Wind Energy sector skills in Europe

2015-1-ES01-KA202-015935

Co-funded by the Erasmus+ Programme of the European Union

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1. Introduction

In order to evaluate the transverse skills needed to qualify the wind energy sector stall and normalize the training at European level it is necessary to analyze the skills that this sector job market is demanding in the different countries that form part of this consortium.

Having in mind the standardization, a research has been done focusing in the European Market to analyze the wind industry sector and its prospective growth in the future years which could affect employment requiring a very high number of qualified personnel. As is later mentioned the trend is an increasing of the number of people to be employed in the sector due mainly to two factors:

- The progressive ageing of the existing wind farms
- The growth of the sector at worldwide level.

The structure of the contents of the SKILLWIND Serious-Game manuals have been developed being compared with the main European training programs for the purpose of obtaining a training material in wind energy that includes the wider variety of skills as possible. In principle the goal of SKILLWIND is centered in on-shore installations but many of its results can be extended to off-shore installations excluding the sea transport of men and equipment.

In Europe, there is then a wide diversity of general training programs related to maintenance of wind installations and focused on different issues following the experience and structure of the maintenance companies in each country. In this sense, the countries with more extended experience have been selected and among them the following differences can be mentioned: Denmark is the country with a more diversified ownership of the wind farms and therefore the installations are small, and the maintenance is carried out by small and medium size companies locally seated.

On the other hand, Spain has a great presence of utilities and construction companies and therefore the ownership is concentrated which has made that the windfarms have an average size of nearby 30 MW and many of them are in the same hands. This structure has also affected to the maintenance companies and it is the country with a great number of ISP (Independent Services Providers) not directly linked to either the OEMs or the owners of the plants. A great number of these ISPs have their own maintenance training courses which have been used as a base of the SKILLWIND guidelines.

Lately, Germany has a structure of the ownership and of the wind farms more similar to Denmark than Spain but in the last years some maintenance companies have been created linked to the Wind Farm owners, so they cannot be considered as pure ISPs, but they train their own staff but not in a similar systematized scheme such as of their Spanish competitors.

Therefore, to pursue the evaluation task the Reference training organizations in Europe in wind energy training have been chosen from those countries[1]: BZEE Academy, the Danish Wind Power Academy and the GWO basic technical training.

A. **BZEE** is a German academy was founded in 2000 and it has become a European model in wind energy training. From the beginning its aim was to fill the qualification gasp within the wind energy sector. Nowadays BZEE is present in 29 different locations offering wide programs in wind energy training oriented to the development of skills needed in the wind energy industry in order to provide with qualified technicians for the production, installations, commissioning as well as maintenance and operation of wind turbines.

B. The **Danish Wind Power Academy** provides with training and services for the main wind turbine owners and manufactures across the globe. It was founded in 2004 and offers a wide variety of training courses to qualify technicians from the main wind turbine owners and operations as well as service providers.

C. **GWO** is a not-for-profit association of wind turbine manufacturers and wind farm owners with the aim to strive towards and injury-free work environment in the wind industry through cooperation among the members and other stakeholders in setting common standards for safety training.

To complement the comparison between these three training courses reference it has been also included the based developed by the previous WINDSKILL project also financed by the EC and ended in 2011, which main goal was to develop too a standard of the windfarms maintenance. SKILLWIND goes a step beyond because not only proposes the course structure but also has developed the main contents which could also be completed by the different centers who will follow the SKILLWIND methodology.

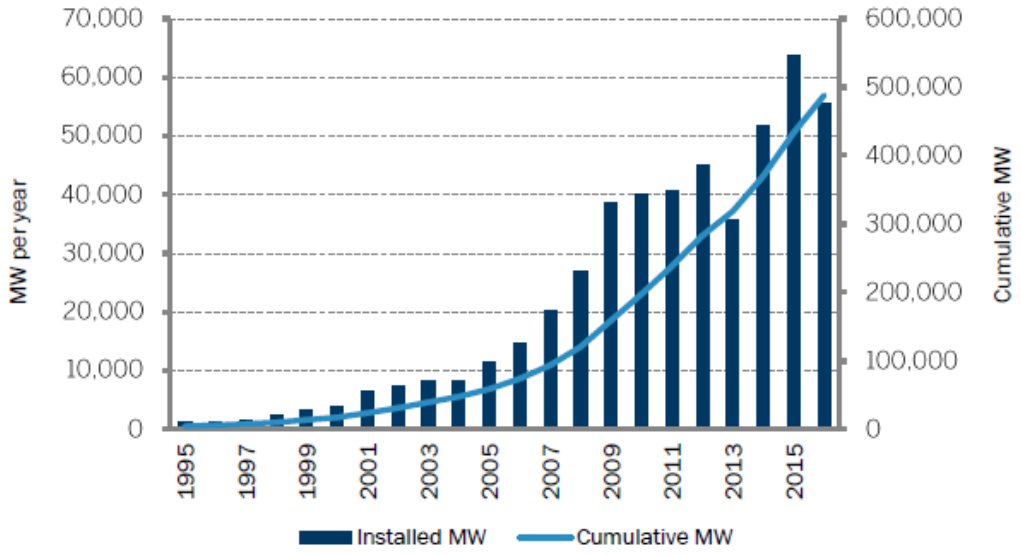
[1] The case of Italy, country of the ANEV partner, is rather more complex as far as the maintenance is carried out by foreign companies and they do not have specific training courses.

The main aim of this parallel analysis is to obtain a summary of the wind industry situation to develop solid content structure for the SKILLWIND training modules that would fill the gap of current training requirements in the wind industry and in parallel, it will allow to standardize the training courses to facilitate the employment of students as well as their integration in different markets. Similarly, to GWO the intention of the partners is to create in the future a certain quality identification of the students trained using the SKILLWIND model.

It is important to insist that some OEMs and ISPs have their own training courses which follows the approach of the SKILLWIND project: general concepts, training course on specific turbines and special training for some components (in our case, blades and converters). The basic approach is that people involved in for instance preventive maintenance is different of those devoted to the blades reparation and it is always with a very practical orientation.

2. Wind sector employment

To understand the European wind industry and its potential as employment source it must be considered the growth that this sector has experienced during its modern life, having just 13 GW of wind power installed in 2000 and reaching 154 GW at the end of 2016, as is presented in the following figure.



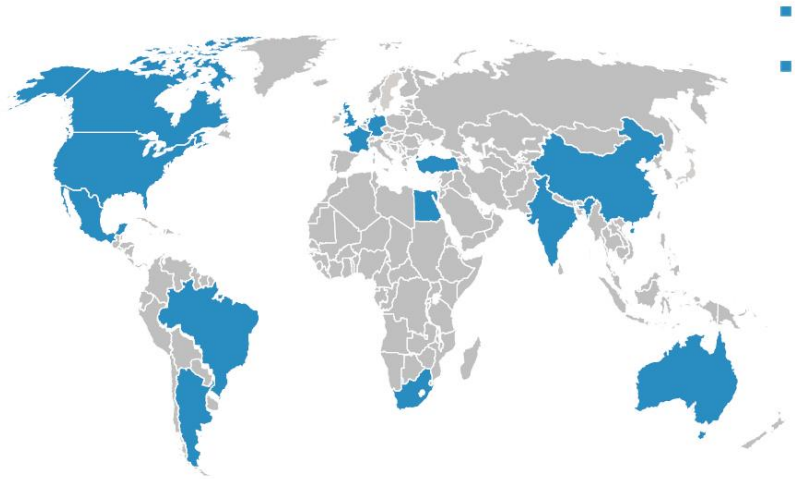
Year	Installed MW	Increase %	Cumulative MW	Increase %
2007	20,286	38%	93,911	27%
2008	26,952	33%	120,725	29%
2009	38,478	43%	159,089	32%
2010	39,989	4%	197,953	24%
2011	40,637	2%	238,139	20%
2012	45,161	11%	283,068	19%
2013	35,655	-21%	318,596	13%
2014	51,716	45%	369,677	16%
2015	63,792	23%	433,118	17%
2016	55,492	-13%	488,259	13%
Compound Average Annual Growth – 10 Years		20.1%		

Figure 1: Wind power growth at worldwide level (Source: FTI Intelligence)

In practice, wind energy is a very young industry with around 20 years of history and where workload is more concentrated in equipment production (with a certain competition from Asian competitors but still much lesser than photovoltaics for instance) and operation and maintenance. The great advantage of this last phase of the supply is that is more sustainable and less affected by regulatory changes and moreover, with a vegetative trend of growth thanks to the fact that existing wind farms are getting older.

