ARUP

SHAPING A BETTER WORLD

Offshore wind substation platforms

Delivering infrastructure innovation

arup.com/energy

Delivering offshore infrastructure innovation

The offshore wind industry has been developing larger and larger wind farms, which tend to be further away from shore. As the capacity of turbines and wind farms have increased, coupled with increasing offshore distances and depth of water, the electrical infrastructure has had to adapt to accommodate the export requirements.

Wind power developers are seeking affordable offshore farms that can be consented in a straightforward manner and delivered by experienced teams who understand the risks of working in an offshore environment. Arup has been responding to these challenges since 2001, successfully transferring valuable skills and experience gained from oil & gas developments to deliver industry-leading offshore wind projects.

Our global team applies offshore structural expertise coupled with knowledge of electrical transmission and distribution systems in the evaluation of the offshore transmission assets that are included in the OFTO transitional regime. Arup was been involved in all of the UK transitional regime OFTO assets and German offshore wind farms. Through this we have gained a unique insight into offshore substation/converter station platform design, delivery and operation.

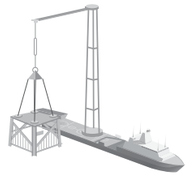
This expertise allows us to advise on offshore wind projects across the globe, taking previous experience and knowledge and applying it to new projects to deliver valuable outcomes. We are committed to helping our clients achieve financially viable offshore wind farms, by driving down cost and risk through innovative and appropriate design.

DELIVERING SUCCESSFUL OFFSHORE PROGRAMMES

Delivering offshore innovation

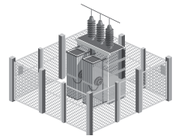
Arup provides a range of comprehensive services that support the entire life cycle of an offshore wind programme. An integrated approach means a seamless service to deliver project objectives and outcomes.

Our approach enables us to help maximise the return from investments, and we can provide better informed advice.



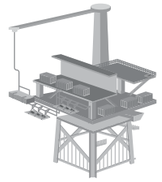
STRUCTURES

Arup works in multidisciplinary teams including clients, constructors and installers to develop topsides and substructure solutions for a substation development. The solutions are always technically assured and innovative whilst adding value by aiming to reduce installed cost with minimal risk.



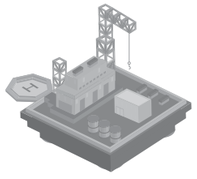
TRANSMISSION AND DISTRIBUTION

We have worked with developers and transmission operators on a range of offshore AC and DC platforms from project concept to delivery. We have developed a reference design for HVDC converter platforms that enables cost saving and minimises risk. A thorough understanding of the platform process coupled with our multidisciplinary approach enables us to produce designs that provide an optimum configuration for equipment, are safe to operate and are efficient in their use of space.



NAVAL ARCHITECTURE

The installation phase of any offshore project carries many risks due to adverse weather and the number of interfaces managed between different contractors. Our specialists use their understanding of the behaviour of offshore structures and maritime equipment, helping reduce risks of installation. Analytical predictions are benchmarked against performance in a wave test facility to ensure that responses and effects can be fully evaluated.



MARINE GEO-ENGINEERING

Our engineers act as a link between the client and the contractor to reduce costs and improve reliability. By working closely with contractors in a collaborative manner, we facilitate overall site investigation productivity and ensure quality. We offer a full range of geotechnical and geo-environmental design and interpretative reporting services to inform and guide the design development process for our clients.

TRANSACTION ADVICE

We provide an integrated advisory service using the combination of established technical and operational expertise together with our financial, economic and commercial skills. Our insight into technical and operating issues within the sector enables our team to provide focused advice, using a combination of industry-leading skills. We advise investors, regulators, governments and major corporations on strategy development, financial modelling, vendor due diligence, lenders technical advisor and post-deal support.

LIFE EXTENSION

Arup has leading experts on corrosion protection and control, durability of materials and all aspects of the integrity of materials in the offshore wind industry. We have been involved in solving many issues regarding steel corrosion, grouting, concrete mix design and steel asset management. Our team specialise in fatigue, corrosion and dynamic analysis and provide expert advice on creating an efficient robust design including retrofit designs with a view to extending life span and guaranteeing income generation.

DELIVERING SUCCESSFUL OFFSHORE PROGRAMMES

New markets, new solutions

Finding the right option

Arup has a history of successful and established technical expertise in offshore wind foundations. These include monopiles, grouted connections, piled jackets, mega scale monopiles, self-installing gravity foundations, suction buckets and foundation remediation and integrity. Our collective knowledge allows us to not only help developers effectively evaluate projects and deal opportunities, as well as helping our clients design and develop bankable energy technology assets.

