MaDurOS program summary

The energy challenge is one of the greatest tests faced by Europe and Flanders today. Rising energy prices and increasing dependence on energy imports jeopardise our security and our competitiveness. Key decisions have been taken to reduce drastically our emissions and fight climate change. What is more, huge investments of around €1 trillion will be needed in the next decade to make Europe‟s installations and infrastructure fit for the future.

On 10 November 2010, the European Commission has adopted the Communication "Energy 2020 - A strategy for competitive, sustainable and secure energy" which was complemented by “The European Strategic Energy Technology Plan (SET-plan)”

In this document the European Union adopted binding rules as a target that, by 2020, 20% of the energy supply needs to be generated from renewable sources. Wind energy will provide an important contribution to achieving these national targets. In order to increase performance efficiency and avoid the slowdown in deployment due to protests from inhabitants against planned wind farm construction, an increasing trend towards offshore wind energy has been observed.

To realize the international targets for the implementation of wind energy both on- and offshore wind energy must become economical competitive with fossil fuel and nuclear power generation. Therefore the current trends, the scaling up of the wind turbines, and of wind farms, needs to be continued in the considered time frame. To achieve the required reduction in investment and maintenance costs, breakthroughs are required in the technology development of wind turbines. Especially for offshore wind the need to reduce investment, operation and maintenance costs puts high demands on reliability, accessibility and operation and maintenance strategies.

The power output of a wind driven generator is directly proportional to the area swept by the turbine blades – which is in relation to (blade rotor diameter)^2 - and the (wind speed)^3. Thus doubling the blade length increases 4 times the power; doubling the wind speed will produce 8 times more power. This explains a couple of trends observed in the offshore wind energy market. The first one is the fact that wind turbine generators are getter bigger to limit the proportionally higher cost of infrastructure and to lower maintenance cost per kW of installed capacity. The second one is that they are being placed further off the coast and into deeper waters in the open sea. In view of the challenges ahead and the opportunities the market presents, R&D efforts are being driven by the offshore demand.

Since wind energy is a renewable energy source the recyclability of all components has to be strived for and in this respect metals are very well positioned. In addition, as was mentioned before, the vast majority (58%) of people employed in the wind sector in Belgium are related to materials (mainly metals) and components production, while our landscape is also characterized by a strong existing industrial footprint.

As the cost of the support structure represents roughly 30% of the total turbine cost, significant cost savings are to be realized in this area in order to bring the cost of electricity (COE) to a competitive level by 2020.

Each wind turbine design however needs to be certified according to accepted design rules, that are published in public (for example Eurocode) or private (for example DNV or Germanische Lloyd recommended practices) documents. Integral design approaches in which the wind industry collaborates with the metals industry and fabricators are a prerequisite for the development of light weight steel components and structures for wind turbines. Development and utilization of new

materials is only possible if material specifications are developed between the specifying wind turbine industry and the supplying steel industry. This however requires materials and/or components to be tested under realistic conditions in medium or large scale testing facilities. As was illustrated by Jos Beurskens from ECN at the occasion of the OWI lab opening, such facilities are missing in Europe with regards to the turbine structure and foundations.

In addition the Off-Shore environment puts severe durability requirements on materials and one of its main inherent characteristics is that material is often exposed to several environmental conditions simultaneously: corrosive environment, fatigue loading, abrasive conditions, … . As a consequence, conventional design rules taking into account individual contributions, can‟t be used for design optimization purposes, leading to (over)conservative engineering approaches. Several national and international consortia have been created which have or will allow to get access to realistic environmental data or which are looking at innovative design solutions. Complementary to those initiatives this new research program "Material Durability for Off-Shore (MaDurOS)" is proposed within the SIM-context as it sets out as main objectives:

1. To gain deeper insight into the material behavior under combined durability conditions (main objective of the SBO-project(s) in the program).
2. While at the same time offering medium/large scale combined loading testing facilities to allow for material screening or development (main objective of the ICON-projects in the program).
3. Finally leading up to the development of new or improved materials, material processing techniques, material applications or monitoring techniques to strengthen the long term competitive position of Flanders in the off-shore market (overall objective of the SIBO-program)

In order to keep a clear focus in this program during its initial stages, while also respecting budget constraints, its scope has been oriented towards iron-based alloys under combined corrosion-fatigue-abrasion conditions. A further future extension of this program towards e.g. Al-based alloys has already been envisaged, while also the interaction between artic off-shore conditions and toughness has already been raised as an additional axis.