It has been also mentioned but the trend observed in the last years is the progressively life extension of the windfarms further than the certificated 20 years by two main reasons: firstly, the owners can increase the economic effectiveness of their investment as far as the possible loan has been already repaid and second, because the reduction of availability is lower than expected in the financial models. Nowadays, it is usual to plan the operation of the windfarms for at least 25 years and even 30, it the assets have been properly maintained making more important the appropriate care of the installations

About the future, in the following figure is presented the markets with more potential for the future, being only a first approach because that potential is conditioned by political decisions and, by the cost of the main competitors, mainly photovoltaic and shale gas.



- The top 15 wind markets are expected to install 515.6 GW, accounting for 83.5% of the new capacity added worldwide in 2017–2026.
- Among the top 15, China is going to add 258 GW of new capacity in 2017–2026, followed by the U.S., Germany, India and France.

Country	Total Installations 2017–2026 (Added MW)
China	258,000
U.S.	65,000
Germany	40,755
India	37,900
France	20,065
Brazil	16,100
UK	14,050
Mexico	11,450
Turkey	11,400
Netherlands	7,750
Canada	7,500
South Africa	7,436
Egypt	6,500
Australia	5,950
Argentina	5,773
Total	515,629

Figure 2: Largest Wind Markets in Terms of New Added Capacity 2017-2016 (Source: FIT Intelligence)

For the period between 2017 -2021 the forecast is based in a combination of bottom-up analysis and a top-down approach is used. Factors considered are mainly those that have an immediate impact on market growth:

- Near-term national energy plans, such as China's 13th Five- Year Plan (for the period 2016-2020)
- Current renewable energy support incentives
- Proposed changes to the market structure, such as the EU's state aid guidelines
- Total projects under construction by the end of 2016
- Total projects either approved by the relevant national authorities or with a signed PPA
- Competitive bidding (auctions) for projects under construction in the near term
- Project pipelines or near-term investment plans of utilities and large energy generation companies
- Infrastructure to support near-term growth, including the electricity grid and road transport
- Deployment of the latest commercial turbine technologies
- Wind turbine pricing and availability of project finance
- New types of wind project investor and owners
- Competitiveness of wind energy compared with other forms of generation, including other renewables, particularly Solar PV.
- Oil/coal/gas prices

- (Financial) ability of project developers and/or contractors to complete specific projects
- Availability of finance (investor appetite)
- Availability of grid capacity/grid connection

Medium-term forecast period (2022-2026), due to the additional uncertainty associated with a longer-term prediction, a top-down approach is deployed for the medium-term forecast period. Factors considered are those that impact the medium to long-term market growth.

- Medium or long-term national (renewable) energy plans/targets
- Regional renewable energy binding/non-binding targets
- Positive outcomes from the latest UN Framework Convention on Climate Change and commitments for CO2 emissions reduction made by the world's biggest emitters
- Level of concern about energy security
- Expected global electricity demand as forecast by the International Energy Agency
- Availability of wind resources and technology breakthroughs for wind turbines and balance of plant
- Infrastructure improvement and a market's ability to integrate wind — for example, a fully integrated European electricity transmission system and sufficient investment in the power grid in China, the U.S. and other developing markets
- Previous market growth patterns for markets with similar conditions
- Cost of onshore and offshore wind energy and its expected ability to be cost-competitive with conventional energy sources, especially, coal and gas.
- Forecasted penetration rate of wind power electricity in the global electricity supply
- The size of the repowering market
- Carbon pricing in Europe and the recently announced carbon emissions trading system in China
- Oil/coal/gas prices
- Population growth and GDP per capita
- Wind turbine pricing and availability of project finance

In the following figure is presented the Annual Growth Rate and in can be observed a continuous growth even in some years there is a certain stabilization related to the decrease of the German market among other things the fulfillment of the EU Directive.

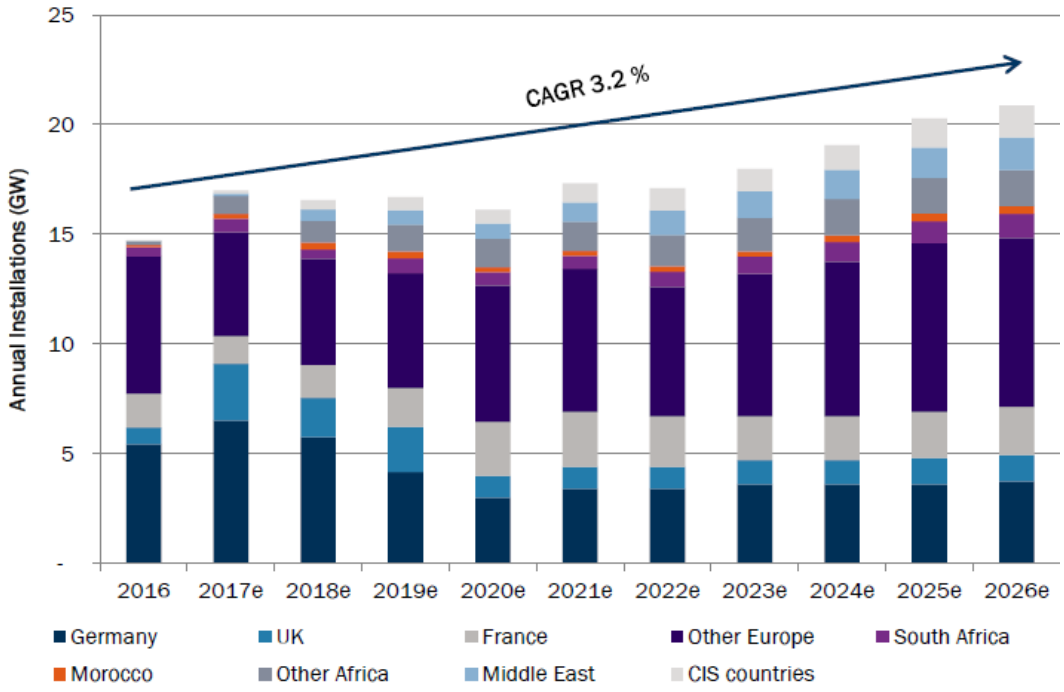


Figure 3: Forecast of wind growth 2016-2026 (Fuente: IT Intelligence)

Following this trend of market evolution as well as the progressive ageing of the existing wind farms the increase of jobs in O&M is presented in the following figure.

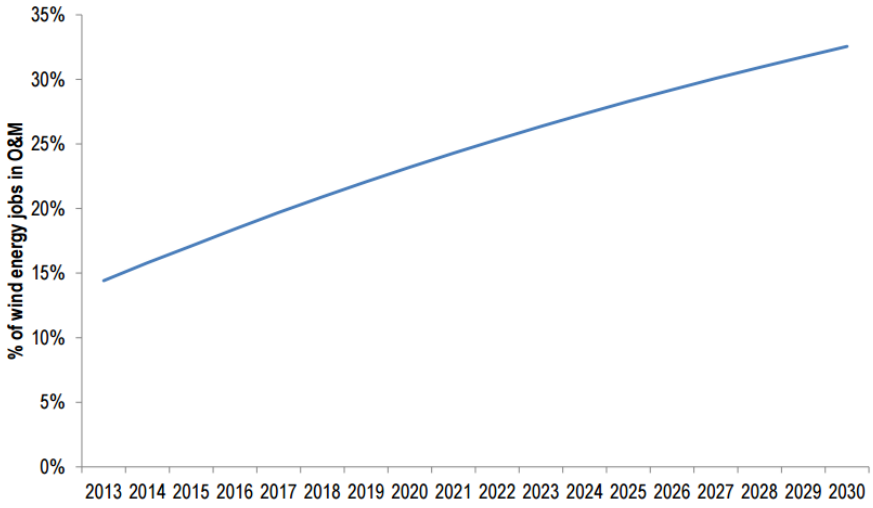


Figure 4. Operation and Maintenance jobs evolution (Source: TPWind Report)

As it can be observed in the figure above almost a linear growth rate in Operation and Maintenance jobs have happened since 2013 and it is expected to keep that progression to fulfill the horizon 2020 and 2030 goals. Furthermore, it is also important to keep in mind the important presence of European companies, OEMs and ISPs, and the progressive delocalization of the workforce making very important their formation in different geographical areas.

