

Reference Projects

Since 2004, IMDC is acting as Owner's Engineer for the marine aspects of the **C-Power Thornton OWF** in Belgium. After being responsible for the EIA, the procurement process, the interface management, the design and installation of the subsea export and inter-array cables, the design, interface and installation of the offshore substation, the design interface with the WTGs, the scour protection and design and plenty of complementary studies, IMDC is now assisting the Project Owner in the management and supervision of most of the offshore O&M activities (e.g. bathymetric surveys, subsea cable repairs, WTG replacement).

In June 2012 IMDC was selected as Marine Consultant for Elia Asset NV and requested to assist Elia Asset NV (the Belgian national grid owner) in the development of their Belgian Offshore Grid (BOG). The main tasks were related to export cable routing, cable burial assessment and seabed survey specifications and follow-up as well as ESIA and consenting phase. For the same project in June 2013, IMDC was selected as Owner's Engineer for the development of an Artificial Island in the North Sea, including interface services concerning the design and installation of the export cables and of the OHVS. During 2016, IMDC was selected as marine consultant for the **Modular Offshore Grid (MOG)** project (that is a continuation of the BOG project) to provide similar services.

The THV Mermaid, founded by Otary and Electrabel, filed a license application for the development of an offshore wind and **wave energy farm** in the Belgian part of the North Sea. In the framework of the project, IMDC was asked in 2014 to write the environmental impact assessment, including a numerical modelling study of the prevailing hydrodynamics and sediment transport of the area for the installation of wind turbines, a plume dispersion modelling study of the dredging works, a nautical safety study, a radar impact study and a Life Cycle Carbon Analysis study.

Also in 2014, IMDC has performed the conceptual design verification, the EIA, the hydrodynamic impacts of the **offshore tidal lagoon** of Iland Valmeer (Belgium). The client's design of the atoll-shaped tidal lagoon is purposefully designed to be emptied during low energy cost, and filled up gravitationally. In 2015, IMDC has provided engineering services to the waterway manager W&Z, to analyse the **energy potential for TECs** at several locations along the

river Scheldt (Belgium). The study started with a selection of possible locations for installing a test set-up for free flow turbines, using available velocity measurement data, simulations with a 2D hydrodynamic model, and execution of additional velocity measurements. Next, after consulting several suppliers and developers of TECs, IMDC provided further assistance during installation and evaluation of the tested prototypes.



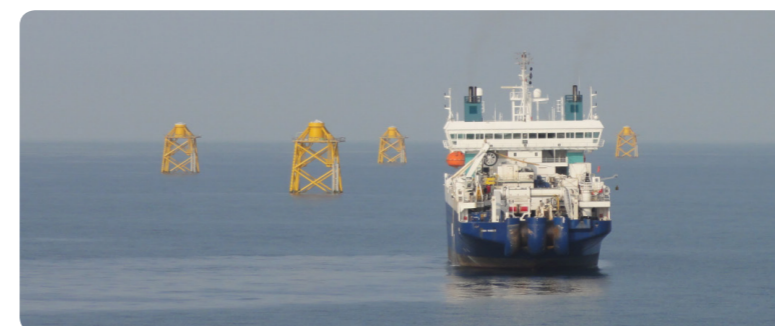
International Marine and Dredging Consultants (IMDC) is an engineering and consultancy company specialised in a vast range of water related projects. Our highly qualified staff offers

advice based on recent research results of leading universities and research institutes and hands-on experience acquired throughout the years.

