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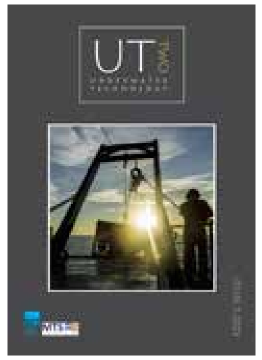
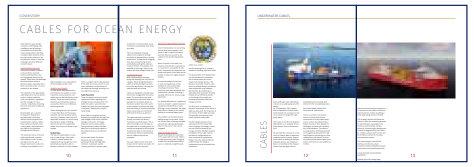


DeRegt cables for Ocean Energy

NEWS

CABLES



ALLIANCE CONTRACTS

Subsea 7 has announced that the Subsea Integration Alliance has signed a memorandum of understanding aimed at forming a framework agreement with bp for integrated subsea developments.

The Subsea Integration Alliance is a non-incorporated strategic global alliance between Subsea7 and OneSubsea, the subsea technologies, production, and processing systems business of Schlumberger (SLB), bringing together field development planning, project delivery, and total life cycle solutions under an extensive technology and services portfolio.

Menawhile, SLB's OneSubsea business has been awarded a multi-million-dollar contract by Petrobras, marking the sixth consecutive contract between the two companies for the supply of subsea trees.

The critical subsea equipment for Petrobras' Búzios-11 project will support the development of Brazil's Búzios pre-salt field in the country's prolific Santos Basin.

OneSubsea will supply 15 subsea trees and electrohydraulic distribution units to Búzios-11, scheduled to begin production in 2027 via the P-83 floating production, storage, and offloading (FPSO) vessel.

The contract scope also includes installation, commissioning and associated maintenance services.

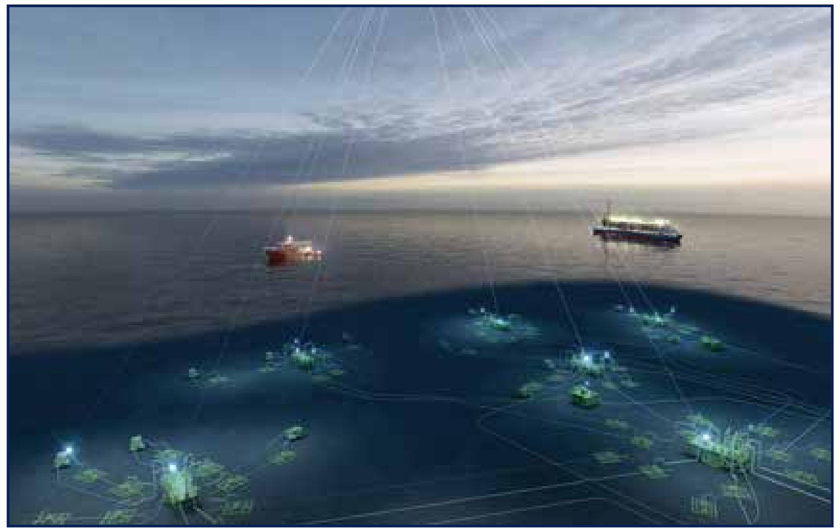
The trees will be manufactured at OneSubsea's facility in Taubaté, São Paulo state, with initial delivery scheduled for the second quarter of 2025. All services will be conducted from OneSubsea's facility in Macaé, Rio de Janeiro state.

● Under a new agreement, SLB, Aker Solutions and Subsea7 have come together to create the world's leading subsea technology and solutions provider.

OneSubsea will be headquartered in Oslo, Norway, and Houston, Texas, with 11 000 people working in all key operating regions around the world.

SLB holds a 70% equity stake in the joint venture, with Aker Solutions holding 20%.

Subsea7 holds 10% of the joint venture, in exchange for a cash consideration of US$306.5 million paid in two equal instalments in 2023 and 2024.



Aker Solutions, SLB and Subsea7 joint venture

NEWS

GREENSEA IQ

Ocean robotics pioneer Greensea Systems has begun the transformation into Greensea IQ, uniting its former subsidiaries; Bayonet Ocean Vehicles and Armach Robotics, into a new business entity. This restructuring reinforces Greensea IQ as a leading force in the use of uncrewed and autonomous systems to better help improve human-kind's interactions with, and understanding of, our oceans.

Greensea IQ CEO, Ben Kinnaman, said that "Greensea IQ's innovative technologies are poised to revolutionise maritime industries globally. EverClean, for instance, offers autonomous hull cleaning services that enhance ship performance, fuel efficiency, and reduce carbon emissions. With a successful commercialisation phase, EverClean has proven the economic viability of its technology, and plans are in place to scale the service to a multitude of ship types in the coming years.

Additionally, Greensea IQ's advancements in the defence and environmental spheres are gaining traction. The EOD Workspace software platform offers autonomous capabilities for mine detection and classification, reducing the risk to personnel in hazardous environments. Furthermore, the company's robotics technologies are finding applications in offshore renewables, performing surveys for pre-construction work and beach landings, where traditional solutions struggle.

The restructure also prepares the company to strategically expand its operations to better serve clients across the globe with likely expansion into Europe, South America, and Southeast Asia, allowing the provision of closer service depots for robot deployments, and more effective customer support.

JOHAN CASTBERG

Operators Equinor has said that the cost of the Johan Castberg development has risen by almost NOK 13 billion since last year. When the plan for development and operation (PDO) was submitted in 2017, the cost estimate was NOK 57 billion. The project cost estimate, which is now NOK 80 billion

Johan Castberg is located around 100 km north of the Snøhvit field in the Barents Sea, 150 km from Goliat and almost 240 km from Melkøya in Hammerfest. Water depth is 360-390m. It is a subsea field with 30 wells distributed on 10 templates and two satellites tied back to a floating production, storage and offloading vessel (FPSO). It breaks even of around US$35 per barrel.

Proven volumes in Johan Castberg are estimated at between 450 and 650 million barrels of oil. The vessel is designed for a daily production of close to 190 000 barrels.

Johan Castberg quayside at Aker Solutions, Stord (Photo: Øyvind Gravås/Equinor)

ROSEBANK

Equinor and Ithaca Energy have taken the final investment decision to progress Phase 1 of the Rosebank development on the UK Continental Shelf (UKCS), investing US$3.8 billion.

Rosebank is located around 130km north-west of Shetland in approximately 1100m of water depth. Total recoverable resources are estimated at around 300 million barrels of oil, with Phase 1 targeting estimated 245 million barrels of oil.

The field will be developed with subsea wells tied back to a redeployed Floating Production Storage and Offloading vessel (FPSO), with start-up planned in 2026-2027. Oil will be transported to refineries by shuttle tankers, while gas will be exported through the West of Shetland Pipeline system to Scotland.

THE INDONESIAN FALCON

Jakarta-based PT Fabila Teknik Sejahtra has purchased a Saab's Seaeye Falcon ROV. The diving company will deploy it in their marine and offshore contracting services support across Indonesia.

