1.0 Introduction

Europe maintains the largest amount of cumulative installed wind capacity in the world and remains the second biggest annual market. During 2011, according to European Wind Energy Association (EWEA) statistics, the European Union’s (EU) wind energy market remained stable compared to the previous year as 9,616 MW of new capacity were commissioned compared to 9,648 MW in 2010.

Of the 9,648 MW of new turbines, 866 MW were installed offshore. However, the amount of new offshore installations decreased slightly (-1.9%) compared to the previous year due to harsh weather conditions in the last weeks of the year delaying work to make connections. However, considerable preparatory work was carried out on new offshore projects and numerous financing deals were concluded, suggesting solid future growth in this sector.

1.1 Overall capacity increases

Wind power capacity increases were led by Germany where 2,086 MW of new capacity were installed during 2011. The United Kingdom (UK) came in second with 1,293 MW, 752 MW (58%) of which were offshore, followed by Spain with 1,050 MW. Italy (950 MW), France (830 MW), and Sweden (763 MW) were followed by Romania (520 MW).

Among the emerging Central and Eastern European markets, after Romania, Poland installed the second most capacity in 2011 (436 MW). Both remain among the ten biggest European markets for the second year running.

Annual installations in the three pioneering wind power Member States has been decreasing. In 2000, 85% of all new installations in the EU were in Germany, Spain or Denmark, whereas in 2011 this share decreased to 34%. Wind power is increasingly being installed across Europe.

At the end of 2011, there were 93,957 MW of total installed wind capacity in the EU, an 11% increase compared to the previous year. This amount of capacity will, in a normal wind year, produce 204 TWh of electricity, enough to meet 6.3% of overall EU electricity consumption (up from 5.3% in 2010).

Over 29 GW (31% of the EU total) is installed in Germany, Spain has the second biggest wind power capacity, almost 22 GW (23% of the EU total). France (6.8 GW) has the third biggest installed capacity, taking the position that was formerly Italy’s (6.7 GW). The fifth largest installed wind power base is in the UK (6.5 GW).

In terms of new power generating installations as a whole, 2011 was a record year in the EU, with 44.9 GW of new capacity connected to the grid, a 3.9% increase compared to 2010. Wind power accounted for 21.4% of new installations, the third biggest share after solar PV (46.7%) and natural gas (21.6%).

No other technologies compete to wind, PV, and natural gas in terms of new installations. New coal installations represented 4.8% of capacity additions, fuel oil 1.6%, large hydro 1.3% and CSP 1.1%. Nuclear, biomass, waste, geothermal, and ocean technologies each represented less than 1% of new capacity installations.

In 2000, new renewable power installations totaled 3.5 GW. Since then, renewable capacity installations grew almost tenfold, to reach 32 GW in 2011. Moreover, the share of new RES installations has also increased steadily, from 13% to 71% in 2011.

During 2011, 6.3 GW of nuclear capacity was decommissioned and over 1 GW of fuel oil capacity was taken offline. More renewable generating capacity was installed in the EU than ever before representing 71.3% of all new installations. Since 2008, renewable capacity installations have represented more than half of all new installed capacity.

In total, 302.6 GW of new power capacity has been installed in the EU since 2000. Of this, 28.2% was wind power, 47.8% renewables, and 90.8% renewables and gas combined.

The net growth since 2000 of gas power (116 GW), wind power (84.2 GW) and PV (47.4 MW) was at the expense of fuel oil (down 14.2 GW), nuclear (down 13.5 GW) and coal (down 10.3 GW). A sharp decrease was seen in 2011 in nuclear capacity due to the early decommissioning of a number of reactors in Germany. The other renewable technologies (hydro, biomass, waste, CSP, geothermal and ocean energies) have also been increasing installed capacity over the past decade, albeit more slowly than wind and PV.

The 21st century sees the EU power sector moving away from fuel oil, coal, and nuclear while continuing to increase its total installed capacity with gas, wind, and PV to meet increasing demand.

1.2 Offshore wind

In European waters, 235 new offshore wind turbines, in nine wind farms, were fully grid connected during 2011. By the end 2011, 1,371 turbines were fully grid connected, totaling 3,813 MW in 53 wind farms in ten European countries. During the year, work was carried out on 15 offshore wind farms. Additionally, preparatory onshore work began in eight additional projects and preliminary work was concluded, suggesting solid future growth in this sector.