In this sense, it is the activity of Operation and maintenance that would be requiring the higher amount of trained personnel and would experience the higher growth rate. The figure below shows the expected employment increase structured by the main activities in the wind industry. And as it can be observed the Operation and maintenance personnel is expected to double from 2020 to 2030.

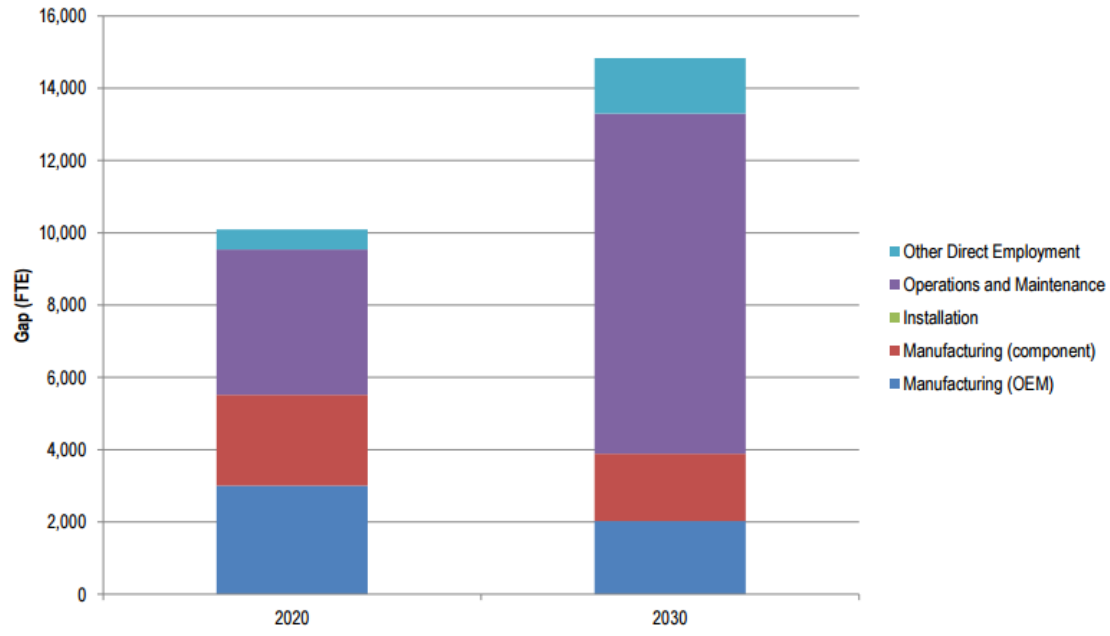


Figure 5. Wind industry estimated employment growth (Source: Wind Europe)

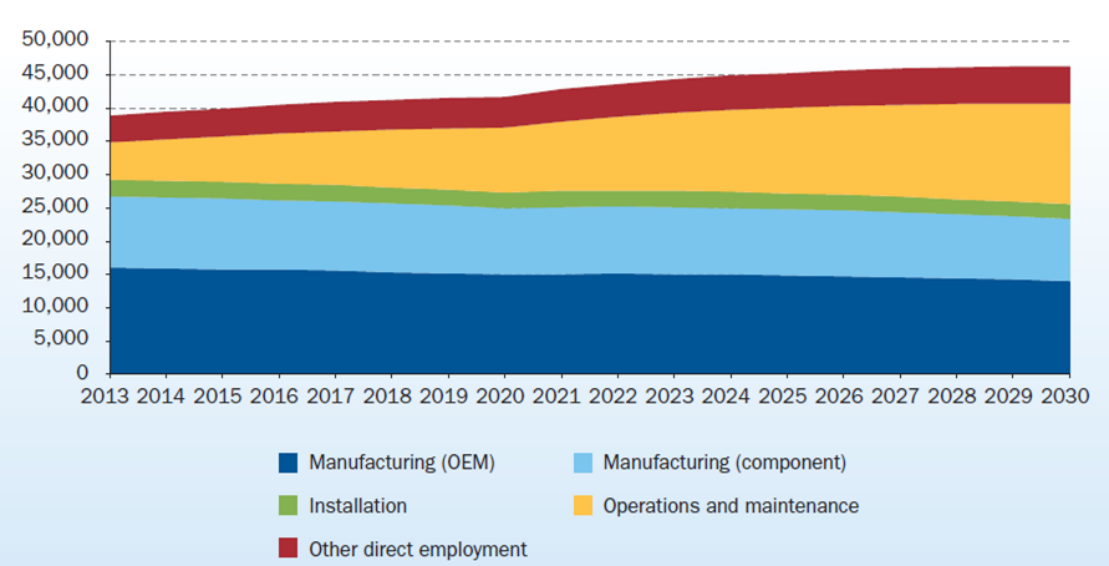


Figure 6. Job creation rate in the Wind energy sector (Source: TPWind survey)

In the following image it can be observed the current employment number related to the renewable energies and its division per technology. As it can be seen more than one million personnel works for the wind industry globally.

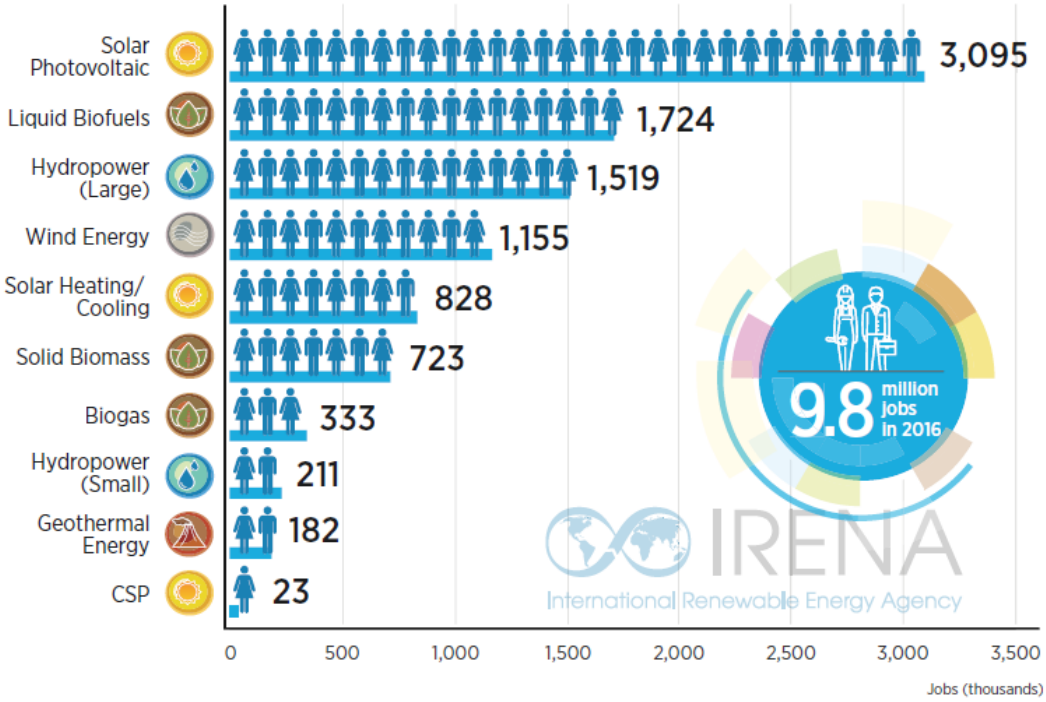


Figure 7. Renewable energy global workforce (Source: IRENA)

As it can also be seen in the figure 8, which shows the Renewable energy workforce evolution, there has been a continuous growth in renewable energies employment. In 2016 this sector

employed 9.8 million people which represent a 1.1% increase over 2015. In the wind energy sector, the latest new wind installations in the United States, Germany, India and Brazil contributed to a 7% increase in global wind employment, which reached 1.2 million jobs.

In Europe, during 2016 there was a slight increase in power installation. This fact helped a 10% job increase in offshore employment in Germany, but total wind employment decreased by 4% due to reduced activity in the onshore sector. Wind energy employment is likely to increase with continuous deployment in line with global climate imperatives which can lead to around 3 million jobs in the sector by 2030.

