GL – Mapping the Future in Offshore Wind
Wind Turbine Installation Ships and Wind Farm Service Vessels
The power of innovation: offshore wind energy

Dynamic growth
Wind energy is one of the key renewable energy sources that will make a significant contribution towards clean and independent energy around the world. As a reflection of this, the wind energy industry is in a period of significant growth and in Europe the main driver is a political one: by 2020 the EU plans to cover 20% of its primary energy consumption using renewable sources. Wind energy will play a key role as 10,000 offshore wind turbines are expected to be installed in European offshore waters.

A wide range of vessels
This development presents ship owners, operators and yards with considerable opportunities in the construction and deployment of suitable vessels. The range of vessels needed to develop, install and operate wind farms comprises multiple crafts such as Wind Turbine Installation Ships (WTIS), crew boats as well as other types such as survey vessels, offshore support vessels, cable-laying vessels and anchor handling tugs.
Increasing demand

Globally, the offshore wind market is growing rapidly. In Europe, UK development is forecast to rise steadily, while projects in Germany and the Netherlands are expected to begin development on a large scale, and other European markets are also becoming increasingly active, as will the North American and Chinese markets.

At present, approximately 1GW is installed per year, which is expected to rise to 5GW. This is equivalent to an increase of:

- from 250 to 1,000 turbines per year
- from 150 to 700 km of export cable
- from 4 to 20 vessels to install support structures
- from 3 to 14 vessels to install turbines
- from 1 to 8 vessels to repair turbines
- from 300 to 500 support vessels

Current figures from the European Wind Energy Association (EWEA) state that in 2010, the total installed offshore capacity reached 3,000 MW. This meets 0.3 % of EU electricity demand. For the year 2030, 150,000 MW of installed offshore capacity are projected, which will meet between 13 and 17 % of total EU electricity demand.

A complex challenge requires innovative solutions

Offshore wind farming requires a series of highly specialized vessels adapted to the particular challenges faced in this sector:

- large units: wind turbine installation, construction and cable-laying vessels
- smaller units: maintenance and supply vessels
- crew transport vessels
- transportation vessels for all equipment from foundation to blades equipment

Increasing turbine sizes and weights need to be taken into consideration, as the offshore wind industry moves into deeper water and further from the shore beyond the so-called 20:20 envelope (20 m water depth, 20 km from shore). This requires vessels that have a high tolerance to adverse weather conditions – speed and resilience to seastate are key factors for wind farm installation and service vessels, just as reliability and flexibility are key factors in their successful operation.

In short, offshore wind farming requires highly sophisticated vessels that operate in challenging surroundings.

GL: your one-stop shop for offshore wind farm vessels

Founded in 1867 as a maritime classification society, Germanischer Lloyd (GL) has expanded to provide a wide range of classification, certification, software and training services. We can point to 240 years of experience and a network of approximately 6,900 experts across 80 countries and in more than 200 locations.

Today, we are proud of our leading position in the field of wind turbine installation vessels and wind farm service vessels. We explore and implement new solutions for the different vessel types required in the offshore wind sector. This includes:

- new ideas and innovative solutions
- expertise from concept to operation
- implementing sophisticated engineering challenges
- developing Rules
- classification of all vessels needed to develop, install and operate offshore wind farms
- expert support in negotiating the difficult terrain of international regulations and compliancy.

Our achievements have led us to:

- set up a dedicated Offshore Service Vessel (OSV) department
- develop rules for OSVs: hull and machinery
- develop rules for crew boats
- present OSV-related expertise at panel discussions, conferences and to ship owners in Europe, China, South Korea, U.A.E. and USA
- provide consultancy in the OSV sector
- support various shipyards with our pool of in-depth knowledge

GL acts as advisor to governments, the IMO, flag states and port states. We are ideally placed to provide guidance on compliancy with all current and upcoming regulations. As a classification society, we have accompanied the design and construction of a number of wind farm vessels, making us your expert partner for all lifecycle stages of offshore wind installation and support vessels.