With 752 MW grid-connected in British waters during 2011, 87% of new capacity was added in the United Kingdom. In Germany, 108 MW were added, a 3.6-MW turbine was grid connected in Denmark, and a full scale 2-MW floating prototype was installed in Portugal. Two other down-scaled floating prototypes were tested in Norway and Sweden.

The UK is by far the largest market for offshore wind power with 2,094 MW installed, representing over half of all installed offshore wind capacity in Europe. Denmark follows with 857 MW, then the Netherlands (247 MW), Germany (200 MW), Belgium (195 MW), Sweden (164 MW), Finland (26 MW), and Ireland (25 MW). Norway and Portugal both have a full-scale floating turbine.

By early 2012, almost 5.3 GW of offshore wind capacity was under construction. Once completed, installed
offshore capacity in Europe will reach 9 GW. Furthermore, EWEA has identified 18 GW of fully consented offshore projects in 12 European countries.

2.0 R, D&D
Wind Energy Projects

In 2011, around 20 R&D projects were running with the support of the Sixth (FP6) and Seventh (FP7) Framework Programmes of the EU (the Framework Programmes are the main EU-wide tool to support strategic research areas). The management and monitoring of these projects is divided between two Directorate-Generals (DGs) of the EC: the Directorate-General for Research and Innovation (DG Research) for projects with medium- to long-term impact and the Directorate-General for Transport and Energy (DG ENER) for demonstration projects with short- to medium-term impact on the market. The following paragraphs summarize both the nature and the main data of EU R&D initiatives funded projects during 2011 managed by DG Research.

2.1 DG Research activities

The last FP6 project UPWIND and two FP7 projects, RELIAWIND and ORECCA finished in 2011. The other FP7 projects SAFEWIND, Marina...
Platform, HAWE, DeepWind and HiPRwind continued their activities while one new project, ClusterDesign, started at the end of the year. The following gives some details about those projects:

UPWIND: This Integrated Wind Turbine Design (www.upwind.eu) activity, started in March 2006 to tackle, over six years, the challenges of designing very large turbines (8 to 10 MW), both for onshore and offshore. UPWIND focuses on design tools for the complete range of turbine components. It addresses the aerodynamic, aero-elastic, structural, and material design of rotors. Critical analysis of drive train components is also being carried out in the search for breakthrough solutions. UPWIND is a large initiative composed of 40 partners and brings together the most advanced European specialists of the wind industry.

RELIAWIND: Offshore wind energy is called to play a key role in the achievement of the EU 2020 objectives. Currently, offshore maintenance costs are still too high and thus require higher feed-in tariffs for the private investor’s business case to reach minimum profitability. The RELIAWIND project aims to offset this paradigm and allow offshore wind power to be deployed in the same way onshore wind power has been. Based on the success of collaborative experiences in sectors such as aeronautics, members of the European wind energy sector established the RELIAWIND consortium to jointly and scientifically study the impact of wind turbine reliability. The mission of the consortium was to change the paradigm of how wind turbines are designed, operated, and maintained. This will lead to a new generation of offshore (and onshore) wind energy systems that will hit the market in 2015. RELIAWIND started in March 2008 and continued for 36 months. This research project has achieved many results related to the following objectives:

- To identify critical failures and components (WP-1: Field Reliability Analysis)
- To understand failures and their mechanisms (WP-2: Design for Reliability)
- To define the logical architecture of an advanced wind turbine generator health monitoring system (WP-3: Algorithms)
- To demonstrate the principles of the project findings (WP-4: Applications)
- To train internal and external partners and other wind energy sector stakeholders (WP-5: Training)
- To disseminate the new knowledge through conferences, workshops, web site, and the media (WP-6: Dissemination).