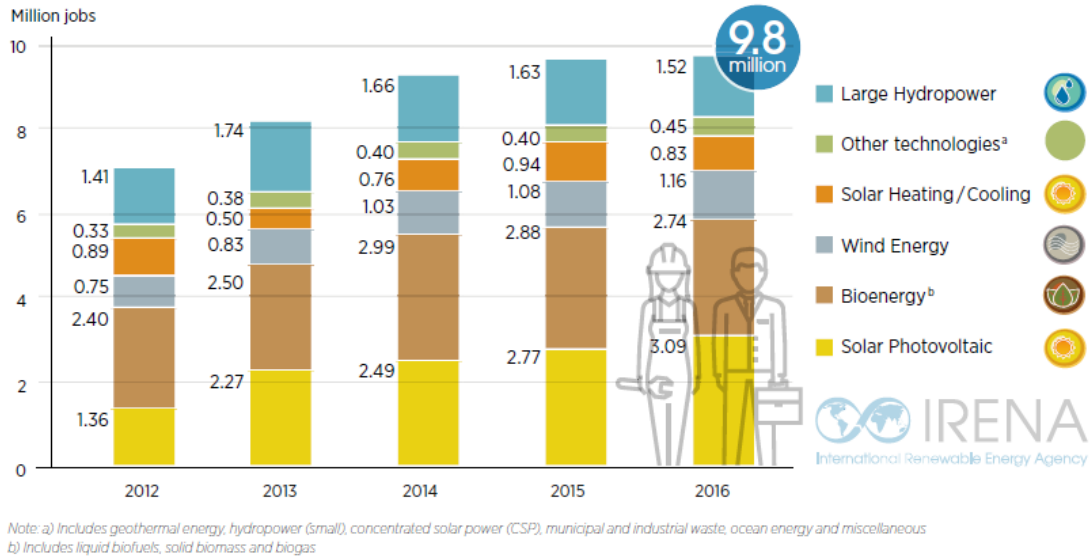


Figure 8. Global renewable energy employment, 2012-2016 (Source: IRENA)

The total power installed in the EU at the year of 2015 was of 145.000 MW and according to the SP and DE standards the number of employees in the maintenance and operation activities is of around 1 person per 6 MW that it means that a total of 25.000 people are employed in these activities. Taking the total power installed at worldwide level will be of 70.000 persons. In these figures are not included labor force manufacturing and repairing components. Furthermore, it is also important to keep in mind that the progressive ageing of maintenance workers who over 45 years have difficulties to work in the harmful and narrow conditions of the old turbines what could be an opportunity for new professionals.

In the EU, there are at least 15.000 Wind farms and some of them are owned by small and medium size companies, mainly in the northern countries, then it is a clear opportunity the methods to evaluate the different options to extend the life of the wind farms and to compare different alternatives, including the replacement of existing WTGs.

This future need of staff answers the wind power to be installed all over Europe to achieve the horizon 2030 goal in renewable energies in addition to the increase in operation and maintenance not only for the wind power increase but for the aging of the wind farms already installed.

In this sense, there is currently a shortage in qualified personnel required by the European wind energy sector each year, reaching 15,000 staff shortage by 2030 if there is not a rise in the number of graduates taking relevant courses. It is an increasing economic concern the lowering numbers of graduates from schools and universities that choose a major in science, technology or engineering. This situation concerns the wind industry where as it was stated the need in adequately trained staff.

In addition, high education programmers normally are focused on academic rather than practical and problem-solving skills which is leading the industry to ask for an EU standardized curriculum.

Besides this group of companies, the staff and operators of the wind farms as a whole can also learn from the experiences in different parts of the world.

Additional renewable energy support policies are needed to help deployment and to create a local workforce that can both increase technology reliability and reduce the need of importing talent. Considering the number of workers in the fossil fuels sectors, training in wind and renewable energy would be the key for transition. Fossil fuel energy sectors will suffer of significant job losses of qualified staff that with appropriate training will be able to shift to the decarbonized energy sector providing this sector of experienced personnel in energy.

Lately, following the accidents statistics of AEE it is observed slight increase of accidents in the maintenance sector as it can be observed in the following figure, the main reasons could be the pressure on prices due to the reduction of income related to the legal reform and the WTGs are getting older. In any case, an appropriate training is always convenient in general but also in HSE matters.

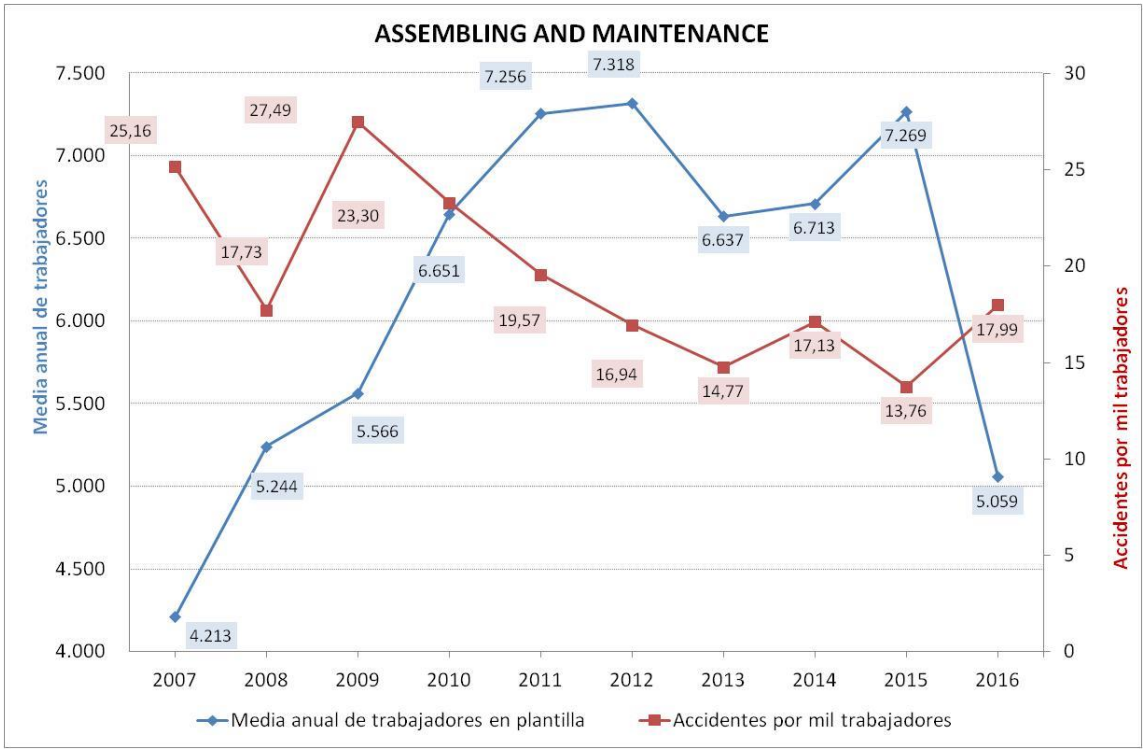


Figure 9: Number of sample employees and accidents by thousands of workers (Source: AEE)

3. European Training programs in Wind Energy

Considering the total wind power installed all over Europe it is understandable the existence of several training programs coordinated by independent bodies and focusing on different professional levels having in mind the current shortage of technicians with specialized skills in wind energy. This shortage could be blamed on the rapid growth of the wind industry added to the wind turbines aging that consequence in a higher demand of operation and maintenance technicians.

As it was stated before a grave shortage of qualified staff in the wind industry has been estimated for the future years to come to succeed in achieving the Renewable energy share that Europe has fixed for 2020 and 2030 horizons.

The professionals needed in the industry and in the wind industry require a specific skills and qualifications that are not easy to find and although there has been an enormous increase in the offer of wind training programs at all levels, they are still lacking specificity and practicality in the contents they transmit.

The chart below presents a summary of the most relevant training programs in wind energy considering the diversity of training centers and training programs. It is important to insist that the SKILLWIND initiative is more concentrated on maintenance whereas the rest of the training courses have a more extended scope, integrating other areas of activity in the wind farm supply chain.