"Offshore wind farming requires highly sophisticated vessels. At GL we are proud of the range and depth of expertise we can offer this rapidly expanding market. From wind turbine installation and construction vessels, to maintenance, supply and crew transport vessels."
The GL Group – global knowledge and local expertise

Unique solutions from concept to operation

Rules and classification

Germanischer Lloyd offers rules and guidelines that cover all aspects of offshore projects: design, development, construction, security, operation and management. GL expertise is currently supervising several offshore service vessel newbuilding and re-building projects, including self-elevating units for wind turbine installation, crew boats, accommodation units, anchor handlers, cable layers, and various supply and maintenance vessels.

GL Rules are constantly being fine-tuned to reflect advances in technology across the industry. The recently issued Rules for the Classification and Construction of Offshore Service Vessels and Underwater Technology include more than 20 special notations for the wide variety of vessels and tasks undertaken in offshore projects. GL Rules include:

- GL Rules for Offshore Service Vessels – Hull Structures
- New GL Rules for Dynamic Positioning System
- GL Guidelines for Gas as Ship Fuel
- 2011 GL Rules for Offshore Service Vessels – Machinery Installations
- New Rules for Loading Gears on seagoing ships and offshore installations

Ensuring compliance for all vessel types

One of the major challenges of all offshore installation and service craft is ensuring compliancy for vessels that integrate sophisticated concepts and fulfill many different purposes. GL is your guide when applying the regulatory framework such as SOLAS, MARPOL, Guidelines for the Design and Construction of Offshore Supply Vessels 2006 (OSV-Code), Code of Safety for Special Purpose Ships, 2008 (SPS-Code), International Code of Safety for High-Speed Craft, 2000 (2000 HSC-Code) and Maritime Labour Convention (MLC). Our experts are at your side for clarification and negotiations with flag states to find the most advantageous and practicable solutions for your projects.
Class notation: Dynamic Positioning

Dynamic Positioning (DP) is a great advantage for wind farm service ships as it is a computer-controlled system that automatically maintains a vessel’s position and heading. Moorings and anchor handling are not needed anymore. Rather, own propellers and thrusters are used while sensors for environmental forces and motion combined with a GPS position reference system control the positioning of the vessel. In the offshore wind sector, typical applications for DP systems are as follows:

- cable and pipe-laying vessels
- diving support vessels
- maritime research vessels
- survey ships
- supply vessels
- WTIS

Hull optimisation solutions

FutureShip is specialised in developing and fine-tuning ship hull forms. Many hundreds or thousands of candidate designs are systematically analysed and varied in an automated process based on a unique parametric approach. FutureShip can thus offer expert advice on choosing the best hull form as well as carrying out the associated tank testing. This improves fuel efficiency and ensures that the hull of your ship is fit for site-specific seakeeping conditions, thus increasing the number of operation days, even in stormy weather.

Noise and vibration challenges

Strong noise and vibration in working and living spaces can be the origin of increased crew discomfort and therefore lead to reduced crew performance. Moreover, excessive vibration can cause damage to structure, machinery and equipment.

FutureShip assists in preventing noise problems during all phases of a ship’s life: from the early design stage, through building and commissioning, to unexpected noises or vibrations during operation.

Construction services

GL Noble Denton provides project management and specialist site personnel on behalf of the shipyard. Under the guidance of GL Noble Denton, units are delivered to the owner’s satisfaction in regard to budget, time and quality standards. Furthermore, GL Noble Denton verifies the tasks undertaken by that particular craft on site: providing technical support, on-location trials, dynamic analyses, lifting calculations and arrangements for transport and installation.

Optimisation of Offshore Construction

GL Garrad Hassan has developed the “Optimisation of Offshore Construction” (O2C) model. This provides Monte-Carlo modelling of installation and construction activities to evaluate project scheduling and installation costs. It allows project owners and their contractors to improve cost efficiency by giving them an insight into the potential temporal and economic implications of adopting different strategies.

Optimisation of Operations and Maintenance

O2M Plus is an upgrade of the GL Garrad Hassan “Optimisation of Operations and Maintenance” (O2M) modelling tool, which builds on experience gained from over 40 projects. It allows differences between alternative wind turbine access strategies to be fully explored in terms of both costs and plant availability, and to thus identify optimal strategies.
Wind Turbine Installation Ships: GL’s expert solutions for WTIS owners and yards

Implementing the ambitious targets of the offshore wind sector requires highly specialised ships capable of anchoring foundations to the sea floor and erecting huge turbine towers. In Europe, in particular, many offshore projects are planned for deeper waters further from the shore. This requires sailing speeds of up to 13 knots and jacking capabilities for water depths of up to 60 m.