PT Fabila's marine and offshore undertakings include condition inspection and surveys throughout Indonesia. The diving company will deploy the Falcon in their marine and offshore contracting services support across Indonesia.

As PT Fabila's marine and offshore undertakings include condition inspection and surveys, their Falcon comes fully equipped for the tasks including a sonar, a cathodic potential probe kit, ultrasonic thickness gauge and a rotary wire cleaning kit.

For diving companies, the Falcon can play a vital role by undertaking missions too hazardous for divers, such as where the depth of water and strength of current become dangerous for divers.

The Falcon can also improve diver safety and increase efficiency by pinpointing and examining locations of interest before sending down divers.

Just a metre in size, it is easily moved and its intelligent control architecture, combined with five powerful thrusters allows precise manoeuvrability in turbulent waters amongst complex structures, whilst loaded with various cameras, sensors and tooling typically found on much larger robotic vehicles.

Jakarta-based PT Fabila Teknik Sejahtra, has bought Saab's Seaeye Falcon ROV

BALMORAL

Balmoral, the Aberdeen-based energy industry specialist, has brought it new bend stiffener connector to market.

Bend restricting devices, which include stiffeners and restrictors, are vital pieces of equipment that are used across the offshore wind and traditional oil and gas sectors where there is a requirement to control the bend radius of a pipe, cable or umbilical.
They are usually attached at topside or seabed connection areas and are typically conically shaped polyurethane mouldings with a cylindrical bore that fits over the asset.

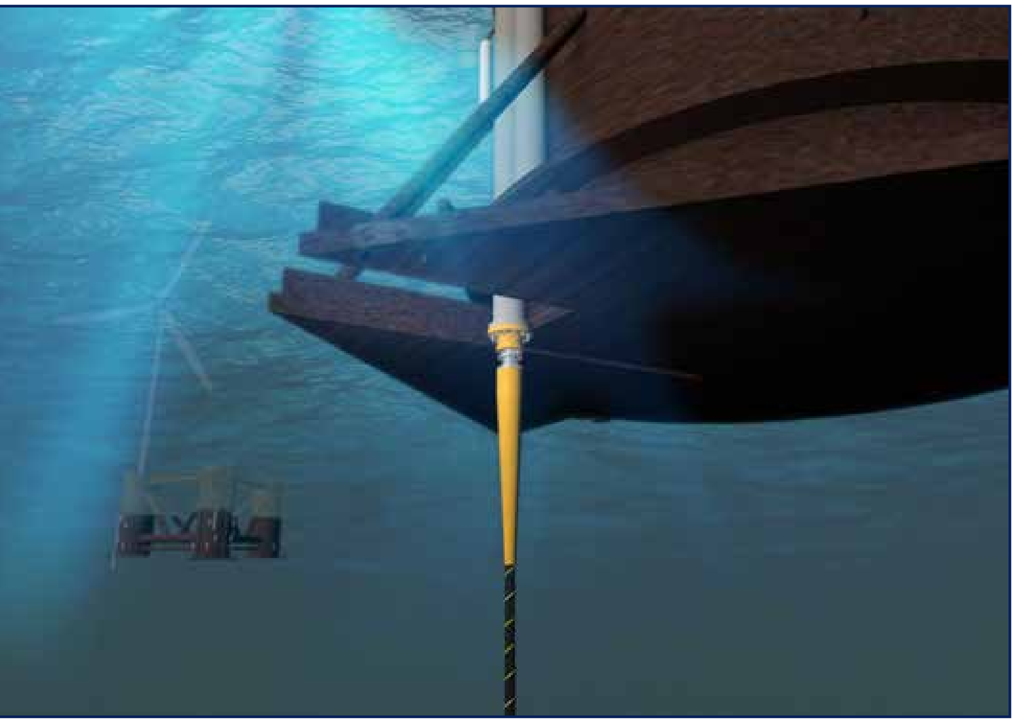
In seamlessly integrating dynamic bend stiffeners with offshore structures, the Balmoral BSC features diverless installation and an elevated level of operational performance.

Balmoral engineering and projects director, Fraser Milne, said: “With the BSC, operational readiness is achieved swiftly and we believe establishes an unparalleled benchmark for reliability and efficiency.

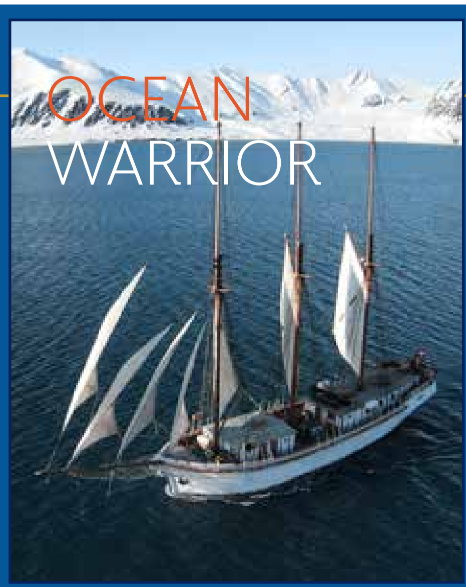
“By enabling a seamless fusion of dynamic bend stiffeners with offshore structures our commitment to pioneering engineering solutions for the offshore energy sector is again demonstrated.”

Diverless installation lies at the heart of this innovation while the design and manufacturing process adheres to API 17L standards.
This commitment to operational efficiency is further highlighted by the incorporation of a reusable pull head which not only enhances installation timelines but also adds practicality to the overall process, the company claims.

The full system consists of a lead-in cone, BSC and dynamic bend stiffener. The BSC is drawn through a bellmouth located beneath a floating platform. As the BSC latching system engages with the bellmouth the anchoring mechanism comes into action. This latch secures the mechanism during descent and maintains system stability as the anchors find their place on the tapered neck of the bellmouth.



Balmoral seamless bend stiffener



OCEAN WARRIOR

A unique voyage is being undertaken to build a greater scientific understanding of the marine environment in the Arctic and the impacts of global climate change.

The expedition aims to install and test scientific and technological equipment such as weather stations, FerryBox, CTD, Bathymetry, Communications, and Safety. Additionally, an online dashboard will be created to convey the findings and capture stories through digital and broadcast content capture.

The project is being supported by Plymouth Marine Laboratory (PML), a world leader in the field of marine research, Valeport, (which designs and manufactures oceanographic and hydrographic instrumentation), Mole Energy, Dartmoor Brewery and Henri Lloyd.

NEPTUNE

Bluefield Geoseis has developed its new Datem Neptune 5K Cone Penetrometer Test (CPT) system. Based on a coiled rod, this versatile sysem can be used on seabed route survey push testing on projects where agility is required, with launch and recovery simplified using a compact seabed frame.

The CPT system has a 30 kN Push Capability and can achieve up to 20m penetration. It can support cones with an area of a 5 cm² or 10 cm², as well as T-bars.

It is housed in an easily-deployed Compact Subsea Frame. There is real time control and display

Power and data is supplied through a single coax connection with automatic safety cut-outs. It uses 240 VAC 1 Ph 50/60 Hz power although the umbilical is rated to 650 VAC.

