Offshore Wind Farm Cable Survey

The international offshore wind farm industry is at an early stage of development and the difficulties that have been encountered along the way are widely recognised. This article describes some of the experiences encountered since the early days and suggests ways in which clients may gain greater cost benefits.

The generation of electricity from offshore wind is one of the main areas of growth for renewable power. There have now been two rounds of licenses issued for developments in UK coast-al waters, with large developments planned in other parts of Europe, in particular The Netherlands, Denmark and Germany. Electricity generated must clearly be transmitted to shore via seabed cables. Output from a wind farm is entirely dependant on the integrity of these cables, yet the need to ensure secure installation and oper-ational life may not win the attention it deserves when compared to higher-profile issues such as turbine layout and foundations.

Difficulties have been experienced with a number of wind farms installed in the UK, some of which may be traced back to planning issues and include failure to appreciate environmental conditions such as sand waves, resulting in deterioration in protection. Other problems have occurred as a result of inherent uncertainties in marine operations, such as failure to achieve the target burial depth. So route selection and survey for the cables represents an essential component of the development process. The Gardline Group of companies, including Titan, SEtech and Gardline Marine Sciences, has great experience and a sound track record in assisting clients plan their work and monitor installa-tions during oper-
ational life.

The Planning

UK developers have to bid to the Crown Estates for a license. To date these have been awarded in two rounds, and several of the Round-1 sites are now up and running. Work is progressing on the Round-2 sites, with a number of consent applications already submitted. Site selection is a complex process; even within the three presently designated Strategic Environmental Assessment (SEA) areas. Preferred locations that optimise construction costs and power generation need to be balanced against many critical constraints: environmental, navigation etc. Grid connection often represents one of these constraints, and therefore options for the export-cable landfall positions tend to be limited for any chosen site. The challenge is to select the best route from the site to the landfall, and then confirm its suitability, prior to submitting an application for consent.

The license application will give details of the cable route and burial depths proposed. Once accepted, approval authorities are reluctant to accept changes, particularly reductions in depth, as these may be perceived as a relaxation to planning consent. It is therefore very important that they are selected correctly. Over-specification of burial depth can cause exponential increase in installation costs, while too shallow a burial depth may leave a cable at risk of damage, bringing significant consequent costs in loss of output and repair. It is therefore important that the fullest information is obtained at the different stages of the development process, while at the same time the speculative nature of the project during its early stages is recognised.

Desk Study

A desk study should always be one of the first activities carried out, ideally at the site-selection stage. There is a great deal of information in the public domain, and a relatively small amount of money invested at this stage can pay significant dividends in the long term. It is essential that individuals with the correct background and experience carry out this work. It is rare to find all the requisite skills and experience within one company, and a multidisciplinary approach provides the greatest dividends. For example, the team should include environmen-tal scientists, geologists, and engineers with experience of the industry. The good news is that expertise does exist, as cable-route desk studies are routinely performed for submarine fibre-optic cable systems and HVDC interconnectors.

The Surveys

The objective of survey for a wind farm is to obtain sufficient and reliable information on the nature of the seabed to permit safe and economic design, installation and maintenance of the works. Developers will always seek to minimise investment prior to consent. The first site investigation is usually a geophysical survey comprising bathymetry, side-scan sonar, sub-bottom profiling and magnetometer mapping. This is usually focused on the prospective site to inform on ground conditions and provide key information for the Environmental Impact Statement:

- acoustic mapping of surface sediments prior to baseline benthic survey
- water depths
- seabed soils and their vertical and lateral variation
- obstructions and hazards such as sand waves or rock outcrops

- archaeological assessment.

Just one geophysical survey is usually performed; however, this can leave gaps in understanding of the site. A particular concern is often the mobility of the seabed and shore approach. For example, many of the sites around northern Europe are characterised by a deposit of sand at the seabed, and this may be mobile. Understanding of any such mobility is important as it could very easily leave a cable exposed on the seabed. Mobility can be easily identified by installation of monitoring equipment or surveys at selected intervals throughout the year, followed by geotechnical investigation that must encompass both cable routes and turbine foundations. The higher costs of these surveys mean they are typically deferred until after consent has been obtained. Boreholes are generally required for the turbine foundations; however, seabed equipment such as vibrocorers and seabed cone-penetration frames can recover samples and test the soils to depth of 3m or more, sufficient for most cable burial requirements.