Most of the specialised vessels now in operation are classed by GL. As world leaders in this market we have accumulated an unrivalled pool of knowledge as well as invaluable practical experience. This enables us to address the complexities posed by these vessels to provide site-specific solutions based on cutting-edge technologies. GL Group services for WTIS include:

- combined assurance, consulting, engineering and execution support
- marine warranty services and dynamic positioning assurance
- classification

FMEA & the redundancy concept

The FMEA is a critical safety element for DP2 and DP3. Cost efficiency can be optimised at this stage if the redundancy concept and the worst-case failure design take into account operating modes (e.g. the work to be carried out, such as pipe laying, crane work, supply, transit etc.) and the operating conditions (e.g. environmental conditions for work, lifting etc.). This allows for appropriate design modifications before they become costly and is provided for in the GL Rules “Guidelines for Vessels with Dynamic Positioning Systems” by early approval of the redundancy concept.

The importance of pre-design expertise

At the pre-design stage, important parameters can be verified by feasibility studies and classification pre-checks, both carried out by GL. As WTIS involve high levels of complexity, early investigations are an effective tool for saving time and money at later stages. Relevant issues include: should the ship be self propelled, with jacking capability; what is the desired sailing speed, size of crane and lifting appliances, number of compartments and dynamic positioning? For vessels with dynamic positioning it is particularly important to define the redundancy concept at the earliest possible stage. Flaws discovered at this stage result in no more than extra paperwork, whereas flaws discovered at later stages, may lead to equipment rework, delays and commercial losses.

Design and construction of custom-built WTIS

At the design stage it is important to determine the most appropriate design to meet specific requirements. Considerations include: expected turbine size, water depth, distance from shore and the time window for installation.

PACIFIC ORCA

Type: Wind Turbine Installation Ship
Length: 155.614 m
Gross Tonnage: 24,586

Class notations hull
- 100 A5, BMW, Offshore Service Vessel, Self Elevating Unit, Operation according to Operating Manual, SPS, WTIS

Class notation machinery
- MC AUT DP 2 HELIL EP

Source: RWE Innogy

Source: Swire Blue Ocean A/S
GL has been involved with three design generations of wind turbine installation ships:

**Generation I** These are combined crane and working barges with high lifting capacity, high deck load capacity and a large working deck. They are used quite often in areas close to the shore, or if suitable generation II and III vessels are not available on the market.

**Generation II** These are jack-up barges without propulsion. They have high lifting capacity, high deck load capacity, large working deck capacity, a large accommodation area, helicopter deck, and they are self elevating. The jack-up barge THOR for Hochtief with a 70 x 40 m working deck and a crane capacity of 500 t is an example of this vessel type.

**Generation III** has all the features of generation II and also propulsion with DP2 / DP3 capability. This generation is mainly used in areas further from shore. It significantly reduces the time needed for installation, as the time for transferring foundations, towers, turbines and blades from transportation barge to installation barge can be saved. This also makes operation much safer. HOCHTIEF’s Innovation or the Pacific Orca belong to this category.
Solving the complexity of compliance

A WTIS may be a ship, jack-up, heavy lifter and passenger vessel all rolled into one. The hybrid nature of such a vessel means that it must simultaneously fulfill rules and regulations that are sometimes very contradictory. Finding a way through the jungle of international regulations is difficult. The IMO has been asked to take action to streamline compliancy issues, and results are expected in the near future. GL actively participates in all important international regulatory committees and is therefore always up to date on regulatory adjustments and changes.

Technical considerations and challenges

Leg types and jacking systems

WTIS leg types and jacking systems fall into two categories:

- cylindrical legs & hydraulic pin in hole
- lattice legs & rack and pinion

Wind turbine foundation installation

The monopile has been the foundation of choice for the offshore wind farm industry to date. However, this is changing as wind turbines move into deeper waters further offshore. Tripod foundations can be installed to a water depth of up to 50 m and jacket foundations to a depth of up to 70 m. In 5 to 6 years’ time, jacket foundations are expected to lead the way.