On the frame is an altimeter and tilt frame sensor. When in operation, the unit can achieve a 2 cm/sec (+/- 10%) penetration speed and a 5cm/sec retraction speed

The Neptune measures 2.325m in length, 2.325 m in width and stands x 2.74 m high. It weighs Weight in air 4500 kg. It can be used in 3000m water depth.

Neptune 5K Cone Penetrometer Test (CPT)

MTS

The Marine Technology Society (MTS) has introduced the Ocean Enterprise Initiative, a flagship programme aimed at spearheading innovation, thought leadership, and economic development within the Ocean Enterprise.

The Initiative includes the expansion of the signature program "Dialogues with Industry," launched in 2022 with partners from the National Oceanic and Atmospheric Administration (NOAA), the Global Ocean Observing System (GOOS), Kongsberg Discovery, and L3Harris Technologies.

The Ocean Enterprise Initiative bolsters the Ocean Enterprise, which encompasses the public, private, non-profit, and academic entities that provide ocean observation measurement, forecasting data, and operational ocean information products and services. Members of the Ocean Enterprise are at the forefront of ocean technology innovation, sustainable ocean use, and economic growth.

The Department of Commerce and NOAA have provided early investment in a $3.9 million grant to advance industry engagement, thought leadership, and community coordination within the Initiative. This grant aligns with President Biden's Investing in America agenda, facilitated by the Inflation Reduction Act (IRA).

This substantial investment will empower MTS to continue its success as a global convener of the Ocean Enterprise.

CABLES FOR OCEAN ENERGY

Tidal turbines, wave energy converters, and floating solar installations are all making a contribution to the drive for ocean energy. When selecting a suitable cable, however, there are many factors that must be considered in order to meet the challenges posed by different converter types.

SEABED-BASED DEVICES

There are a number of devices such as bottom-mounted turbines and tidal kites, that are strategically placed on the seabed. These have the advantage that they operate without dynamic cables, especially when their connection point is in close proximity to the seabed.

The selection of the appropriate cable depends on various factors such as seabed conditions, local municipalities' regulations and the strength of ocean currents. Sometimes, trenching becomes necessary to adhere to regulations.

Buried cables are a solution for long-term deployment and especially connecting offshore wind monopiles and transformation stations. When these cables are buried at the correct depth, they experience very little to no movement throughout their lifespan.

The stationary nature of buried cables significantly increases their lifespan to over 30 years and allows for the use of cheaper aluminium conductors. However, one drawback is the

high installation cost, especially for shorter lengths (under 5 km).

SEABED-LAID CABLES

In cases where deployment times are limited or the seafloor is rocky, it becomes more practical to use cables that can be laid directly on the seabed. These are used for shorter distances and temporary setups in areas where there are no fishing or anchoring vessels.

When testing devices, this method is more often than not the easiest, cheapest and most practical option. There are, however, a few risks and downsides involved. It's worth noting that dynamic cables of floating devices also become seabed-laid cables once they touch down on the seabed.

Seabed Type

The type of seabed plays a crucial role in cable design. If the cable is laid on a sandy seabed, the seabed itself may change over time, potentially causing the cable to become unburied. On rocky seabeds, there is a higher risk of cable abrasion if the cable can move around. In such cases, additional reinforcement of the cable and thorough securing it to the seabed is necessary.

Cable Placement

There is a balance to be struck with seabed-laid cables regarding their strength and secure placement. The better the cable is secured to the seabed, the lower the risk of damage or abrasion, allowing for a simpler cable design.

If the cable is not tightly secured, increasing its weight and strength can help mitigate some of the potential damage or abrasion. For longer distances across sandy seabeds, strong and heavy cables with little effort put in securing the cables to the seabed can be a cost-effective option.

On the other hand, for shorter distances and rocky seabeds, particularly those with high tidal velocities, investing in seabed securing methods to prevent cable movement is recommended, as any movement can gradually wear down any cable.

The main drawback of laying cables on the seabed is the high possibility of external factors causing interference. Fishing vessels dragging their nets and anchoring vessels accidentally catching the cable are common threats. Fortunately, most methods of securing a cable to the seabed also help mitigate these risks.

FLOATING DEVICES

Most ocean energy converters, along with floating solar, fall into this category. When designing dynamic cables to withstand high sea states, one of the key factors is limiting the load the cable has to bear.

Cables are designed to handle linear tension but struggle with transverse loads. The areas where the cable can experience transverse loads are typically the connection points to the device and/or the anchor point on the seabed. To prevent the cable from exceeding its minimum bending radius, these areas are reinforced with bend restrictors as add-ons.

The cable attached to the device should not hinder the device's movement caused by waves. This is where moorings come into play, as the cable and its mounting point are usually not designed for this purpose. To allow the cable to move freely in any direction without experiencing tension, different layouts are employed.

The Lazy-S layout is the most well-known, but for calmer sea states, the J-lay layout can also be used.

RESTRICTED MOVEMENT DEVICES

One of the key factors of connecting devices that remain steady in the waves is their shape of the cables and how they are secured to the seabed in the specific deployment area.

When it comes to the cable, the amount of movement it experiences is crucial for its survivability. If only minor movements are expected, the design and layout of the cable can be simpler compared to highly dynamic designs.

A major advantage of these low or slow-moving devices is their similarity to semi-submersible oil and gas structures. These structures have been equipped with umbilicals for decades, providing a valuable reference for ocean energy generators.

For floating tidal devices, a significant factor to consider is cable movement caused by turbulent flow. In areas with high current velocities, the cable may move or vibrate in the current, leading to increased fatigue loads.

This problem can be addressed by adding fairings to the cable. There are various types of fairings available, and with the right fairing installed, tidal currents up to 5 m/s can be mitigated.

FREE-FLOATING DEVICES

Devices that follow the movement of the waves will encounter millions of load cycles every year. Designing a cable that can withstand shallow waves is relatively straightforward, but the challenge lies in making it capable of handling high wave states.

Cable cross-section

The wave profile of the deployment site and the device's movements due to these waves are crucial inputs in the design process. This dynamic movement model is a key factor in multiple design calculations, often performed using software like OrcaFlex.

By combining our cable data with customers' OrcaFlex models we can efficiently iterate on the design of the cable and interactions between cable and energy converter.

The first job is to correlate the dynamic movements of the device in high sea states with the frequency of occurrence of these high sea states. This provides an overview of the cable's dynamic load profile.

The first design iteration of the cable based on this load profile. Once complete, the design is input into the OrcaFlex model of the energy converter.

Multiple iterative simulations of the cable, layouts, and add-on configurations are then conducted to optimize the design. Once the optimal solution is determined, the design is finalised and can be translated into production.

ADVANCED CABLE VESSELS

CABLES

Calypso

Van Oord's new cable laying vessel *Calypso* was recently Christened in Rotterdam. The vessel had just sailed in from the Vard Brattvaag shipyard in Norway, where the cable-related equipment was installed. The *Calypso* will be mainly deployed to install inter-array grid and export cables for offshore wind projects, including high-voltage direct current cables.