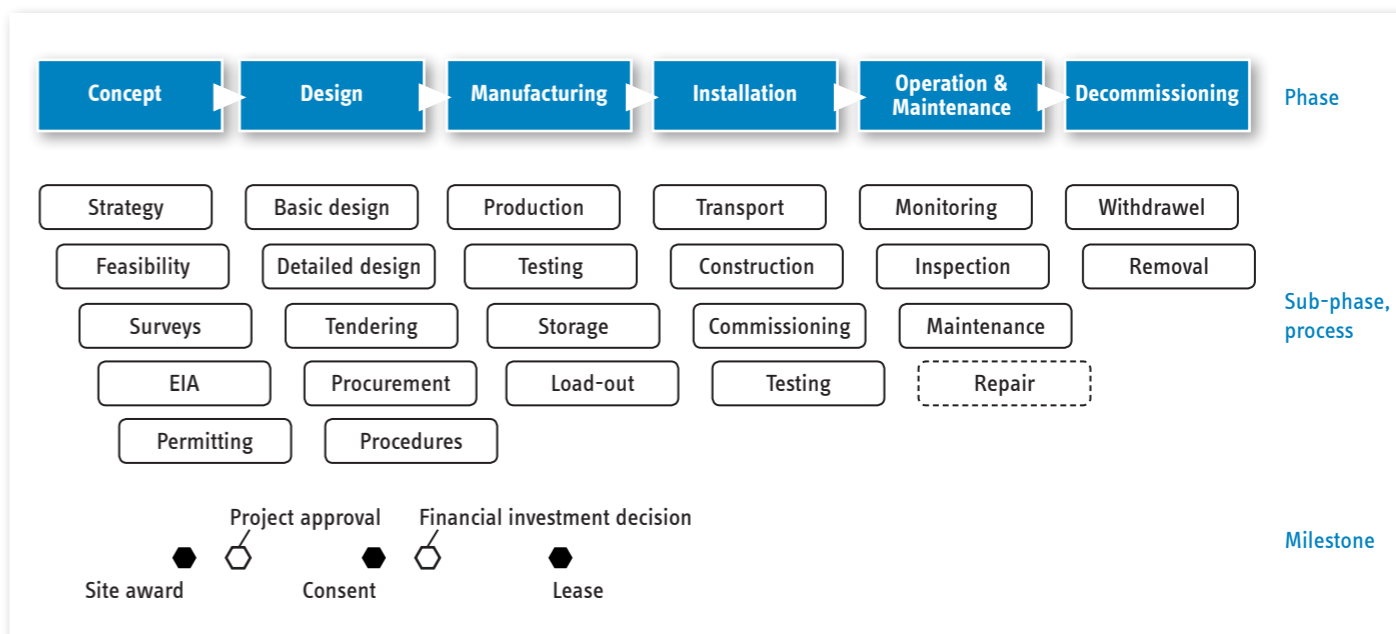
One of IMDC's core activities is presented in this booklet: Offshore Energy.

More information can be found on our website: www.imdc.be

Offshore Energy



Since the start of the offshore energy development in Belgium in 2001, IMDC has assisted project developers and contractors through the different phases of their projects, starting with permit applications, procurement and contracting, engineering, execution, operation and maintenance requirements. The lifecycle of an offshore energy project, wind turbine generators (WTG), wave energy converter (WEC) and tidal energy converter (TEC) farms, may be characterized by a number of specific phases and processes that are illustrated in below figure.



These processes can run in sequence of each other or simultaneously and can be active over a different number of phases. IMDC can assist in all processes of the project and is able to bring each phase toward a project milestone according to industry offshore standards (e.g. DNV-GL, Noble Denton) and

guidelines due to the strength of our highly qualified staff, years of experience in the industry and project interface management. Additional services along the project phases related to offshore energy market are discussed further in this brochure.

IMDC SERVICES

Procurement Stage and Management

IMDC manages and ensures the success of the project with the safety philosophy implemented in the different parts of the management system. The safety objective is quantified by key figures related to aspects such as safety, environmental and project / economical risk. The overall safety can be obtained by complying with the prescriptive requirements in this standard combined with a risk assessment (**HAZID-based**) that assures that all additional risks not covered by the prescriptive requirements are identified and mitigated.

Years of experience in the sector guarantees that IMDC can cover the **interface management** of offshore energy projects, coordinating procedures between data providers and the various designing, manufacturing, transporting, installing, or other relevant parties, and the different work packages of such complex projects. An interface manual is typically developed to manage the critical interfaces. This interface manual will describe responsibilities, data requirements, data format and due date.

The extended marine expertise of IMDC together with collaborations with universities, Tractebel complementary expertise (e.g. electrical, foundations, wind turbines, WEC), ties with professional associations, participation to seminars etc., guarantees the support and guidance of project developers and contractors along all phases of their offshore energy project.



O&M and decommissioning

Based on involvement in all phases of the project, IMDC can deliver a high quality **Operational and Maintenance Plan** and **OPEX** estimations for subsea cables, scour protection, dredging works and any interface construction with other marine structures (foundations, turbines, crossing of other cables / pipelines). The O&M plan is based on continuous iteration with the Client and according to the latest guidance on the topic from DNV-GL standards – the Risk Based Inspection and Maintenance concept.

During the last years, IMDC has also been involved in **management and supervision of O&M monitoring and maintenance works** for subsea cables (e.g. cable replacement, cable offshore repairs), for periodical interpretation of geophysical surveys and for major replacement works (e.g. WTG replacements). IMDC has also set up monitoring campaigns to monitor in real-time the scour evolution around offshore foundations.