On a macro-economical level, the valorization of the SIBO-program MaDurOS is linked to the realization of the international targets for the implementation of wind energy both on- and offshore: wind energy must become economical competitive with fossil fuel and nuclear power generation. Foundations represent roughly 30% of the total turbine cost. It is clear that the trend towards bigger turbines placed into deeper waters is having a direct impact on the foundations on which the wind turbines are placed. The realization of the 2020 objectives (both on- and off-shore) will have a significant impact on the material (steel) consumption to construct those foundations, especially since the off-shore variants are significantly more material intensive than their on-shore counterparts. Over the next 10 years, the wind-energy segment in Europe is expected to consume an average of 1.5 million tons of steel per year, which accounts for a total material cost of 900 million EUR per year. If we now imagine that new developments with regards to materials production, welding and assembly processes, design and fabrication, fatigue and corrosion resistance, … could allow for a 10% more efficient material use in foundations, than this would bring about 90 million EUR annual direct savings, which most likely need to be doubled when taking also all indirect savings into account.

A similar reasoning could be set-up for the cast parts in the nacelle, which account for up to 60% of the total nacelle weight and for which weight reduction targets of up to 25% are set forward by experts.

Besides the costs involved with the production of a wind turbine, the total cost of electricity (COE) is also dependent on the installation costs. In the case of off-shore wind turbines one can notice an increasing diversification of dredging companies in the installation business, which isn‟t surprising at all given their long-term experience in the off-shore context.

Since 2000, the dredging market turnover has nearly tripled. At the end of 2011 the global turnover for the dredging industry was estimated to be almost 11 billion EUR as opposed to 4 billion EUR at the end of 2000. Turnover in the dredging market has also increased in Europe, from EUR 800 million in 2000 to EUR 1,850 million in 2010.

Corrosion, fatigue and abrasion

Offshore structures, and the equipment used in offshore construction (dredgers, construction vessels, …) are subject to corrosion, fatigue and abrasion. This leads to high operational and maintenance costs, and in some cases to dramatic failure. In all these instances, development and testing of new materials is difficult and very costly because only full scale testing can corroborate the improved performance. Predictive models have the potential to close the gap between development and full scale application.

Abrasion and corrosion of vessel‟s structure

At this moment the affected areas of the vessel‟s steel construction are provided with wear and corrosion allowances. During the lifetime of the vessel, part of the structure will need to be replaced by new constructions. Improved or new materials may reduce the need of providing extra allowances, and the cost of repairing and replacing worn or corroded structural parts.

The Jan De Nul Group fleet consists of 26 hopperdredgers ranging from 2320 to 46000 m_3 hopper capacity. Replacing of the hopper plating may be required after every 8 to 12 years of operation.

Abrasion wear

Wear resistant parts are installed in the dredge pumps and pipeline systems. These wear resistant materials are mostly white irons, with insufficient structural strength and ductility. As a result, the pump and pipeline systems are in “double-walled” execution, i.e. with wear resistant component in contact with the dredged spoil, and a structural pressure resistant component. Improved or new materials can reduce the amount of wear parts used; also, they may eliminate the need to have “double-walled” executions of these parts.

A similar process occurs in stone dumping systems. However, in this case corrosion is a more important parameter.

Presently, development is based on full scale testing of new materials on board; this involves high costs, and results are not clear in view of the very variable operation conditions on a dredger.

Presently, the fleet of Jan De Nul Group consumes yearly about 1250 tons of iron-based (cast iron and cast steel) wear products in the dredging installations. This offers a huge potential for improvement.

Low cycle fatigue and corrosion

Some parts of Cutter Dredgers are subjected to very high cyclical loads, in combination with corrosion. Cracks will appear and in some cases dramatic failure occurs. Improved or new materials should increase the capacity of these systems, and result in a more predictable performance. The potential benefit of avoiding similar failures is evident.

Next to this macro-economical valorisation, a successful realisation of the objectives of this SIBO-program will also contribute to creation or preservation of employment. Today the off-shore wind sector employs roughly 35.000 FTE‟s in Europe. According to an Agoria publication of 03/07/2012, a total of 6040 employees (3476 direct + 2564 indirect) are active within this segment in Belgium, the vast majority of which (58%) is related to materials and components production. By 2020 these figures are projected to grow to respectively 170.000 in Europe and 13.000 in Belgium.

When only direct employment is considered, the dredging sector occupies 25.000 FTE‟s, with the four largest European dredging companies alone almost doubling their workforces in recent years.

Indirect employment accounts for another 48.300 FTE‟s including suppliers, shipbuilders and consulting engineers.

As was mentioned by Jos Beurskens from ECN, large scale experimental facilities act as a magnet for industrial high-tech activities, they enhance the position of local enterprises and facilitate establishing new innovative companies, while unique facilities also attract international business.