SAFEWIND: The integration of wind generation into power systems is affected by uncertainties in the
forecasting of expected power output. Misestimating of meteorological conditions or large forecasting errors (phase errors, near cut-off speeds, etc.), are very costly for infrastructures (such as unexpected loads on turbines) and reduce the value of wind energy for end-users. The state-of-the-art techniques in wind power forecasting have focused so far on the “usual” operating conditions rather than on extreme events. Thus, the current wind forecasting technology presents several strong bottlenecks. End-users argue for dedicated approaches to reduce large prediction errors and for scaling up local predictions of extreme weather (gusts, shears) to a European level because extremes and forecast errors may propagate. Similar concerns arise from the areas of external conditions and resource assessment where the aim is to minimize project failure. The aim of this project is to substantially improve wind power predictability in challenging or extreme situations and at different temporal and spatial scales. Going beyond this, wind predictability will be considered as a system parameter linked to the resource assessment phase, where the aim is to make optimal decisions for the installation of a new wind farm. Finally, the new models will be implemented into pilot operational tools for evaluation by the end-users in the project. SAFEWIND started in September 2008 and will last for 48 months. The project concentrates on:

- Using new measuring devices for a more detailed knowledge of the wind speed and energy available at local levels
- Developing strong synergy with research in meteorology
- Developing new operational methods for warning/alerting that use coherently collected meteorological and wind power data distributed over Europe for early detection and forecasting of extreme events
- Developing models to improve medium-term wind predictability
- Developing a European vision of wind forecasting that takes advantage of existing operational forecasting installations at various European end-users.

ORECCA: The objectives of the Offshore Renewable Energy
Conversion Platforms – Coordination Action are to create a framework for knowledge sharing and to develop a research roadmap for activities in the context of offshore renewable energy (RE). In particular, the project has stimulated collaboration in research activities leading towards innovative, cost efficient, and environmentally benign offshore RE conversion platforms for wind, wave and other ocean energy resources, for their combined use as well as for the complementary use such as aquaculture and monitoring of the sea environment.

The use of the offshore resources for RE generation is a relatively new field of interest. ORECCA has contributed to overcome the knowledge fragmentation existing in Europe and to stimulate the key experts to provide useful inputs to industries, research organizations and policy makers (stakeholders) on the necessary next steps to foster the development of the ocean energy sector in a sustainable and environmentally friendly way. A focus was given to respect the strategies developed towards an integrated European maritime policy. The project has defined the technological state of the art, described the existing economical and legislative framework and identified barriers, constraints and needs within.

ORECCA has enabled collaboration of the stakeholders and defined the framework for future exploitation of offshore RE sources by defining two approaches: pilot testing of technologies at an initial stage, and large scale deployment of offshore RE farms at a mature stage. ORECCA has finally developed a vision including different technical options for deployment of offshore energy conversion platforms for different target areas in the European seas and delivered integrated roadmaps for the stakeholders. These will help to define the strategic investment opportunities, the R&D priorities and the regulatory and socio-economic aspects that need to be addressed in the short to the medium term to achieve a vision and a strategy for a European policy towards the development of the offshore RE sector aims to overcome knowledge fragmentation in Europe, with a focus on platform designs and technologies including supply chain issues.

Marina Platform: Research in the MARINA Platform project will establish a set of equitable and transparent criteria for the evaluation of multi-purpose platforms for marine renewable energy (MRE). Using these criteria, the project will produce a novel, whole-system set of design and optimization tools addressing: inter alia, new platform design, component engineering, risk assessment, spatial planning, and platform-related grid connection concepts, all focused on system integration and reducing costs. These tools will be used, incorporating into the evaluation all, presently known proposed designs including (but not limited to) concepts originated by the project partners, to produce two or three realizations of multi-purpose renewable energy platforms. These will be brought to the level of preliminary engineering designs with estimates for energy output, material sizes and weights, platform dimensions, component specifications and other relevant factors. This will allow the resultant new multi-purpose MRE platform designs, validated by advanced modeling and tank-testing at reduced scale, to be taken to the next stage of development, which is the construction of pilot scale platforms for testing at sea.

HAWE (High Altitude Wind Energy): The quest for clean and renewable energy sources found tremendous potential in wind power. So far, it has been harvested mostly by wind towers, which use only wind currents close to the ground (bellow 200 m). Since low altitude wind currents are slow and intermittent, most wind farms operate, on average, 25-35% of their capacity. This represents a severe limitation to current state-of-art wind power technology, as towers can hardly be taller than 130 m without prohibitive costs and insurmountable technical difficulties. To bypass these difficulties, it is proposed to perform R&D in a multitude of technology fields such as materials, aerodynamics, and control, further developing a wind power system capable of harnessing the energy potential of high altitude wind without the need for heavy towers or expensive elevated nacelles. HAWE consists of a buoyant air ship anchored to a ground station by a tether cable operating a two phase cycle. During the power production phase the airborne module generates lift, pulling up the tether cable which, at the ground station, is in a winch drum driving a flywheel connected to an alternator producing electricity. When the tether cable
is fully unwound, the recovery phase starts - as the cylinder rotation ceases and the cable is reeled back to its initial position decoupled from the flywheel, completing a cycle. This is performed continuously. The successful implementation of this concept will increase the share of renewable energy in Europe since the achievement of the goal to produce renewable energy at competitive prices with coal derived energy should lower its cost. A high security of supply, a cleaner environment, and the possibility to keep Europe as a global leader in wind power, are other benefits of this technology.