The vessel is not only fitted with a cable carousel on deck but also with a second below-deck carousel. This gives it a total cable-carrying capacity of 8000t. It can lay two cables simultaneously.

It has been designed with the latest sustainable technologies in order to reduce its carbon footprint during operations and when on port standby. Apart from the ability to run on biofuel, this hybrid vessel has future-ready engines with built-in flexibility to anticipate e-fuels. It has a large battery pack, a shore supply connection and a state-of-the-art energy management system.

This sustainable set-up will result in greater energy-efficiency, with significantly reduced CO_2, NO_x and SO_x (carbon, nitrogen and sulphur oxides) emissions. Offshore wind is a key contributor to achieving climate change targets around the world.

The construction of the *Calypso* in Norway has enabled Van Oord to secure a Green Loan from Eksfin, a Norwegian governmental enterprise. This recognition stems from the *Calypso's* role in enabling expansion of renewable offshore energy. Financing is provided as a corporate loan and will be partially used to fund the final construction milestones of the *Calypso* and help optimise Van Oord's financing structure.

New Nexans Vessel

Nexans Marine Operations and Ulstein Verft have entered into a contract on the construction of a large DP3 cable laying vessel.

The vessel, an ST-297 CLV design by Skipsteknisk, is an updated version of the *Nexans Aurora*, delivered in 2021.

This new ship goes further with improved design, comfort and capabilities. Equipped with three turntables, it can offer a 13,500-tonne loading capacity. It also hosts a large range of subsea tooling including jetting and ploughing tools.

This vessel will be capable of laying up to four cables simultaneously to meet specific customer requirements, especially on large-scale projects.
"This cutting-edge cable laying vessel features a split turntable on deck capable of holding up to 10,000t of cable, an under-deck turntable with a 3,500t cable capacity, and a fibre optic basket holding 450t.

The vessel measures 31 metres in width, 149.9 metres in length, and is accommodated for a crew of 90.

This vessel will be delivered in 2026.

"By adding this vessel to its fleet, Nexans is also enhancing its versatility and flexibility covering a widening geographical footprint," said a spokesperspon.

"From an environmental standpoint, the new vessel with its increased load capacity, an advanced hybrid power system and capable of running on biodiesel mix, will offer a significant reduced footprint, reflecting the Group's strategic environmental vision.

The vessel is specially designed to carry out the transport and laying of various types of subsea cables, including cable bundles as well as recovery and repair.

It can perform effectively even in challenging weather conditions and is said to boast exceptional manoeuvrability and station-keeping capabilities.

DEVELOPMENTS IN UMBILICAL TECHNOLOGY

FOR SHALLOW WATER APPLICATIONS

Organised by the SUT and Umbilical Manufacturers Federation (UMF)

In May, the Middle East branch of the SUT and the Umbilical Manufacturers Federation (UMF) jointly held an online conference on **Umbilical Developments in the Middle East**. Four speakers discussed widely different aspects of umbilicals technology and operations. One of the speakers, Joe King, Umbilical Product Manager – Umbilicals at Aker Solutions looked at long step-outs in Shallow waters.

"What is an umbilical?" he posed. "The API 17e defines an umbilical as a group functional elements such as electrical cables, tubes and fibre optics that are bundled together in a single conduit.

"The assembly of an umbilical is called 'Lay Up' and there are two common ways. The first and most common is the 'planetary' method.

"Numerous individual functional elements are loaded from the transportation reels into a large functional revolving disc. As this disc turns, the functional elements pay off from the reels and into the umbilical to produce the helix.

"The key point with the planetary lay-up is that all elements spin in the same direction so from one perspective, they resemble a screw or bolt thread.

"The planetaries have a limited number of positions on the main disc that they can physically take while there are also weight limitations. This is acceptable for smaller umbilicals but for larger

Traditional planetary bundling machine. Component reels are loaded onto rotating primaries. The elements are pulled off the reels and through the bundling point as the primaries rotate, which applies the continuous helical pattern into the umbilical.

designs that exceed the maximum quantity of positions, it may be necessary to conduct multiple passes. This is called a 'double closing 'or even a 'triple closing' if the umbilical is large enough.

"Because all functional elements are positioned inside their own conduit and act independently of each other, a long umbilical lay length can be achieved, which is the distance it takes one element to rotate 360deg. This generates a very low torque on the final umbilical. Because there's a low torque, it is not necessary to 'torque balance', and/or to use armour wires

"The alternative method to a planetary closing is an OsciLay or an alternating helix. This method is widely used for umbilicals incorporating power cables and thermoplastic hoses. Generally, it is not used for steel tube umbilicals.

"Using a low lay angle, it is possible to incorporate 1.5in diameter steel tubes."

Each of these lay up methods has its own advantages and disadvantages but the most suitable method must be decided at the planning stage.

"In a long length power cable, it is desirable to limit the number of splices as these are theoretical points of failure," continued King.

"OsciLay systems can accommodate longer element lengths and thus avoid the splices.

"Elsewhere, in an umbilical with a complex cross section containing more elements than a planetary machine can hold, it may be better to use an OsciLay method and manufacture the umbilical in one pass."

CHALLENGES

"A key engineering challenge for shallow water umbilicals is the weight-to-diameter ratio.

"Wave and current action impose an increased force on umbilicals in shallow waters as opposed to umbilicals being laid in deeper waters.

"In order to have a stable umbilical, therefore, the line needs to be heavy, however, in some cases, it can't be made heavy enough to be stable on its own."

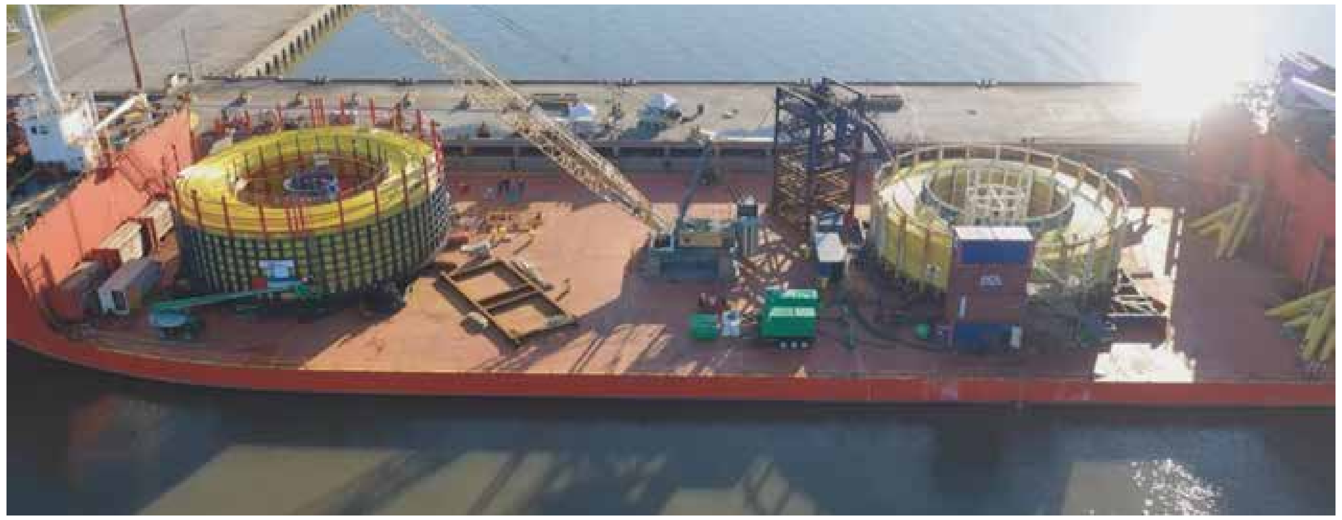
Another challenge, specifically in shallow water, is that it is likely to require a shore approach. This means that the umbilical will be dragged over the seabed for some distance to the hang-off point.