MEGA SCALE MONOPILES

From the beginnings of the offshore wind industry, shallow water and smaller turbines, to today's deeper water and >10MW turbines, Arup has been a leading engineering consultant advising on key frontier applications of the monopile foundation. We have developed key integrity strategies to ensure the foundation to turbine tower connection will meet the needs of these larger, more dynamic installations.

SELF-INSTALLING PLATFORMS

Created and designed by Arup, the industry recognised ACE platform is capable of lifting and lowering up to 13,000te offshore, making it a viable option for a substation. The structure is made up of four main components, a barge deck, gravity steel base, jacket and jacking system. ACE platforms can be fabricated at local yards almost anywhere in the world, without the need for extensive equipment or specialist expertise. This makes the construction phase shorter and reduces delivery risk. Our self-installing platforms reduce life-cycle costs through ease of installation and removal.

> We have created efficient offshore wind foundation screening tools that enable us to identify the most promising foundation solutions for specific offshore wind farm locations, globally, with the most basic of information.

> We identified weight savings of up to 20% when auditing the design of an offshore jacket carried out by others, in turn reducing cost and construction time.

Offshore substation platforms

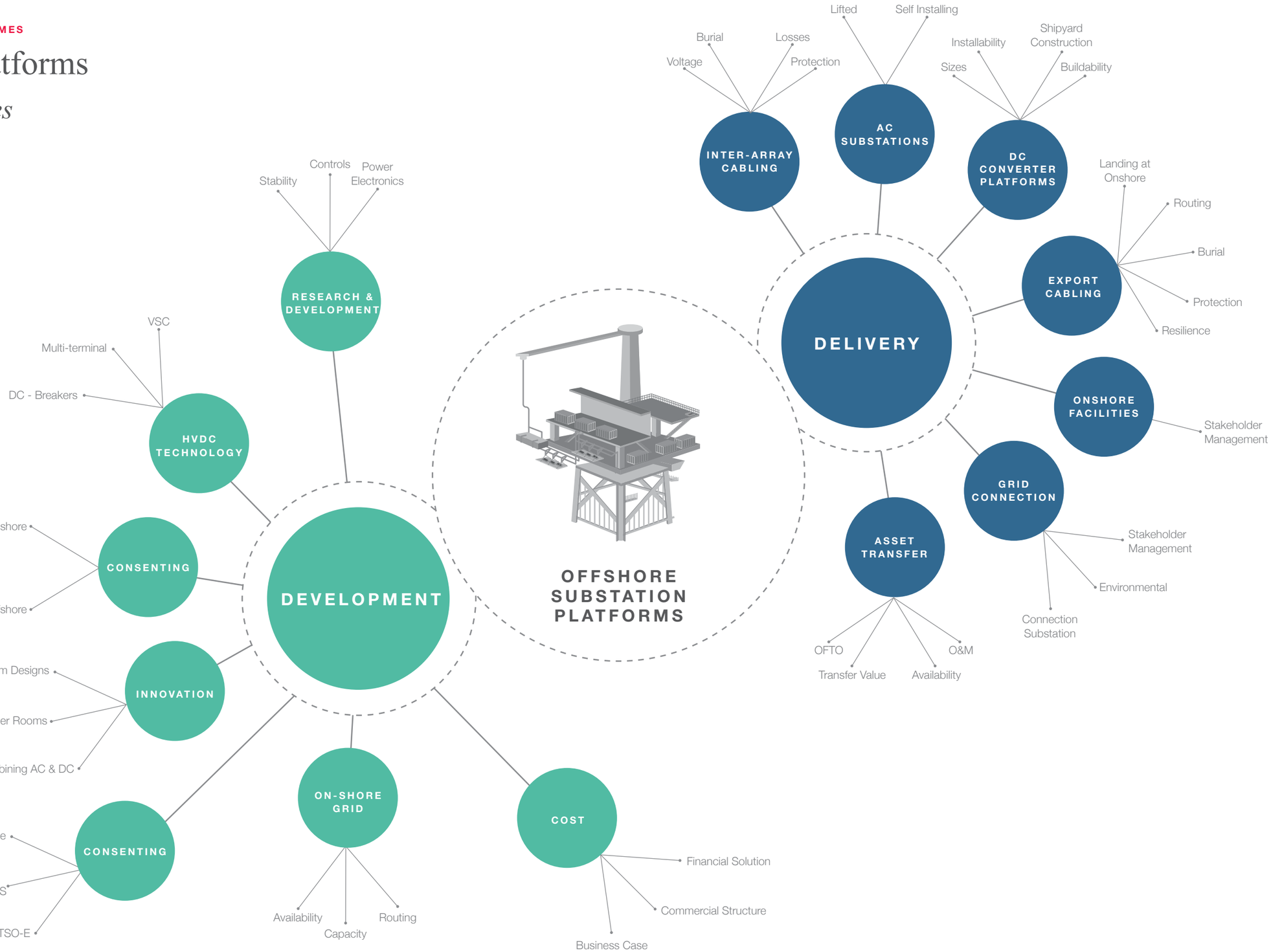
Potential development issues

The offshore wind industry has been developing rapidly. As the capacity of turbines and the wind farms have increased, coupled with increasing offshore distances and depth of water, the electrical infrastructure has had to adapt to accommodate the export requirements.

TRANSPORTATION AND INSTALLATION CONSTRAINTS

HVDC platforms have reached a size where a simple offshore crane lift is no longer an option. Instead options such as a floating or self-installing build arrangement needs to be considered.

These new options and requirements make it timely to undertake a fundamental review of the design basis for large offshore windfarms to see if there is a more appropriate direction to take.



Expertise in offshore wind: Delivering value for our clients

HVDC OPTIMIZATION

Location: UK

Client: The Carbon Trust

Our comprehensive review addressed the development of converter topologies, and optimized configurations and layouts to accommodate new HVDC voltage source converters. We integrated schematic layouts onto a smaller platform structure resulting in a reduction of overall capital expenditure by more than 10%.

TOPSIDE DESIGN

Location: Race Bank,UK

Client: Alstom Grid