This places additional demands on the capabilities of wind turbine installation ships. GL is meeting these demands by moving forward into unchartered technical territory and pioneering future technologies.

“The Pacific Orca” – a GL Group success story

With a total length of 161 metres, a breadth of 49 metres and a depth of 10.4 metres, the Pacific Orca is the largest WTIS ever built.

The vessel is capable of carrying and installing up to twelve wind turbine units of 3.6 MW during one voyage. Furthermore, the Pacific Orca can install foundations and erect turbines in water depths of up to 60 metres and with leg extensions this increases to 75 metres.

Several business segments of the GL Group had been involved in this project:

- GL Noble Denton undertook engineering and design of legs, spud-cans and jacking system, including FMEA, as well as integration of these components into the ship’s hull. They also provided the shipyard consultancy and site-specific assessment services.
- FutureShip carried out global strength and fatigue analyses for the ship afloat, and was responsible for owner consultancy.
- GL as classification society conducted the in-place analysis in jacked-up mode, as well as providing the classification services.

On 27 July 2012 Swire Pacific Offshore Operations took delivery of the Pacific Orca from Samsung Heavy Industries in Geoje, South Korea.
Crew boats – ensuring safe and speedy passage

Transfer of personnel to site and turbines

As offshore wind developments move further offshore, into deeper waters with more extreme weather conditions, the challenge of providing support during construction, operations and maintenance is growing. Personnel access solutions need to be safe, fast and cost effective.

So far, personnel access to both wind turbines and offshore substations has been achieved mainly through the use of relatively small work boats. Speed and resilience to seastate are the key elements when deploying boats that transfer personnel to a site. Lack of these elements, particularly tolerance to adverse weather, has been a major contributor to reduced operation availability in the past. The ideal access solution is a small, fast and cost-effective vessel capable of transferring technicians in high seastates.

The current standard is characterised by the following benchmark specifications:
- Passenger Capacity: 12 PAX
- Length: ~15 - 25 m LOA
- Beam: ~6 m
- Draft: ~1.8 m
- Design: Multi-cat
- Speed: 25 knots (max)
- Propulsion: Typically 2 x 800 hp
- Deck crane: 2 tonnes SWL

Far-shore sites: ideas and developments

As proximity to a far-shore site is vital, interest in “floatel” or “mother ship” based strategies is growing. These provide offshore accommodation near the site for the operation and maintenance of projects further than 50 km from port.

Under these strategies crews live aboard large, floating vessels located within the vicinity of the wind farm, typically adopting a 2-week on, 2-week off shift rotor as practised in the oil and gas industry. Access to turbines can be achieved by daughter craft and / or heave-compensated access systems (such as Ampelmann or OAS), which can operate in high seastates. Such floating, offshore-based strategies can maximise time available for plant maintenance by reducing transit time to turbines and enabling access in severe seastates.

Mother ships in particular have the ability to deploy multiple small, agile craft during periods of benign weather conditions, or transit to the turbine themselves and use a specialist access system during periods of more severe conditions.

Pioneering solutions, delivering results

The challenge of finding solutions to the difficulty of fast, safe, reliable and weather-insensitive transfers of technicians and components is ongoing.

**SWATH vessels**

One emerging solution, currently being trialled at the Bard Offshore Wind Project in the German Bight, is the use of a small water plane area twin hull (SWATH) vessel. In a SWATH vessel the majority of the buoyancy is well below the waterline. This maximises the vessel’s stability, ensuring that it is less affected by wave action, even in high seas and at high speeds.

**Fjellstrand WindServer Trimarans**

The Fjellstrand WindServer is one of a new generation of offshore service vessels. It includes a number of innovative features which have been designed to improve access to offshore installations in rough weather, optimise fuel efficiency, ensure the safety of the personnel on board, and reduce running costs. The vessels will be equipped with four engines that power two controllable pitch propellers, giving improved operational flexibility while ensuring redundant capacity.

GL is very proud to be providing classification services for the first newbuildings of this innovative design. The order comprises six new vessels – two 30 m vessels and four 25 m – built by Fjellstrand for Danish shipping company World Marine Offshore A/S. The vessels will have a service speed of 25 knots and the capacity to carry 25 and 12 service personnel, respectively. They are scheduled to enter service in March 2013 and open a new chapter in offshore crew boats.
Crew boats – ensuring safe and speedy passage

Crew boats – the challenge of compliancy

As with many vessels in the offshore wind sector, crew boats integrate new designs and fulfil sophisticated requirements. This can make them difficult to categorise and class.