The work may also require the umbilical to be pulled through a conduit with a number of bends.

Additionally, this increases the amount of load on the umbilical may not be immediately apparent.

OsciLay manufacturing line. This equipment has rotating heads that interface with the umbilical bundle to apply the alternating helix (OsciLay) pattern into the umbilical.

Aerial photo of the component reels positioned in the OsciLay line. The components are pulled off of the reels and into the bundling machine located inside the building.



Aerial view of the transportation vessel during umbilical load out. Umbilical is being spooled from the onshore carousel and onto the vessel carousel.

Until the umbilical is being actually laid, the contractor may not know how close the installation vessel can get to land and therefore, how much 'pull' will be required. This makes it a challenge to design an umbilical optimised for strength and weight.

Sometimes it is counter-productive to make the umbilical stronger to handle the loads because the designer also wants to minimise the amount of material for cost reasons.

Maybe the biggest challenge for the long lengths is how it is delivered. There are two basic ways- on a carousel and on an installation reel.

"The carousel is very popular, however, the load-out costs are high as it takes time to get long lengths spooled to the installation carousel," said King. "In the installation reel alternative, the umbilical can be ready on the quayside, simply waiting for the installation contractor pick it up.

"This makes loadout is very quick – maybe half a day. The downside is that it is only possible to get limited lengths of umbilical on the reel."

In a recent job in the Middle East, Aker Solutions delivered an umbilical using the OsciLay manufacturing method. The total length of the whole field was around 100km and split between four different umbilicals.

The umbilicals supplied power, communication and injection fluids to the well-head platforms. The top side terminations meant that both

DELIVERY METHOD OF LONG UMBILICAL LENGTHS

	PROS	CONS
Carousel	High capacity, lengths limited by vessel carousel (AkerSolutions have delivered up to 160km continous length)	Transportation cost from manufacturing site to field Duration for transpooling to installation vessel.
Installation reel	Transportation cost from manufacturing site to field. Flexibility in transport vessel	Multiple in-line mechanical connections may be necessary depending on length

ends had to be terminated out of the water.
In the project, the umbilical was hung off using a J-tube, exiting some distance above the sea-floor where there's a heavy influence of wave and current.

"There is always a risk of over-bending or over-stressing the umbilical at that point," said King."The umbilical, therefore, needs to be protected with bend restrictors Integrated with J-tube seal plugs to allow the introduction of corrosion inhibitors.

"One of the biggest challenges was to keep the umbilical stable. It was possible to add weight to the design for some parts of the field, but the shallower regions required secondary stabilisation such as trenching rock dumping mattresses

"The Middle East has extreme climate – being very hot has its own challenges, specifically the high temperatures inside the J-tubes which can be difficult to dissipate. This can be especially problematic when the umbilical incorporates a power cable that acts like resistive heater. To minimise this, the J tubes are often shaded and sometimes painted with a bright colour to reflect the heat."

Typical umbilical cross sections for power, chemical injection, hydraulic service and communication.

TESTING THE INTEGRITY OF SUBSEA CABLES

THE ADVANTAGES OF LOW VOLTAGE

C-Kore Systems, a UK company that specialises in the development of innovative subsea testing tools, have been providing the operators and installers of subsea cables with integrity testing technology for more than 10 years. Over that time their rental tools have helped customers in 25 different countries to identify and locate faults in subsea cable networks and to monitor the installation of more than 50 umbilicals.

When installing a subsea electrical cable two measures of its integrity are of particular importance; its capacity to conduct the electrical current and its ability to insulate the conductor from the environment.

In the particular case of subsea cables, the later ability is of great importance because seawater ingress at weaknesses in the insulating media, or at connections and splitters, is an enemy that only gets stronger with time and can, in an alarming percentage of cases, lead to the failure of power circuits and the loss of production from seabed wells.

Put simply, healthy insulation is mission critical to production from subsea oil & gas wells.

In addition to the commercial cost of excessive leakage currents passing to the sea rather than the flowing through the Subsea Control Modules that they were intended to be powering, operating a circuit with very low insulation resistance (IR) can be a safety risk for personnel on the topside facility and for divers on the seabed.

The commercial and safety imperatives make the monitoring and management of IR a vital element of the manufacture, installation and operational life of all subsea umbilicals.

Whilst degradation of the electrical services in an umbilical can happen at any time over the life of a subsea production system it is during the umbilical installation process that cable integrity is particularly at risk; a time when unexpected loadings and torsions can cause serious damage.

The monitoring of umbilical integrity during the lay process is therefore critical to the health of the umbilical services over the course of its planned operational life.

Insulation Resistance, the measure of the integrity of the electrical insulation, is most often determined by hand-held test devices or Line Insulation Monitors (LIMs) that apply a known voltage between two conductors, or a single conductor and earth, and measures the current that flows.

From the elementary physics known as Ohm's Law the IR can be determined by dividing the applied voltage by the current. Various specifications and standards suggest different voltages for such tests, but up to a voltage many times higher than the rating of the cable (known as the withstanding voltage) the relationship between the applied voltage and the current that passes through the insulation is linear.

This means that the IR measured should be the same, regardless of what voltage a tester chooses to apply.

When developing their Cable Monitor device in 2010 C-Kore decided right from the start that they would use a very low voltage for conducting IR tests in order to make the tool completely safe for use by divers when conducting subsea fault-finding operations.

The design that they chose embodies extremely sensitive and accurate current measurement electronics which make it capable of measuring IR up to 10GΩ with a test voltage of 3.3V.

The technology that C-Kore developed has subsequently been adopted by subsea operators, installers, and intervention contractors for monitoring umbilical cable integrity through the potentially hazardous installation operation, as well as to speed up the location of subsea electrical faults in mature fields.

NOVACAVI IN NEMO'S GARDEN

NOVACAVI has recently supplied a special underwater LAN hybrid cable to be deployed for the farm experimental project called Nemo's Garden. Since everything is monitored on land through cameras and sensors, the underwater cable will enhance this innovative system of exploring the benefits of the sea for farming.

Nemo's Garden is the world's first underwater cultivation system of terrestrial plants. It consists of an array of suspended, transparent, dome-shaped greenhouses called biospheres, anchored to the bottom of the sea.