Arup developed a substation topside tender design, including a weight report and cost estimates. This empowered our client to challenge their appointed designer's assumptions and ensure that the costs of their current substation were economic and the project could continue as planned. Our layout of the HV cabling and transformers reduced the load on the overhanging elements of the topsides. We reduced the structure and blast wall costs whilst still allowing adequate ventilation to the transformer halls.

MET MAST FOUNDATION

Location: Hong Kong

Client: CLP Power Hong Kong Limited

CLP Power commissioned Arup to design a 20m tall structural steel offshore meteorological mast which will collect wind and metoceandata for a two year period. Conventional anemometers and innovative LIDAR techniques will be used to collect data for the design of the proposed offshore wind farm. Arup designed and obtained government permitting for the innovative suction bucket foundation design –delivering success in its very first implementation in Hong Kong.

CONCRETE GRAVITY BASE FOR OFFSHORE WIND

Location: UK

Client: Hochtiefand Costain

As lead designers, Arup developed a foundation solution that can be economically mass produced and installed with low marine operation risk. The structure's innovative self floating shape allows it to be towed to site without requiring specialist towing vessels and to be installed using simple water ballasting operations. The foundation caters to water depths of up to 60m and will suit turbine sizes up to an anticipated 10MW.

SUBMARINE TRANSMISSION CABLE

Location: Baltic Sea

Client: nktcables

Arup used advanced finite element techniques to assess the integrity of an in-situ wind farm export cable as it exited the J-tube at the seabed. Our assessment established that component stress levels were acceptable and that cable integrity was not compromised.

STANDARDISATION OF HVDC PLATFORM

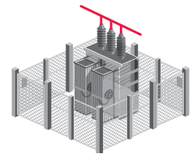
Location: UK

Client: Confidential

We undertook a feasibility study to develop a standardised 900 MW HVDC convertor platform to be used in the development of offshore windfarms in the North Sea. The study involved the development of a 'standard' platform concept, which would be capable of accommodating equipment from different HVDC manufacturers. We developed two solutions for the deck structure of the platform, one based on stiffened panels and one based on a braced truss, each supported on an identical jacket substructure. The platform was based on HVDC-VSC technology and the scope of work included the deck arrangement for equipment from three different manufacturers, routing of cabling to and from the platform and assessment of limiting met-ocean conditions for deck installation.

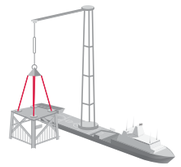
How can we achieve 20% cost saving in transmitting offshore wind power to shore, worth £7/MWh LCoE?

+30%
transmission capacity

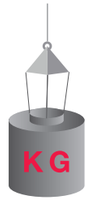


-40%
offshore manning

-40%
topside volume



-20%
installation time



-45%
topside weight

Shaping a better world

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