Educational initiatives	Apprenticeships and technical courses	Dedicated training centres	University courses	Knowledge sharing networks and supporting wind energy training
BZEE Skills passport	Energy Management Technician in Europe	Asociación Empresarial Eólica	Erasmus Mundus European Wind Energy (TU Delft)	Bundesverband WindEnergie
European Academy of Wind Energy	Siemens, Renewable UK and Weir apprenticeships	Cabinet Metrol	European Master's in Renewable Energy	Centro Nacional de Energias Renovables
European Institute of Innovation and Technology		National Renewable Energy Centre (CENER)	MSc Wind Power Project Management (WPPM)	EWEA
Upwind project		Danish University Wind Energy Training	University of Strathclyde Doctoral courses	Global Wind Organisation
Windskill initiative		Danish Wind Power Academy	Wind Energy MSc (DTU)	Innovate
		German Wind Energy Institute (DEWI)		IIR
		ForWind		IRELP
		GL Academy		Italian Wind Energy Association
		Haus Der Technik		Renewables Innovation Network
		Training Centre for Renewable Energy (BZEE)		

Chart 1.Overview of education and training initiatives (Source: European Wind Energy TP)

Even with the wide training offer in wind energy, there are still some specific jobs that require skilled worked and that currently the work market has difficulties to provide. As it can be observed all the occupations in question are related with the technical field that requires mostly highly qualified engineers and service technicians.

Sub-sector	Occupations
Wind energy	Project developers, service technicians, data analysts, electrical, computer, mechanical and construction engineers
Solar energy	PV and solar thermal system installers and maintainers, building inspectors
Hydropower	Electrical and operation &maintenance engineers, technicians, trade personnel, sustainability specialist
Geothermal	Trainers, geothermal engineers
Bioenergy	R&D and design engineers, service technicians, trainers

Chart 2. Principal occupations difficult to fill per sub-sector (Source: REN Alliance survey)

This analysis of the wind sector work market poses a question that has not been answered yet. As it was stated currently there are plenty of training programs with diverse scope. In addition, renewable energies are more and more accepted by society considering the increasing pollution problem in big cities and the tendency to reduce the greenhouse gases.

Therefore, the seeds have been sown and have started to sprout, but there is still a long way to go in which motivating young adults and teenagers to involve them in green energy policies and grant a future workforce for the industry.

The key would be to keep wind training programs up to date, guaranteeing a practical approach no matter the learning level, i.e. technicians or engineers, and evolving with the technology. Something is clear in this aspect, technology evolves so does the tools and this evolution requires constant update.

In the following table is summarized the main characteristics of each training course, concentrated in on-shore installations, which could be easily extended to the on-shore plants.

Training name	Goal	Organization	Contents
WINDSKILL	To develop an European Qualification Framework	Modules based on technical criteria	• Installation • Inspection and maintenance of electrical systems • Inspection and maintenance of mechanical systems • Inspection and maintenance of the hydraulic systems • Inspection and maintenance of safety-relevant apparatus • Inspection of rotor blades • Repair of rotor blades • Trouble shooting • Fire fighting • Working at heights and rescue • Environmental awareness and protection • General health and safety • Wind energy systems
DANISH WIND POWER ACADEMY	To provide with basic training for those who want to work in wind turbines O&M	Training contents structured by wind turbine form different manufactures	• Personal and turbine safety • Wind turbine types • Maintenance programs • Blades • Gearboxes • Cooling systems • Hydraulic systems • Instruments and measuring • Electrical circuits • Control systems and operation • Sensors • Trouble shooting
BZEE	To provide with a flexible program complying with the European Qualifications Framework to enable a personalized training plan	Modules structured by career either installer or technician and by onshore or offshore wind turbine technology	• Health and safety • Wind turbine electronics • Wind turbine mechanics • Hydraulics • Rotor blade • Transport • Wind energy technology • Offshore operations • Operations management

Training name	Goal	Organization	Contents
GWO	To develop a standard in technical training for the wind industry	Modules are divided by mechanical, electrical and hydraulic systems in a wind turbine generator	• Mechanical module • Electrical module • Hydraulic module

SKILLWIND	To standardize the maintenance training and develop an App based on the serious game approach.	Modules organized in different blocks based in the different training paths	• Health and Safety (GWO)
			• Wind Energy systems
			• Installation and EPC
			• Maintenance WTG specifics
			  • Preventive
			  • Corrective
			  • Predictive
			• Blades inspection and reparation
			• Converter reparation
			• HV (lines and SE) repairs

Chart 3. SKILLWIND wind industry training program comparison

As it will be later explained, SKILLWIND training structure has been oriented to the specific group of maintenance activities (predictive, preventive and corrective) with additional contents for those developed by special trained people as blades and electrical components. All these contents have been completed with general information on Wind Turbines as well as on the development, construction and assembling of a wind farm and last but not least Health and Safety contents.

3.1 The Windskill project

The “Windskill” project (2006-2009) was a first-time initiative to meet the skills gap in the expanding wind industry via the development of a flexible European qualifications structure that puts specific assignments into the context of the wind energy work process. The integrated process approach to qualifications replaces the fragmented delivery of stand-alone skills and certificates and allows for skills development and individual career paths within the industry. Within the value chain frame framework, the prime focus of project development has been directed towards operation and maintenance assignments in both onshore and offshore work environments.

The Windskill Qualification Standard was compiled within a multi-stakeholder network and consists of both demand profiles and customized training modules designed to deliver the targeted process competencies. Both individual stakeholder perspectives and inputs from pioneer training activities within the partnership have been merged to implement the European Union’s Lifelong Learning agenda in the field of vocational education; the European Qualifications Framework has been deployed as a development platform thereby providing a transnational reference framework for wind energy qualifications.

In the latter part of the project the training program was positively tested and evaluated at a range of European training locations, hence contributing to the building of the needed training infrastructure. Finally, the Windskill Agency was designed with a view to ensuring ongoing development of both the Windskill Profiles and Modules and to monitoring compliance of training activities with the Windskill Standard. The set-up of the Agency as an industry accreditation body is targeted for 2010 immediately following the completion of the project and will provide quality assurance and certification measures for the European and international qualification market.

More specifically the objectives of the project were:

I. Build a Wind Energy Education Network
II. Develop a European Qualification Profile
III. Develop a modularized training program to deliver the Profiles
IV. Conduct a series of pilot training sessions to test the market feasibility of the profiles
V. Design the Windskill Agency to enable ongoing development and monitor the implementation the Windskill Standard in training activities

3.2 The Danish Wind Power Academy

The Danish DWPA are recognized as the premier, independent industry-training organization within the wind-turbine industry. DWPA provide in depth turbine-specific training, as well as basic beginners' courses for the wind industry. DWPA conduct seminars and business development sessions based on our understanding of the challenges for the global players, as well as their drivers and plans within the wind sector.

Reviewing some training programs from the Danish Wind Power Academy it can observed that most of training courses approach the wind energy education from the point of view of each of the main manufactures and some of them are dedicated exclusively to specific machines maintenance.

The training offered by the Danish Wind Power Academy in wind energy is divided in different courses that have a very different approach and duration. Seminars in turbine technology and practical maintenance are offered with duration of 3 hours and a half to give a general understanding in the subject aiming to create foundation knowledge.

2 days training is available in wind turbines from Vestas and Siemens to obtain a specific maintenance training in depth, going through all the procedures theoretically to undergo the maintenance of each manufacturer wind turbine in the bottom section, tower, nacelle and hub.

The Danish Wind Power Academy also offers a more general training program with a duration of 10 days which is denominated "Wind industry Essential Training". This training has three different training methods including class room lectures, group work and workshops.

This course contents are designed as an introduction to the wind industry, creating a good start point for the professionals who want to develop a career in the wind industry as technicians or in operation and maintenance.

The training contents present the following topics:

- Personal and turbine safety
- Wind turbine types
- Wind turbine documentation
- Maintenance programs
- Blades
- Gearboxes
- Cooling systems
- Hydraulic systems
- HV working
- Instruments and measuring
- Electric circuits
- Control systems and operation
- Sensors in wind turbines
- Operation and safety strategy
- Trouble shooting

3.3 BZEE Academy

BZEE training programs are vaster and some of them are dedicated exclusively to professionals who have already knowledge of the wind industry or even of that popper training module but need refreshment in the subject.

The training courses are modularized and tailored to wind-specific activities targeting different professionals of the wind industry. The main courses offered are the following:

- Wind turbine manufacturing specialist
- Service technician for onshore wind energy facilities
- Service technician for offshore energy facilities
- Assembly technicians for onshore and offshore wind energy facilities
- Service technicians for rotor blade repairs

In addition, there is training specifically designed for training professionals in the field.