The **decommissioning phase** is an important part of the project cycle. IMDC can provide decommissioning plans including work schedule and risk assessments for any offshore structure.

Site supervision and control

The IMDC offshore engineers all have ample practical experience with working on offshore installation projects. Therefore we can supply **offshore client representatives** to supervise the contractor with expert knowledge, so that the works are executed and completed in full compliance with the client's needs and expectations. This includes among other things: accurate progress monitoring, relevant quality checks and technical and practical advice on the job with the support of an experienced multi-disciplinary back-office team where needed.

From feasibility studies to execution

The evolution from a project idea until the realization is a long and complex process: IMDC supports their client, a project developer or a contractor, in this design process from start to finish, from the concept to the execution phase:

- IMDC's environmental team with the support of the engineering team initiates the Environmental and Social Impact Assessment (ESIA) study that will be the basis for permit applications and to feed the regulatory frameworks (see product sheet "Marine Environment");
- **Desktop and feasibility study** for development of your offshore energy project. All relevant site data are collected: metocean (wind, waves, current) data, geophysical / geotechnical surveys, position of existing subsea infrastructures, presence of cables / pipelines, relevant commercial / military / natural areas, wrecks, regulatory frameworks;
- Determination of **wave energy potential** by means of metocean data analysis and large-scale hydrodynamic numerical wave modelling (e.g. using proven software tools such as SWAN, TETHYS, Telemac);
- Determination of **tidal energy potential** by means of metocean data analysis and large-scale hydrodynamic numerical tidal current modelling;
- **Site selection** of the most appropriate area for development of offshore energy farms based on several **selection criteria** (e.g. energy production, site location, seabed conditions, environmental constraints) and based on a Multi Criteria Decision Method analysis;
- **Optimization of WEC farm layout** by simulating wake effects of WECs within the farm, and analysis of the impact of the WEC farms on the hydrodynamic and morphologic site conditions;
- **Optimization of TEC farms layout** by simulating the wake effects of TECs within the farm, and analysis of the impact of the WEC farms on the hydrodynamic and morphologic site conditions;;
- Assist in the **design of WECs** by applying CFD analysis of WEC dynamics for different design types, e.g. floating or embedded in coastal structures;
- Assist in the **design of TECs** by full 3D CFD analysis of flow around a single TEC and its foundation;
- **Concept and Design Basis** with regard to hydrodynamic and metocean site conditions, seabed morphology and morphodynamics, workability assessment, general functional requirements;
- IMDC has years of experience in managing **geophysical and geotechnical offshore surveys** from writing technical specifications, managing the procurement stage, the supervision, review of the procedure and review of the collected data. Besides, IMDC also has an extensive experience in the execution of metocean measurements, such as waves and currents.

- Based on the collected site data, IMDC can develop **engineering studies** which will feed the design phase of the project as interpretation of geophysical and geotechnical reports (including 3D ground model), numerical modelling of waves, wind and currents, seabed morphology and morphodynamic studies.
- **Optimization of WTG, WEC and TEC layout** in respect to areas with high seabed morphodynamics;
- The prediction of **local and global scour development** around the offshore foundations;
- The **conceptual and detailed design for scour protection**;
- **Workability assessment** and estimation of weather downtime for specific offshore tasks based on collected historical data of the site;
- **Dredging consultancy** from the conceptual stage to detailed studies, CAPEX / OPEX and design calculations (see product sheet "Dredging");
- Marine consultancy and detailed engineering for **subsea power cables** (see product sheet "Subsea cables and pipeline brochure");
- **Dredging Plume modelling** for prediction and fate of dredge-borne sediment originating from any of the offshore works;
- **Underwater noise** assessment caused by any of the offshore works;
- The **3D motion analysis** for vessels, floating and fix structures. These are typically used to design floating WTGs, WECs and TECs, to calculate hydrodynamic forces on these structures, and to design offshore foundations, key walls, mooring arrangements etc.;
- 3D modelling of **interaction between hydrodynamic forces and underwater and above-water structures** (e.g. wave converters, tidal turbines, foundations);
- Detailed engineering studies and modelling for **off-loading, transport and installation** of WTG, WEC, TEC and other offshore structures.

Furthermore, all collected and processed data are managed via GIS-tools, which enables us to share geographic information in a database during the entire duration of the project. The Client, other shareholders, and stakeholders can have access to this database at all times.