DeepWind: The hypothesis of this project is that a new wind turbine concept developed specifically for offshore application has potentials for better cost efficiency than existing offshore technology. Based on this hypothesis the objectives are:

• to explore the technologies needed for development of a new and simple floating offshore concept with a vertical axis rotor and a floating and rotating foundation
• to develop calculation and design tools for development and evaluation of very large wind turbines based on this concept and
• evaluation of the overall concept with floating offshore horizontal axis wind turbines.

Upscaling of large rotors beyond 5 MW has been expressed to have more cost potentials for vertical axis wind turbines than for horizontal axis wind turbines due to less influence of cyclic gravity loads. However, the technology behind the proposed concept presents extensive challenges needing explicit research, especially: dynamics of the system, pultruded blades with better material properties, sub-sea generator, mooring and torque absorption system, and torque, lift, and drag on the rotating and floating shaft foundation.

In order to be able to evaluate in detail the technologies behind the concept the project comprises:

• numerical tools for prediction of energy production, dynamics, loads and fatigue,
• tools for design and production of blades
• tools for design of generator and controls,
• design of mooring and torque absorption systems, and
• knowledge of friction torque and lift and drag on rotating tube.
• The technologies need verification, and in the project verification is made by:
  • proof-of-concept testing of a small, kW sized technology demonstrator, partly under real conditions, partly under controlled laboratory conditions,
  • integration of all technologies in demonstration of the possibility of building a 5 MW wind turbine based on the concept, and an evaluation of the perspectives for the concept.

HiPRwind: The aim of the HiPRwind project is to develop and test new solutions for very large offshore wind turbines at an industrial scale. The project addresses critical issues of offshore wind turbine technology such as extreme reliability, remote maintenance and grid integration with particular emphasis on floating wind turbines, where weight and size limitations of onshore designs can be overcome. HiPRWind will test a cost effective approach to floating offshore wind turbines at a 1:10 lower MW scale as a first of its kind worldwide. Innovative engineering methods, new rotor blade designs and built-in active control features will reduce the dynamic loads and thus weight and cost drastically compared to existing designs. It will overcome the gap in technology development between small scale tank testing and full scale offshore deployment. Thus HiPRWind will significantly reduce risk and cost of deep offshore technology commercialization.

The HiPRwind project can make use of two existing offshore test areas, with a favorable permitting situation and suitable infrastructure such as the grid connection and monitoring facilities. In WP 1, a floating support structure and the moorings system will be designed and manufactured. WP 2 covers the operation of the research projects of the platform. Within WP 3 to 6, critical aspects of the floating wind turbine are investigated, such as the structure and its system dynamics, the controller, high reliability power electronics to be tested in the lab at a multi-MM scale, the condition and structural health monitoring systems and the rotor based on innovative blade designs and features. The results feed into WP 7 to identify and refine new concepts for very large offshore wind turbines. The full impact of the project is ensured by a strong participation of leading industrial as well as R&D stakeholders from the offshore-maritime and the wind energy sector with a strong background in harsh environment industrial developments.

ClusterDesign: Today, an offshore wind farm is merely a collection of wind turbines where the components of an offshore wind farm cluster are optimized but not the overall cluster. In the future, the best-performing wind farms will be designed with an integrated approach. For this purpose, design tools for offshore wind farm clusters must then yield for the overall optimum. This means they must integrate the cluster and grid connection design with new intelligent mechanisms for wind turbine, farm, and cluster control already in the design phase.

The objective of the project is to develop toolbox for such an integrated offshore wind farm clusters design. In line with the call this is achieved by combination of the following different design optimization tools elements as advanced wake models, turbine load models, grid interconnection models, and by incorporating the operation of the offshore clusters as a virtual offshore power plant. The consortium will depart from existing state of the art models that are further developed within the project. In parallel, extensive measurements and data collection is carried out in order to validate the models, to calibrate and further improve them. Furthermore the developed control mechanisms for virtual offshore power plant operation will be tested in existing wind farms to verify that indeed an increase of the overall energy yield, a reduction of load on the single turbines, and a flexible operation of the wind farm clusters is achieved.