It must be remarked that the BZEE training is certified by Det Norske Veritas and count with the satisfaction of GWO meeting its minimum requirements.

Some of the modules taught are compulsory for some of the courses mentioned above, others are highly recommended for different courses and some of them are specific for specialist in the subject. The modules are structured in the following topics:

- Health and safety
- Wind turbine electronics
- Wind turbine Mechanics
- Hydraulics
- Rotor blade
- Transport
- Wind energy technology
- Offshore operations
- Operations management
- Support

The module contents comprehend different sub-modules of training, although some of them offer a basic insight in a concrete subject and have an advanced sub-module that follows each targeting different technicians training. In addition, some sub-modules offer a refreshment of the subject that would be convenient for the professional technicians.

3.4 Basic Technical Training GWO

The GWO basic technical training (BTT) program is still developing and the information used in this report comes from the draft version of the program as the final version has not yet been released.

The contents of the GWO BTT are structured in three main modules which are: electrical, mechanical and hydraulic.

Each of those modules have a very general approach and include the main technical topics that can be of interest for an operation and maintenance technician to acquire basic technical knowledge.

The mechanical module introduces the principles of bolted connections and how to tighten them as well as the main mechanical components of a wind turbine such as the gearbox, the braking system, the yaw system, the cooling system and the lubrication system.

The electrical module follows the same pattern. It is divided in eight lessons introducing electrical concepts, safety related to electricity, symbols and components, sensors, circuits and measuring instruments.

To conclude the evaluation of the GWO BTT, the hydraulic module will be reviewed. It is as extensive as the mechanical module, both structured in 12 lessons. Those lessons give general information about the main components of the hydraulic system such as pumps, actuator, valves, accumulators, sensors, pipes and connection and oil filters.

All the three training modules include a lesson of introduction and summary, as well as a safety lesson.

The MAERSK Training Center provides a GWO Basic Safety Training Onshore

This course is designed to provide personnel with the basic skills that will enable them to work in a safe manner in the wind industry.

About the **content**, the GWO Basic Safety Training Onshore enables delegates to support and care for themselves and others working in the industry, through possessing the knowledge and skills in several areas. In case of an emergency, delegates will be able to evacuate, rescue and provide appropriate First Aid to casualties.

In terms of objectives, the training will equip participants with the knowledge, skills and confidence to appropriately respond in the event of an emergency and to increase their safety through proper use of Personal Protective Equipment, emergency equipment and procedures.

This course is approved by the GWO.

https://www.maersktraining.com/courses/category-list/wind#default:selected=true|views:view=jplist-grid-view

3.5 European Energy Center

The European energy Center delivers a course in Wind Power Qualification Training

This course is designed for technicians and individuals intending to learn how to install, maintain and repair wind turbines, as well as design engineers and architects.

The course is composed of the following structures:

- Introduction
- Wind energy conversion
- Wind & wind turbine structures,
- Wind turbine drive train
- Electrical connections & control

In terms of practical skills, the course will teach you how to assemble a wind turbine, to do site selection, resource estimation, planning & installation, performance evaluation.

The course is internationally recognised and approved by the SQA Centre.

More information available at https://www.euenergycentre.org/training/70-wind-power

3.6 DNV GL Training on Wind Farm Construction and operations

DNV GL is a global quality assurance and risk management company. DNV GL provides classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. They also provide certification, supply chain and data management services to customers across a wide range of industries. DNV GL's Energy Academy provides a wide range of courses for the electricity supply chains, bringing together courses from legacy DNV, GL, Garrad Hassan and KEMA.

DNVGL provides the "Wind farm construction & operations procurement Training"

This one-day course is aimed at anyone wishing to gain an in-depth understanding of the procurement and contracting process for wind farm projects. Following an introduction to wind farm terminology and the typical contracting structures required for project financing, the course splits into two distinct sections.

The first section focuses on the essential knowledge required to support the construction procurement process, including the advantages and disadvantages of the different structures and forms of construction contract, the purpose of common contractual clauses and typical associated benchmarks, and the importance of developing a comprehensive and appropriate Employer's Requirements.

The second section focuses on the intricacies of the operational procurement process, including the advantages and disadvantages of the different structures and forms of operations contract and current contracting trends, the typical scopes of service works and acceptable exclusions and the purpose of common contractual clauses and typical associated benchmarks.

As regards the content, the course is focusing on wind farm terminology, typical contracting structures, Construction contracts and Operations contracts.

The course is aimed at developers, investors, lenders or other industry specialists involved in contracting or procurement for wind farm projects. The content will have a technical focus, provide anecdotal examples and convey the importance of the style and content of contracts in an accessible manner. There is no specification as to whether this training is accredited or no.

More information available at https://www.dnvgl.com/training/wind-farm-construction-operations-procurement-11041

3.7 GE Renewable Energy Training on Wind Energy Turbine Services

GE Renewable Energy provides flexible and customized operations and maintenance support to fit specific needs.

GE provides technicians and training for wind farms. GE provides a rigorous certification process with 1,200 hours of practical and classroom experience in its fleet. GE has two Wind Energy Learning Centers in Niskayuna, NY, USA and Salzbergen, Germany where technicians are trained—with a strong focus on **safety**—to inspect and repair actual GE wind turbine components. GE wind technicians can earn up to 50 college credits toward completing their Wind Technician Certification Program by partnering online with Excelsior College.

To earn GE's Lead Certification Standard, technicians must complete more than 500 hours of classroom, online and practical, hands-on field training on wind turbine components at GE's Energy Learning Center (ELC) in Schenectady, N.Y., where GE's renewable energy business is headquartered.

At the ELC, technicians are trained---with a strong focus on safety---to inspect and repair actual GE wind turbine components, including the nacelle, which is installed atop a 200-foot steel tower and houses the wind turbine's generating equipment.

Technicians who complete the certification program now are eligible to earn up to 49 credit hours for their work experience through Excelsior College, the leading non-profit, regionally accredited distance education institution in the nation.

More information at https://www.gerenewableenergy.com/wind-energy/turbine-services

3.5 SKILLWIND modules

SKILLWIND training consists in customized training modules designed to deliver the targeted process competencies in the wind industry. Its aim has been filling the educational gap in the expanding European wind industry developing training course oriented to maintenance and operation within a European Qualification Standard. The development of SKILLWIND has also taken into consideration the results of the comparison of the different training courses included in the Annex.

The SKILLWIND training course is structured in six modules which are the following:

- Basic concepts
- Engineering, Procurement, Commissioning and Operation
- Predictive maintenance
- Preventive maintenance

- Corrective maintenance
- Health and safety

The training modules are structured as it can be observed in the following figure, having three different levels. The training begins with the more basic concepts, advancing through the specifics and finalizing with the advanced ones.

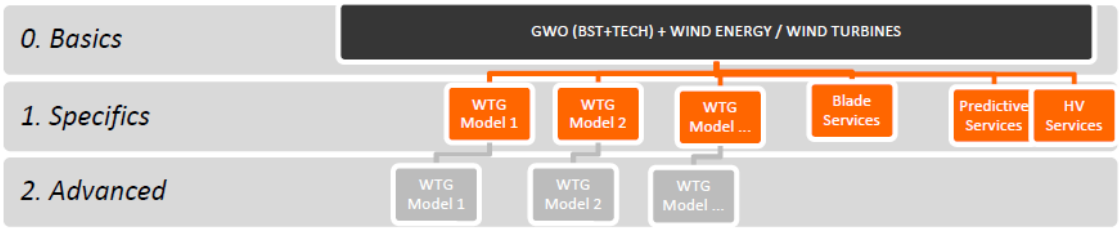


Figure 10. SKILLWIND training structure

The SKILLWIND modules offer a very complete training in the wind energy industry, giving a wide insight of the wind farm and the wind turbine generator, remarking the maintenance procedures from the predictive, going through the preventive and ending with the corrective maintenance and paying special attention to the basic safety training in the following areas:

- First aid
- Fire awareness
- Working at heights
- Sea survival

Related to the training in terms of wind farm, it comprehends from the task of design, the study of wind conditions in a specific site, the calculation of the wind generation, etc. to the wind farm arrangement, the road transport and the assembly task of the wind turbine facilities describing precisely the equipment and tools to be used in the assembly as well as the assembly sequence. In addition, the wind turbine energization procedure is explained in detail, including all the tests that should be run in the pre-operation state to guarantee the perfect functioning of the wind turbines.