The geophysical and geotechnical surveys may complete the development phase of a project. But it would be very wrong to think that no further work is required. There is a clear need for continued monitoring to fulfil both statutory and maintenance requirements. Aspects that need to be considered are primarily associated with sediment mobility. This may take the form of sand migration on the cable route, either on the shore approach or across sand waves and megaripples, which could result in the cable becoming exposed. But the potential for scour around foundation bases also cannot be ignored. Scour pits can form very quickly around a foundation, some cases having been report-ed of these occurring within a single tidal cycle. As most wind turbines are founded upon monopiles of approximately 5m in diameter and scour pits are typically 1.3 times pile diameter, this can very quickly develop into a 7m lowering of the seabed. It is a relatively simple matter to design the pile to allow for this scour pit, but the cable must emerge from the base of the tower and pass along the seabed. Cables and 'free spans' are not good bedfellows, and it is the cable that will lose out. To further complicate matters, scour pits can come and go with weather and seasonal changes.

It is normal for post-construction cable route (inter-turbine plus export routes) plus scour pit monitoring to be specified in the licence conditions. These monitoring programmes are designed to meet regulatorsâ€™ needs; it is up to the developers or installation contractors to determine if these meet their project needs.

Cable Burial
It is generally recognised that burial in the seabed is the most effective method of protection for submarine cables. The hazards to cables from other seabed users are primarily from fishing and ships' anchors. Where cable armouring does not provide adequate protection from the identified hazards, cable burial is used to mitigate the risks. The depth of interaction of different activities will vary depending on the type and size of hazard and the strength and nature of the seabed.

The difficulties so far experienced have led developers and operators to increasingly examine cable burial and protection. Using risk-assessment techniques, the hazards to wind-farm cables can be evaluated on a project-by-project basis, with the key aspect of the process bring identification of hazards. The adequacy of the risk assessment is very much dependant upon accurate quantification of hazards. To date, this has relied on readily available information obtained during the planning stage, often related to the Environmental Impact Assessment. Studies to provide specific information aimed at assisting in cable routing, burial, and protection are rarely carried out. The risk-assessment process should ideally take place prior to installation of the cable and be used to aid selection of appropriate burial depths and provide recommendations for appropriate trenching equipment. However, post-installation or following subsequent monitoring survey, the risk-assessment process can be used to recommend further protection where required.

Guidelines
Various organisations provide guidelines for carrying out site investigations and various aspects of subsea plant. Documents have been issued by the Society for Underwater Technology (SUT), the UK Offshore Operators Association (UKOOA), and the International Cable Protection Committee (ICPC) that contain a great deal of useful information for planning and carrying out wind-farm cable installations. However, documentation specific to the planning and installation of wind-farm submarine cable systems is not yet available.

Case Studies
The experience gained on previous projects, and the application of lessons learnt, is always of great benefit. Within the Gardline Group, SEtech have particular experience in assessing risk to buried cables and the practicality of such burial. They have had some involvement in almost all of the UK wind farms installed to date, as well as a number of overseas developments.

At one offshore wind farm site the export cable was installed to a target burial depth of 2m. However, subsequent surveys have apparently shown exposures of the cable, particularly in an area of sand waves and megaripples. The cable recently failed, possibly due to impact from a shipâ€™s anchor. It is likely that the cable became ex-posed over time, leaving it at risk of the damage that subsequently occurred. The lesson learnt here is that where there is a risk of damage from other seabed users developers must ensure that cables are buried below the depth of any mobile layer, or that additional protection is provided.

At a second site the developer was aware of mobile sediments along part of the cable route and originally specified a burial requirement of 2m along the entire cable length. But the majority of the route comprises stiff clay, which is stable on the seabed and provides good protection against fishing gear and ships' anchors.

Over-specification of burial depth along much of the route limited the number of trenching machines capable of meeting the developerâ€™s requirements, impacting significantly on costs and availability. Risk-assessment techniques have made it possible to demonstrate that shallow burial in stiff clay will provide sufficient protection and allow relaxation of burial requirements. This has in turn realised significant cost savings whilst ensuring the cable remains adequately protected.