2.2 Future R&D projects

New FP7 projects to start in 2012 will address the topics of innovative wind conversion systems (10 to 20 MW) for offshore applications (EC Call FP7-ENERGY-2012-1) and demonstration of innovative designs to reduce fatigue loads and improve reliability
of multi-MW turbines (FP7-ENERGY-2012-2). R&D for offshore wind energy is also included in the 2011 “Ocean of Tomorrow” topic “multi-use offshore platforms”.

3.0 Plans and Initiatives
The Strategic Energy Technology Plan (3) is a pragmatic and pioneering tool for supporting the development of low carbon technologies to significantly contribute to the European energy and climate change objectives. As part of this plan, eight European Industrial Initiatives were set up to include the industrial sector in setting priorities, objectives, activities, and in identifying the financial and human needs to make a step change in the energy sector (including in wind power).

The European Wind Initiative, which was launched in June 2010, has the objective to make wind one of the cheapest sources of electricity and to enable a smooth and effective integration of massive amounts of wind electricity into the grid. To achieve this, special efforts will be dedicated to greatly increase the power generation capacity of the largest wind turbines (from 5 to 6 MW to 10 to 20 MW) and to tap into the vast potential of offshore wind. This will pave the way for achieving ambitious targets by 2020:

• Supplying up to 20% of the EU electricity consumption
• Making wind energy the most competitive energy source
• Enabling the development of new types of turbines reaching up to 20 MW.

The European Wind Initiative, which has a budget of 6 billion EUR (7.76 billion USD) (public and private resources) for the 2010 to 2020 period, is now being implemented by EU institutions, increasing funding to EU wind energy R&D, and Innovation; Roberto Gambi, European Commission, DG ENER; Dorina D’Estaintot, European Commission, DG RESEARCH; Thierry Langlois d’Estaintot, European Commission, DG Research, Office CDMA 5/138 B-1049 Brussels Belgium Tel. direct: +32-2-295.07.65 Fax: +32-2-299.49.91 Email: thierry.d’estaintot@ec.europa.eu

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5.0 The European Wind Energy Technology Platform
5.1 Description
The European Wind Energy Technology Platform (TPWind) was officially launched on 19 October 2006, with the full support of the EC and the European Parliament. Tpwd is an industry-led initiative, The Secretariat is composed of the EWEA, Garrad Hassan, and Risø DTU. Its objectives are to identify and prioritize areas for increased innovation, new and existing research, and development tasks and to formulate relevant funding recommendations to EU and national public authorities in order to support wind power R&D.

Historically, the main drivers for wind energy cost reductions have been R, D&D, for approximately 40% and economies of scale for around 60%. The scope of the TPWind mirrors this dual focus: TPWind focuses not only on short-term technological R&D but also on market deployment. This is reflected in the TPWind structure, which is composed of four technical working groups a one working group focusing on policy issues.

Further to that, TPWind also has a Member States Mirror Group gathering representatives from national governments. The Platform is led by a Steering Committee of 25 Members, representing a balance between the industry and the R&D community, and between European countries. Altogether, TPWind is composed of approximately 150 high-level experts representing the whole wind industry.

Since December 2010, TPWind selected an Advisory Board composed of external stakeholders that acts as a quick access point to the expertise and know-how developed by other sectors, which is essential to reduce fragmentation of R&D activities. TPWind also provides an opportunity for informal collaboration and coordination between EU member states, including those less developed in wind energy terms.

5.2 Achievements
The main deliverables of the Platform so far are the following:

• The Strategic Research Agenda / Market Deployment Strategy (SRA/MDS), which outlines the main R&D challenges faced by the EU wind energy sector (published in 2008);
• The European Wind Initiative (EWI), a long-term, large-scale program for improving and increasing funding to EU wind energy R&D. The EWI, which is rooted in the EU Strategic Energy Technology Plan (SET-Plan) was published by the European Commission in 2009 and is now being implemented by EU institutions, member states, and TPWind. The budget of the EWI for the 2010-2020 period is 6 billion EUR (7.76 billion USD), including public and private resources.

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