The project originally started when Sergio Gamberini, founder of diving equipment firm Ocean Reef Group, wondered if it would it be possible to create the perfect growing conditions for basil underwater. Like most herbs, basil prefers protected, sunny locations with well-drained soils and a constant, stable temperature.

He started experimenting, sinking transparent biospheres 20ft below the surface of the sea and filling them with air. The underwater farm is currently composed of 6 air-filled clear plastic pods, anchored to the bottom of the sea by chains and screws, just off the coast of Noli, Italy.

These acrylic structures, resembling large balloons, hold approximately 2000lit of air and float at different depths, between 15 and 36 ft below the surface of the water.

Each biosphere has a step grid where the divers may stand to operate. When a diver is in the biosphere, half of their body is outside of the water.

Inside the biospheres, water condenses on the inner walls, dripping back down to keep the plants watered, while the warm, near-constant sea temperature between day and night creates ideal growing conditions. The microclimate and thermal conditions within the biospheres are optimal for plant growth and crop yields, not unlike a conventional greenhouse, yet it requires no additional energy sources.

The use of renewable energy harnessed from the sun and of fresh water obtained by desalination of seawater, make Nemo's Garden a self-sustainable system.

At the centre of Nemo's Garden, stands the Tree of Life, a 12-feet-tall, 10-feet-wide metal structure weighing approximately half a ton. It serves an important function in the Garden, in that it conceals the cables running to each biosphere and allows to monitor the area from above, controlling the light levels through a live camera feed.
In addition, two webcams are located in each biosphere, while a wide angle horizontal webcam is placed at the bottom of the sea.

The Nemo's Garden Pilot Plant in Noli is commenting with Land infrastructures while the 9 biospheres are planned to be fully operational imminently. Biosphere #3 has been already seeded (72 plants) while the #6 sphere has a quite old Tobacco plant and an ALOE that was seeded in the summer 2021 !

The Pilot Plant will be integrated with an artificial reef 9 meters long, 2 wide and 1.2 high for the analysis of water current speed and possibility of production energy for the utilities of the lab. Seven biospheres will contain a new hydroponic cultivation system increasing the number of crops to 100 each biosphere.

HIGH POWER DYNAMIC CABLES

For many years, wind energy companies have firmly established themselves in the fixed-base, shallow water workspace. Wind turbines are typically installed in less than 60m of water where cables rated up to 66kV carry a turbine power output of up to 15MW between them and back to shore.

Some companies, however, are already looking to harness additional wind power that is found further offshore. The deeper waters require floating wind turbines. Much of the enabling technology was pioneered by the oil and gas industry, where dynamic cables connect to shallow water semisubmersibles, but there still remains a particularly big challenge for offshore cables.

The greater turbines mean that voltage levels will increase and the cables will become commensurately larger to carry this power. Furthermore, instead of the static cables that presently run on or beneath the sea floor between fixed structures, floating turbines will also require dynamic cables.

“Offshore cables are already a major focus for attention,” said Alan Dobson, Senior manager, R&D and Technology, TechnipFMC. “Statistics show that around 84% or more of failures in offshore turbines are directly associated with the cable infrastructure.

"This may come from a variety of reasons such as ageing, manufacturing issues, installation techniques etc, but if the high failure rates of relatively benign cables are transposed to highly dynamic cables in some of the most energetic seas in the world, then it is likely that the failure rate is going to be unmanageable."

Dobson recently spoke at a conference in Melbourne organised by the ASME entitled Challenges Associated With High Voltage Dynamic Inter Array Cables where he warned that the industry needs to focus on system reliability and gain a greater understanding of various failure mechanisms such as material fatigue, creep, hydrolysis and corrosion.

“Particularly around Europe, a number of floating wind developments have reached a pilot stage and are already generating energy," he said. "Hywind Scotland,

for example, commissioned in 2017, has five 6MW turbines situated in up to 120m water depth while the Scotwind leasing programme hopes to generate 25GW of energy across 15 development zones. Around 60% of this, 15GW, is expected to come from floating wind turbines.

"The move to multiple floating foundations and suspended cables in highly dynamic configurations, however, pose both a high risk of failure due to uncertainties on system loads and an increased probability of failure due to the large number of cables in operation."

Dynamic cables are subjected to significant functional and environmental loading which can directly result in electrical and mechanical stresses in their constituent parts. Coupled with this are second order effects which impact on reliability due to high temperature and induced electromagnetic forces.

CABLES

The main functional unit of a typical power cable is the power core. At the centre of the power core is the conductor which provides the power transfer. This is surrounded by a semiconducting layer which minimises electrical stresses between the conductor strands and the next insulation layer.

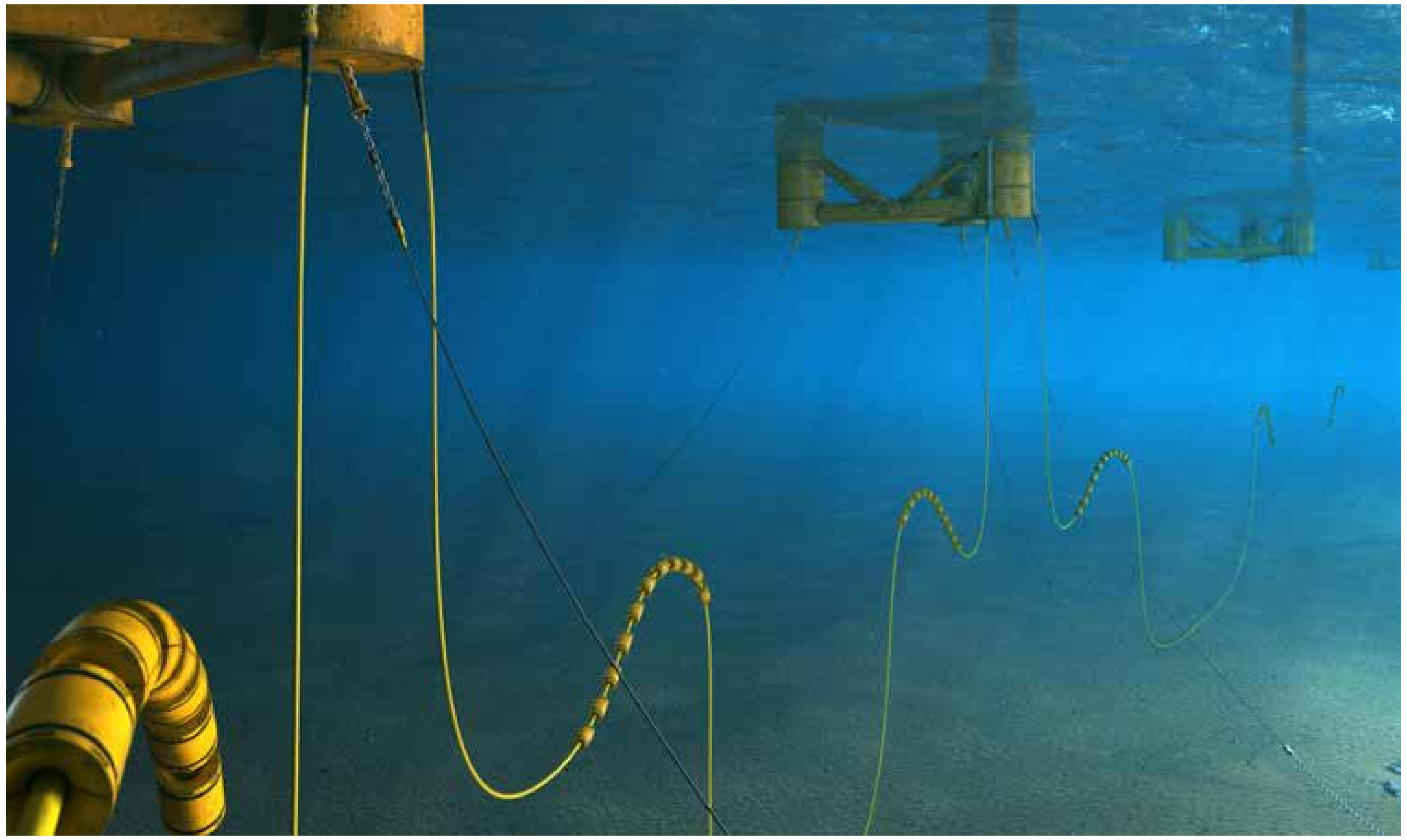
The insulation layer isolates the conductor from the sea water. It is of sufficient thickness to withstand high voltage. It is surrounded by a second semiconducting layer and then a conductive screen layer. The conductive screen, designed to provide sufficient current carrying capability to ground secondary currents, is finally protected by an outer sheath.