The wind turbine module describes the basic key points of the technology as well as the systems and components, detailing the operational states and safety systems. Among the systems operating in the wind turbine generation, all of them are explained in detail including the mechanical system with all its components such as the drive train, yaw system, pitch system, blades, etc., as well as the hydraulic and electrical system, paying special attention to the control system and its elements.

3 Wind energy course programs comparison

3.6 SKILLWIND training VS. the Danish Wind Power Academy

As it can be observed the training programs offered by the Danish Wind Power Academy, they only have one training course in the wind sector that is comparable with the SKILLWIND training manual that would be the Wind Industry Essential Training because of the contents of the training program.

The main differences between these two programs are the module concreteness. As it was stated before the training program offered by the Danish Wind Power Academy targets two wind turbine generators from two of the biggest manufactures in the industry such as Vestas and Siemens. And all the control systems and operation, the sensors as well as the trouble shooting are explained concretely for the Siemens and Vestas wind turbine generators.

The rest of the modules of the Danish Wind Power Academy have a more general insight, as it does the SKILLWIND training in the Serious Game application.

3.7 SKILLWIND training VS BZEE training

The training offered by BZEE Academy approach wider contents and more specific modules oriented to different professional that may be already working in the field. That is the main difference observed between the BZEE training program and the SKILLWIND training modules.

As it was mentioned before, BZEE Academy have different courses oriented to different professional, to concrete the comparison only the training for service and assembly onshore technicians is compared as it is the training that have more similarities with the training offered by SKILLWIND. Having the latest in addition, the interactive training offered by the Serious Game, that allows anyone training in the Wind industry repeat and revise those modules which could be his or her weakest points.

In the comparison module by module is allowed, it can be observed that both training programs cover the same main contents. For instance, in the Health and Safety modules training about first aid, working at heights, fire awareness even rescue, and evacuation are taught in both training programs.

If the comparison is kept module by module, it would be found the same level of coincidence. The main differences in the program lay in the following modules:

- Hydraulics
- Rotor blade
- Transport
- Operations management and support

While doing the comparison, it was observed that the Hydraulics module contents are very specific in the training offered by BZEE, up to the point of describing each component of the hydraulic system of a wind turbine generator assembly and maintenance.

The other three modules mentioned above do not have their equal in the SKILLWIND program. The rotor blade module contents of the BZEE Academy are far too specific for what it is intended in the SKILLWIND training, although SKILLWIND includes the rotor blades in its training, it is done in a more general approach.

The transport module offered by BZEE Academy is focused in the licensed needed by the operators to drive the necessary truck, forks and cranes used during the assembly and maintenance. On the contrary, the transport module in the SKILLWIND training is oriented to the different transports used depending on the size of the wind turbines.

The modules about operation management and support do not have the equivalent in the SKILLWIND training, as the information given in management is not specific from the wind energy sector and it would not fit in the SKILLWIND project goals. And the support module offers training in English, which is not necessary in this project as it would be available in four different languages, and team training and industry internship which is not part of the self-training offered by SKILLWIND.

3.8 SKILLWIND training VS GWO Basic Technical Training

There are several coincidences between the GWO Basic Technical Training and SKILLWIND approach. Both programs have been thought to be used by future technicians of wind farms.

However, if a comparison is done lesson by lesson of each of the modules, it can be observed that the GWO training modules are oriented to safety and how to work with some of the wind turbine components and using the measuring instruments.

On the other hand, SKILLWIND training program includes a general description of the whole wind turbine and how it works apart from the description in details of each of its main components and circuits and the main operations carried out.

4 Conclusions

From the research in European training programs with solid structure and expertise in the wind industry that has taken place it can be considered that the SKILLWIND program and the Serious game fill the existing training gap in the wind industry, offering an ambitious training program with vast contents related not only to operation and maintenance but also all the general information needed to understand the wind energy and the wind turbines operation.

The **Serious Game** offers not only the contents of a very complete training program but also the means to acquire the knowledge from the basic concepts to the more advanced ones. By simply installing this application, the user would have access to the contents, would be able to be tested periodically and know the advance in the different subjects. Obtaining in the end, solid knowledge in Wind energy which is the main aim of the SKILLWIND project.

5 Bibliography

http://cursosinem2017.com/c-curso-inem-2017-tecnico-superior-en-instalacion-y-mantenimiento-de-sistemas-de-energia-eolica-a-distancia

https://www.seas.es/energias-renovables/curso-energia-eolica

http://mtcmaintenance-online.com/master-en-gestion-del-mantenimiento/

https://windeurope.org/about-wind/reports/

http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=3828

http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=3802

http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=2729

http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=3852

https://osha.europa.eu/en/tools-and-publications/occupational-safety-and-health-in-the-wind-energy-sector

http://renovetec.com/174-curso-de-mantenimiento-y-diagnostico-de-aerogeneradores

- NATIONAL CATALOGUE OF PROFESSIONAL QUALIFICATIONS. INCUAL March 2008

ANNEX: TRAINING COURSES BY COUNTRY

In this Annex a recapitulative of some training courses is presented as a reference of the conclusions of this Output 1. It is important to mention that probably the best suited for the goal of our project are the internal training courses of the Maintenance and OEM companies but unfortunately their contents are not usually public.

Spain

After the economic crisis many courses have flourished in Spain with different contents and duration, in general all of them are touching key maintenance aspects but no one follows the structure proposed by SKILLWIND. The next courses have been evaluated, the text is kept in Spanish such is in the original course:

INEM (INSTITUTO NACIONAL DE EMPLEO)

It is the public body belonging to the Labor Ministry and entrusted to the employment creation.

Among different activities they also have training courses and the below agenda is an on-line course devoted to the installation, operation and maintenance.

INEM WIND ENERGY PROGRAM:

Main goal of the training course INEM FPO: Superior Technician on Maintenance and Installation of Wind Energy Systems:

To study the prospects for this type of energy. Learn the systems connected to the network as well as autonomous systems and identify the features and operation of each of the components of a wind turbine.

Knowing this type of energy environmental impacts and make the right decisions to tackle these impacts. To explore into the normal regime of a wind turbine operation, taking good account of highlighting the techniques used in the regulation of the power of the machine. Installation and operation of a wind farm.

Thematic:

Chapter 1. THE RENEWABLE ENERGIES

Chapter 2. INTRODUCTION TO THE WIND ENERGY

Historical considerations of wind energy
Which is wind energy?
Current situation

Chapter 3. OPERATION AND MAIN WTG COMPONENTS

Tower
The operation of the wind turbine
Wind turbine generating set

Chapter 4. APPLICATIONS AND WIND ENERGY USES

Pumping water e
Electricity generation
Desalinization
"Green" hydrogen production

Chapter 5. TYPES OF WTGs AND DESIGN CALCULATIONS

The different types of WTGs
Typology
Other types of wind turbines

Chapter 6. WIND ENERGY CONVERSION EFFICIENCY AND THE PRINCIPLES OF AERODYNAMICS

The wind as source of primary energy
The main factor affecting to the wind efficiency
Principles of basics aerodynamics
Principles of WTG operation

Chapter 7. THE WIND FARMS AND THE CONSTRUCTION PROCEDURES

The wind farms
Research and technological process
Connection of a wind farm to the grid
Construction of small wind turbine

Chapter 8. CONSTRUCTION AND WIND FARMS MANAGEMENT

Costs control in the operation and maintenance of a wind farm
Incentives management
Basic engineering project execution
Planning and work organization of a small wind farm
Future perspectives

Chapter 9. THE OFF-SHORE WIND ENERGY I

The off-shore wind energy
Main advantages of the off-shore wind energy
The off-shore conditions
Main research topics of the off-shore

Chapter 10. THE OFF-SHORE WIND ENERGY II

Foundations of the wind turbines
Off-shore energy in Spain
Off-shore wind farms connected to the grid
Key elements for the development of off-shore wind farms
Environmental management near shore

Chapter 11. THE HYBRID SYSTEMS

Introduction
Main components of the hybrid systems
Operation modes
Design of the hybrid systems

Chapter 12. WIND FARMS MAINTENANCE

Maintenance types
Maintenance of the wind farms
Management and organization of the small installations

Chapter 13. THE SAFETY SYSTEMS AND THE ENVIRONMENTAL PROTECTION

Safety systems
Environmental impact
Impact assessment of desalination plants

Comments: this is an on-line and general course with a structure rather similar to other courses in Spain. It is not structured as SKILLWIND from the general concepts and splitting the contents in different modules. Furthermore, the INEM course puts too much the accent on desalination and very little on Health and Safety.

