposition to risk, chairmanship of risk workshops, and applying the ‘management systems’ approach to risk management.

Andrew Gromadzki
Cost Management

Andrew is a quantity surveyor and chartered construction manager with over thirty years of experience. His background leans heavily towards industrial projects, and has provided strategic contract and cost advice, contract administration, cost consultancy and general commercial advice on global projects working with a broad range of cultures.

Rob Duffin
Naval Architecture

Rob has over 20 years of experience working on offshore infrastructure projects, both for contractors and consultants. Prior to joining Arup Rob led the Marine Technology Group at Crondall Energy Consultants, focusing on deep water floating solutions. He also worked on business development for a subsea cable installation contractor.

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James Tunney
Project Finance

James specialises in commercial and financial advice to public and private sector clients. He advises on the full spectrum of the infrastructure financing cycle, ranging from concept initiation and business case preparation to financial modelling, fund raising and risk mitigation. James has significant experience advising private sector sponsors and understands how to structure a commercially deliverable project, guiding several bidders to a successful financial close.

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Project Management

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Daniel Powell
Advanced Technology

Daniel is experienced in completing and managing a broad range of complex engineering projects. His areas of particular expertise are: design and analysis of offshore structures; structural dynamics; vibration mitigation and damper design; wind sensitive structures and heat transfer. He is our lead jacket specialist and has designed flexible masts and towers subject to wind excitation.

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