These power cores are typically arranged in groups of three, with polymer fillers introduced to protect then and other components within the cable such as glass fibre optic cables. The bundle is surrounded by a tape layer, which maintains the helical lay of the components. It also facilitates the components being able to slip past each other when in dynamic operation, to minimise fatigue loading.

Cables often include an inner polymer sheath to protect the bundled functional components, as well as multiple layers of helically-wound metallic armour which provide ballast, strength and mechanical protection. An outer sheath protects the armour layer.

LOADING

“The power cores are sensitive to all modes of mechanical loading



from handling, the operational environment and interaction with ancillaries as well as from their own functional loading through electrical stresses and thermal loading," said Dobson.

"The conductor can be subjected to bending and compression at various positions which can result in fatigue loading, tensile or compressive creep, tensile overload and compressive buckling. Each of these failure modes are directly associated with the mechanical properties of the power core.

"The entire helical bundle can be affected by temperature so as the greater wind speeds generate higher amounts of power, the entire assembly heats up and this reduces the mechanical capacity. In addition, the second order effect of voltages induced in metallic components result in mechanical and chemical ageing.

"Any over bending, tension, torsion, axial compression or abrasion incurred during installation or general handling, can also be linked to cable ageing or mechanical failure.

Along its length, the cable requires ancillaries such as clamps which practically hold it in place. If these clamps are attached with too much pressure, they may restrict lateral movement of the helical components and in this dynamic environment, could lead to compressive overload or alternatively, amplify fatigue loading in the armour or conductors.

CABLE HANDLING

There are three key areas during the installation process, where defects may be introduced into the cable.

The tensioner needs sufficient grip on the cable to tensioner, to enable it to maintain the catenary in the correct shape. Incorrect loading on the tensioner however, can crush the cable. Other areas of contact are at the overboarding chute when buoyancy clamp attachments are poorly applied.

Radial over-loading can cause the

components to be ovalised. This will reduce insulation thickness as it is more compressive than the copper core. Permanent ovalisation means that the cables will suffer from much higher electrical stresses which, in turn, will accelerate the ageing of the insulation.

Mathematical tools can be used to assess loads and provide robust design guidance. Applying limit state guidelines from the tensioners to the stabilisation clamping can reduce overall stresses.

COUPLED LOADS
"There are three main areas of high stress along the cable configuration but very little knowledge of the effect of temperature, electrical stress and mechanical fatigue in a dynamic system," said Dobson.

These main areas of risk are:
• The Sag Bend (concave) and Hog Bend (convex), where the cable will be under the influence of the buoyancy and clamping loads while being subjected to cyclic compression and bending.

• The Touch Down Point (TDP), where the cable will be subjected to cyclic bending, compression and abrasive loading from contact with the sea bed.

Within the SAG bend, the Hog Bend, and at the touchdown point the cable will be subjected to cyclic compression, which can be severe due to the inertia of the floating foundation as it moves in the water column.

• The cable hang-off
The cable is connected to the host and typically surrounded by a bend stiffener. At this point, the cable temperature can be in the region of 90 Deg C. due to service loads (both mechanical and electrical), solar radiation or insulation from ancillaries and the system being subjected to high tension and curvature loads and static tensile loads.


Lay-up machine

"An increased temperature will particularly reduce the strength and stiffness of the copper cores. These could yield and through subsequent bending cycles suffer compressive buckling or overbending.

Copper will begin to creep if subjected to elevated temperature for a significant amount of time. Creep is a time-dependent, permanent deformation of any material that has been subjected to a force. For a cable, creep can result in either the material continually elongating until it can no longer support the tensile load.

'We discovered that relatively small amounts of heat will cause copper creep over a period of 40 days. If the strain within the cable is not managed effectively, material creep will result in buckling of the conductor during bending cycles," said Dobson.

CYCLIC MOTION
Cyclic bending and tension within the cable is reduced by a bend stiffener, however, fatigue loading of the cable still occurs. Under small amounts of curvature, the Power cores cannot slide relative to each other in the helix and a consequence, the cores bend across the central axis of the helix resulting in a high strain growth.

"As the curvature builds, the force from the strain in the axial direction of the core starts to overcome the friction in the cable bundle," said Dobson. "Individual cores start to slide relative to each other, bending along their own axis and reducing the rate of strain increase with applied curvature.

"Ultimately, the motion reverses and the strain cycle repeats but in the opposite direction, resulting in tensile and compressive cycling of the cable cores. This, however, introduces the risk of fatigue failure which is compounded by high contact stress due to the counter helical wires in the copper core crossing over the top of one other. This visually resembles a trellis and is called Trellis Wear.

The wires cause stress concentrations, resulting in fretting and eventual failure. As one wire fails, other start to yield and suffer from a more ductile failure.

"Fatigue failure of a stranded conductor is also influenced by the construction of the stranded conductor, the size of the strands, their helical lay angle, the degree of compaction applied to the conductor, temperature and the effects of any water blocking mediums used between copper strands," said Dobson.

"Strain cycling will also effect other metallic elements within the power core and cable, such as the metallic screen on the power core, the metallic tubes and armour within the fibre optic cable and the layer of metallic armour used to protect the cable.

WAVE MAGNET

While there advantages of linking floating solar with wind generation, exactly the same is true of wave energy conversion. There are various types of wave conversion devices and these work on a variety of principals, but all are essentially designed to convert the vertical up-down motion of the waves into mechanical energy which in turn is used to generate electricity.