RENOVETEC

It is a private company with experience in training in different technologies either conventional power plants or RE installations, mainly wind and biomass.

RENOVETEC TRAINING COURSE

Main goal of the RENOVETEC training course:

This is a short duration training course of only 16 hours to be financed by the trilateral Spanish systems. The topics are well addressed but they are rather general due to the course span.

Thematic:

Maintenance of the main elements and systems of a wind turbine

Tower
Nacelle
Blades
Hub
Slow shaft
Gearbox
Lubrication system of the gearbox
Fast shaft
Generator
Cooling system f
Pitch system of blades
Yaw system of the nacelle
Braking system
Centralized lubrication
System Instrumentation in wind turbine
Electrical systems

Scheduled maintenance control

Maintenance strategy
Elaboration of maintenance plan for a wind farm
Instructions for generic maintenance
Lubrication tasks
Technical cleaning

Blades cleaning

Nacelle cleaning

Monthly/quarterly maintenance

Semi-annual/annual maintenance

Great review

Corrective maintenance

Small corrective: detailed analysis small troubleshooting

Great corrective: detailed analysis of the great corrective

Spare parts

The spare parts problem

Criteria of the spare parts store

Criteria for the selection of spare components.

Wind farm warehouse: composition

Regional warehouse: composition

Central warehouse: composition

Technical solutions to reduce the cost of the spare components

Technical means

List of mechanical tools

List of electrical tools

List of sensors and instrumentation tools

Diagnosis of the WTG state

Analysis of the historical of production

Analysis of the historical of maintenance.

Visual inspection: main points to be evaluated

Oil analysis: main parameters and their meanings

Baroscopic inspection

The problems of vibration analysis

WF maintenance contracts

Materials and time contracts
Preventive maintenance contract
Preventive maintenance contracts
Closed price contract
Win-win contract: prices by MWH.
Present trends

Conclusions

Comments: it is the more similar to the SKILLWIND approach of all training courses evaluated but it is affected by the reduced duration of the course.

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SEAS (ESTUDIOS SUPERIORES ABIERTOS)

It is a private university with many different teaching areas, this training course is addressed to grade students.

SEAS TRAINING COURSE

Main goal of the SEAS training course:

Wind energy course aims to train students in the sector of wind energy facilities, applications and in aspects such as control of the installations and the wind forecast. It will differentiate between connected to network, terrestrial and marine installations and isolated power distribution network.

Thematic:

- **Yesterday and today of wind power**

  Introduction.
  A bit of history
  Classification of wind farms
  Current situation of wind energy in the world

- **The wind turbine**

  Wind resource
  Types of WTGs
  Classification
  Wind turbine components
  Basic concepts

- **The wind farm installations**

  Additional facilities wind components of wind installations.
  Classification of wind installations.
  Isolated wind farms.
  Wind farms connected to network

- **. Promotion and exploitation of wind farms**

  Measurement, evaluation and quantification of the wind resource.
  How to interpret a wind project?
  Wind forecast software manufacturers. WASP and WindPRO: software of prediction models.
  Types of prediction models

- **. Wind farms maintenance**

  Maintenance management
  Mechanical maintenance of wind farms.
  Electrical maintenance of wind farms.
  Maintenance of the power conditioning and control systems
  Trouble shootings and main faults
  Corrective maintenance
  HSE. Individual protection equipment

  - **Control and management of wind farms**

    SCADA
    Communications standards of wind farms

  - **REGULATION**

Comments: very general training course even if they put the accent on the maintenance module.

MTC

It is a private company belonging to the Tobalina Consulting group specialized in on line maintenance courses.

MTC TRAINING COURSE

Main goal of the MTC training course:

The main objectives are the following: -provide an in-depth overview of all areas and functions that make up the management of the maintenance as well as an introduction by major lean six sigma tools applicable to the processes of maintenance.

Thematic:

Module 1. Strategy and General Maintenance Organization

- **Module** 1.1. Strategy and General Maintenance Organization
- **Module** 1.3. Maintenance human resources
- **Module** 1.4. Maintenance costs
- **Module** 1.5. Maintenance Safety
- **Module** 1.6. Environment protection in the maintenance

Module 2. Design of the Maintenance management

- **Module** 2.1. Introduction to the Asset Management
- **Module** 2.2. Design of the RCM/RCS maintenance Plan
- **Module** 2.3. Other methods for the Design of a Preventive Maintenance

Module 3. Maintenance Operational management

- **Module** 3.1. Organization and Planning of the maintenance tasks
- **Module** 3.2. Corrective and preventive management
- **Module** 3.3. Predictive management
- **Module** 3.4. Maintenance warehouses and supplies control
- **Module** 3.5. Maintenance efficiency and productivity
- **Module** 3.6. Maintenance quality
- **Module** 3.7. Maintenance information systems

Module 4. Maintenance continuous improvement

- **Module** 4.1. Trouble shooting analysis
- **Module** 4.2. Lean Six Sigma Yellow Belt. The maintenance continuous improvement
- **Module** 4.3. Total productive maintenance (TPM)

Module 5. The maintenance of the future

- **Module** 5.1. Asset management 4.0
- **Module** 5.2. The technological management. The internet of things.
- **Module** 5.3. On line asset management

Module 6. Final project

It is a comprehensive maintenance management project to develop during the last stage of the course to choose between a project proposed by the student or by MTC.

Comments: It is a well-organized training course more oriented to maintenance management

UOC WIND ENERGY TRAINING PROGRAM

Main goal of the UOC training course:

This wind energy program provides with the necessary skills to coordinate the assembly, starting-up and operation and management of wind farm coordination according to the legislation.

Thematic:

Module 1: Planning, organization and supervising the provisioning and assembly of wind energy facilities.

Module 2: Installation project development for small wind turbines.

Module 3: Operation and starting up of wind energy facilities.

Module 4: Wind farm maintenance management.

Module 5: Security and evaluation of professional risks in wind farms.

Module 6: Assembly and mechanical maintenance in a wind farm.

Module 7: Assembly and electrical maintenance of a wind farm.

Module 8: Assembly and maintenance of the wind farm control systems.

Comments: This training program is fully oriented to learn the main maintenance aspects to provide professionals for the wind energy operation and maintenance activities and it also gives an insight in management of resources in assembly of a wind farm and in maintenance that could help technicians to advance in their careers in wind energy.

Belgium

TECHNIFUTUR TRAINING ON WIND ENERGY

This is a training for maintenance agent/worker for wind farms

The training is available to workers willing to become maintenance agent for wind farms. At the end of the training, the candidate will be able to proceed to major interventions of maintenance, and troubleshooting on wind turbines after diagnosis and from instructions, plans, and diagrams. He/she will be able to operate in different technical sectors such as: electricity, mechanics, and hydraulics.

The training is made of several modules:

- Wind energy – Introduction module
- VCA,
- Electricity
- BA
- Mechanics
- Hydraulics
- Initiation to 5S
- Composites
- Maintenance, Knowledge of the environment
- Management
- English
- Computing
- First aid
- Slinging and aerial work

The duration in of the course is 80 days There is no information as to whether this training is accredited or not.

More information is available at: http://www.technifutur.be/formations-energie-et-environnement-energie-eolienne-formation-eolien-qualifiante-pour-demandeur-d-emploi

Italy

In Italy most of training for wind farms maintenance are given by ANEV (Associazione Nazionale Energia del Vento) in collaboration with other entities such the labor union UIL (Unione Italiana del Lavoro) or the Order of Engineers of the Province of Rome. Courses are certified and at the end they issue professional formative credits with the purpose of professional upgrading of Engineers and last between 2 and 5 days.

Some of these courses are the following (names translated from Italian):

- Safety in the wind farm
- Renewables: advanced course on wind energy. From permissions to network connectivity, from design to management
- The Minieolico: Business Plan, development, authorization, implementation and management

Courses are also given within bigger events and fairs, such Key Energy, the leading fair for renewable energies in the Mediterranean area. Focus on photovoltaic and storage, solutions for the energy efficiency in the industry and residential, solutions for sustainable intermodal and connected mobility. Events. It takes place yearly at Rimini Fair and inside the event there is the Key Wind expo which is focused on wind energy