To address this challenge, GL released the first comprehensive set of classification rules for Crew Boats and Offshore Wind Farm Service Craft in May 2012. These rules were developed by bringing together all GL rules, international codes and recommendations with relevance to the classification of crew boats. They will allow designers to develop customised vessels that reflect the individual needs of their clients, with full confidence that these vessels will meet classification approval. The GL rules were developed in consultation with flag states and will contribute to the development of international standards for crew boats.

Additionally, in order to establish suitable safety levels for service craft of more than 12 service personnel, GL is actively contributing knowledge and expertise to the ongoing IMO debate regarding the categorisation of service personnel.
Many tasks, multiple vessels: support and survey crafts

GL provides expertise for all vessel types that are needed for the highly specialised, demanding tasks involved in the design, construction and operation of wind farms. Our knowledge becomes your competitive edge when identifying solutions that ensure safety, reliability and cost effectiveness.

Multiple craft deployment in the offshore wind sector may include:

**Guard vessels**

Every site needs a guard vessel. This needs to be a very robust vessel with good endurance so that it can remain on site during severe weather conditions. Main requirements for guard vessels include modern radar with AIS / ARPA, all VHF communications as well as morse flash-lights to communicate with vessels. Buoy-laying and retrieval capability is advantageous to monitor and maintain buoy positions.

**Support vessels**

Support vessels cover a broad range of tasks and capabilities. During foundation installation of structures such as jackets and tripods, grouting is usually required. In general, it is more cost effective to have the main installation vessel continue in this role and to deploy a dedicated grouting vessel. A specialist dive support vessel may also be advantageous as a contingency for failure repairs.

Standard support vessels in German waters also include ones for piling noise mitigation measures. For this, the Bubble Curtain deployment and energising vessel is fast becoming the approved choice.

**Fall-pipe vessels**

A fall-pipe vessel is capable of depositing material with great accuracy in deep waters. Such a vessel may be necessary for laying scour protection over cable repairs, filter-layer deployment prior to piling monopiles, and seabed preparation for concrete gravity bases.

**Side-dumping vessels**

Heavy scour protection of foundations is usually a job for side-dumping vessels. They are able to place rocks of sizes of 60 cm to 1 m dia. adjacent to monopiles or gravity based structures (GBSs).

**Cable-laying vessels**

(for array and export cables)

Cable laying vessels of two types are required – for array and export cables. DP2 offshore supply vessels can be retro-fitted with cable-reels and cable engines. A frequent requirement is to tow a jetting sled, therefore a knuckle-boom crane or aft A frame is a valuable addition for launch and recovery.

**Survey vessels**

Survey vessels come in several forms. Environmental survey vessels run transects across the area, often on monthly cycles, starting months or years before the actual installation phase. Studying seafloor relief and terrain usually involves bathymetric survey vessels with multi-beam side-scan sonar, sub-bottom profiling with boomer / pingers and towed hydrophone arrays. Magnetometer surveys may also need to be carried out to measure the strength and direction of magnetic fields.

**Additional vessels**

To fulfil the large number of tasks needed for the installation, operation and maintenance of offshore wind farms, vessels for the deployment of helicopters, a parts store, office space and other general facilities may also be required.
Many tasks, multiple vessels: support and survey crafts

**GO Cougar**
Type: Supply Vessel
Length: 67.6 m
Gross Tonnage: 2,180

Class notations hull
- 100 A5, DP2 DG

Class notation machinery
- MC AUT FF1 CM-PS

**Magnus**
Type: Anchor Handling Tug
Length: 54.13 m
Gross Tonnage: 1,767

Class notations hull
- 100 A5 E2, DP2 DG, Tug

Class notation machinery
- MC E2 AUT FF1

**FUGRO EQUATOR**
Type: Special Purpose Ship
Length: 59.07 m
Gross Tonnage: 1,929

Class notations hull
- 100 A5, IW, Special Purpose Ship, Survey Vessel

Class notation machinery
- MC AUT DP 1
State-of-the-Art Offshore Wind.
Germanischer Lloyd.

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