Many rely on parts that are connected together but move independently. The wave physically moves something in relation to something else and the mechanical energy is converted into and electrical energy. This naturally also places stress on the hinge joints between plates and this stress can affect the design life.

One company, Sea Wave Energy (SWEL) has developed the novel Wave Line Magnet (WLM). This is comprised of an array of flexible assemblies linked by a spine power system. The patented technology allows the wave to pass through the system, generating power as the wave rises and falls.

A system of lightweight platforms are connected to a pressurised open circuit sea water, zero impact working fluid, Power Take Off system (PTO). The majority of the WEC can be made using 100% recyclable and minimal impact HDPE plastic (or equivalent) materials, and even be fabricated using plastic waste achieving a negative net carbon footprint.

Wave Line Magnet (WLM).

In the event maintenance is due, the modular nature of the technology permits incredibly easy, fast, and efficient replacement of any parts during operation, minimising downtime.

It has the ability to increase power production as wavelengths increase, producing volumes of power on large scales, by more than 10 times the comparable standard methods used.

In conjunction with the engineered neutral spine which tames the perceived harsh ocean environment to a smooth and forgiving power source that it's controlled by the WLM, not the other way around.

"The wave energy converter is designed to embrace the surface of the sea, or the 'wave line' as it is sometimes referred," said SWEL's Chief Technology Officer Adam Zakheos.

"This allows the wave energy converter to become a moving mass with the wave itself. It creates a unique interaction that allows SWEL to regulate how much energy is extracted from the wave in a controlled and non-disruptive manner.

"The seamless and frictionless interaction is a unique characteristic of the technology that allows it to work in harmony and in synchronization with the deployed sea area, irrespective of the wave profile and the weather conditions."

SWEL say that using the data collected by European Marine Energy Centre's (EMEC's) Datawell Waverider Buoy, one WLM system would be rated at over 100MWh of mechanical power, with the annual equivalent of exceeding 140,000MWh or 3,596,000 kg's of Green Hydrogen, at a cost of 0.0251 € / kWh (Mechanical).

"One of the main advantages of the Waveline Magnet is that it provides a secure area that can be used as an offshore floating hydrogen production and storage plant, maximising the efficiency of energy production but also by-passing the problems associated with onshore grid connection, storage and the infrastructure required to accommodate it" said Zakheos.

"The technology and principle of operation has been through intense development for over 15 years in both wave tank-controlled environments and open sea trials, producing and testing various iterations to reach the current stage of development.

"The WLM is now ready to challenge the entire industries understanding of the power in our oceans, on top of true scalability from moderate wave climates through to calculations demonstrating a rated output of over 100MW per deployed system in energetic environments, at a cost of only cents per kWh.

"The technology can be applied to desalination, electricity or hydrogen production. With other beneficiary applications such as self-sustained fish/algae farms.

"Having concluded exhaustive studies and tests on the Waveline Magnet (WLM) technology at Ecole Centrale de Nantes (ECN) Test Facility, with Marine Energy Alliance (MEA) and industry leaders, it is clear that the technology displays tangible potential to solving the decades-old enigma of wave energy.

Testing in a wave tank

CABLE BIOFOULING

Any Structure exposed to open water maybe subject to biofouling – the accumulation of unwanted marine growth, and this is especially true of dynamic cables that transfer electricity from offshore floating wind turbines to the substation. If this marine growth is not accounted for in the cable design and monitored, it can add considerable maintenance costs over the lifetime of the wind farm due to repeated cleaning and may even result in cable failure if significant build up occurs.

So say Fugro, which has looked at the issue.

First things first: what exactly is biofouling? It's a term used to describe the complex process that involves an accumulation of marine organisms on structures immersed in seawater, which can affect biodiversity, the design tolerance of submerged assets and require additional maintenance.

"Broadly speaking there are two types," said Sophie van Zanten- Global lead, power cable routing and design. "It can accumulate as hard fouling such as algae and sponges; or soft fouling like mussels. As the extent of the biofouling increases, the dynamic cables may be affected by a number of processes.

This includes

STRUCTURAL FATIGUE

"An excess of biofouling may push the weight, mass and diameter of the cable beyond the parameters of the original engineering design," said van Zanten. "This may change the structural drag and added mass coefficients, affecting how the cable moves in the water in response to tides, currents and storms. Biofouling may also start or accelerate corrosion. Over time, the structural integrity of the cable may reduce. And if left unchecked, this could lead to cable failure."

INEFFICIENT HEAT TRANSFER

"The biofouling may act as an added layer of insulation that prevents the cable from dissipating heat effectively. This creates a risk of overheating. Thermal conductivity of the soil is a key design parameter for buried cables. A dynamic cable's ability to transfer heat will be affected by the type of biofouling.

"The Industry still has a lot to learn about how biofouling affects dynamic cables," continued Principal Marine Ecologist Stefania De Gregorio. "How much does the biofouling weigh and what effect does it have on buoyancy and stability? Is the weight evenly distributed along the cable. How long does it take for a species to dominate a biofouling community and do electromagnetic fields affect their growth rate?

Although there are patches of data and knowledge about these challenges within the industry, it's largely internal, scattered and fragmented. There's no high-level overview and little evidence of information-sharing.

REDUCING RISKS

Having robust and site-specific data on the engineering effect of biofouling onto submerged assets will allow planning and design closer to the environment. This is because biofouling is influenced by site-specific environmental variables.

Biofouling

"We have supported many environmental offshore wind studies in recent years," said van Zanten

"Together with project partners, Fugro are developing innovative methodologies and technologies for remotely collecting environmental DNA samples in the North Sea. This will help measure the impact of turbine structures on biodiversity by monitoring, characterising and analysing species.

"Similarly, they are undertaking research studies on biofouling development with our environmental consultants and laboratories. The group are currently involved in commercial studies that are exploring biofouling and its implications for engineering design of an offshore wind farm.

They say that it is important to take a joint approach and start gathering data on as quickly as possible. A 10-year prediction, will require a two-year study, to ensure capturing seasonal and temporal variation of marine growth;

This data can then be fed into cable design.

Biofouling from below the surface in the water at Bracklesham, UK after a six month immersion period

HUISMAN CABLE CAROUSEL

A carousel will be installed on pipelay vessel Orient

Huisman has signed a Letter of Intent with DFO for the delivery of a cable carousel and the option for a complementary cable-lay system. Initially, the cable carousel will be installed on pipelay vessel *Orient Adventurer*.

Together with the existing Huisman Vertical-Lay System, the carousel will be deployed for subsea cable-laying projects in fixed and floating offshore wind.

The cable carousel has a storage capacity of 3,000mt and will be positioned below deck, maximising free space on deck. Huisman has based the proposed design on its existing proven carousel and storage components design to reduce delivery times and technical risk. Delivery is scheduled for the first half of 2024.

Furthermore, DFO has expressed its intention to order a horizontal Huisman Cable-Lay System. This brand-new cable-laying concept is specifically developed by Huisman to be temporary installed on, for example, a multi-purpose offshore vessel. The system has been designed to be (de-)mobilised quickly and easily.