IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

MEETING THE CHALLENGES OF SAFETY MANAGEMENT IN WIND ENERGY INDUSTRY

T.E. VIGNESH[1], S.P. GOWTHAM[2]
1 PG STUDENT 2 ASSISTANT PROFESSOR
INDUSTRIAL SAFETY ENGINEERING
KSR COLLEGE OF ENGINEERING, TAMILNADU, INDIA

ABSTRACT

Countries promoting renewable energies encounter a variety of phenomena that can challenge the implementation of further onshore wind energy development. Those challenges can be observed in many multi-level governance systems, as exhibited in the U.S., Germany, and Mexico, where various regulatory and institutional levels must agree on goals and responsibilities. This is a challenge, as both forms of governance (top-down and bottom-up dominated) are present in wind energy planning and policy. (1) Political and market phenomena, (2) siting issues, (3) the green vs. green dilemma, and (4) social acceptance are selected challenges within the different levels of decision-making processes in wind energy implementation. (1) Political and financial factors can influence the development by implementing incentive- and market-based policies, command-and-control policies, and feed-in tariffs. However, success of these policy designs for renewable energies is based on different political environments, and their electricity markets nationally, regionally, or statewide. (2) Spatial limitations in planning are created based on limited land availability due to conflicts with other land uses such as aviation, nature reserves, residential areas, their respective buffers. (3) The "green vs. green" dilemma involves the incoherent relationship between policies promoting renewable energies with policies protection species and their environments, becoming a major point of concern during siting and operations of wind energy. (4) Lastly, while there is a general overall support for wind energy, social acceptance on a local level is influenced by institutional settings i.e. information availability, as well as public and stakeholder concerns. Involvement in decision-making as well as financial participation (e.g. community-ownership) affects public participation and acceptance. This paper goes into detail on these phenomena and discusses case studies in Europe and North America. Often, these challenges can enhance outlooks in policy and planning, posing solutions to wind energy challenges even in sensitive environments and triggering innovations such as adaptive management.

Keywords: Wind energy, OSH risks, Safety and Environments

1. INTRODUCTION

Wind energy is renewable and clean, and produces no greenhouse gas emissions. In 2012, it accounted for 11.4 % of the European Union's (EU's) power capacity and 26.5 % of all new power capacity in Europe (EWEA 2012a). As the EU power sector continues its move away from oil, coal and nuclear fuels, wind energy has experienced tremendous growth over the past decades, and this is expected to continue. Annual installations of wind power have increased steadily over the past 12 years, from 3.2 gigawatts (GW) in 2000 to 11.9 GW in 2012, a compound annual growth rate of 11.6 %. In 2010, there were 70,488 onshore wind turbines and 1,132 offshore turbines across the EU (European Wind Energy Association, 2013). A total of 106 GW is now installed in the EU, an increase in installed cumulative capacity of 12.6 %

compared with the previous year. The wind power capacity installed by the end of 2012 would, in a normal wind year, produce 231 terawatt-hours of electricity — enough to cover 7 % of the EU's electricity consumption. The total number of wind turbines worldwide at the end of 2012 was around 225,000, spread over 79 different countries (Global Wind Energy Council, 2013). In its recently published research agenda (EWEA, 2010), the European Wind Energy Technology Platform (TP Wind) proposes an ambitious vision for Europe. In this vision, 300 GW of wind energy capacity will be implemented by 2030, representing 25 % of the EU's electricity consumption. Moreover, the TP Wind vision includes a sub objective on offshore wind energy, which it believes should represent 10 % of EU electricity consumption by 2030. Wind energy is a mainstream renewable power source and, if the right steps are taken, this source will be essential in meeting Europe's 2020 renewables target, tackling climate change, strengthening energy security and creating new jobs (Europa, 2009).

At present, the European wind energy sector provides jobs for 192,000 people, and many more well-trained workers are needed in areas ranging from manufacturing to project management. It has been predicted that by 2020 there will be 446,000 jobs in the wind energy sector in Europe (EWEA, 2012b). Growth in the wind energy sector can be attributed to a number of factors, including financial confidence, technological advancements, legislative support from local governments and increased public support and awareness. As the EU's wind energy industry continues to grow, new challenges begin to emerge. With an increasing number of workers now employed in various aspects of the wind energy sector, occupational safety and health (OSH) becomes a prime concern. Many aspects of siting, erecting, maintaining, servicing and possibly dismantling wind turbines are unique, and even if most of the job hazards that these workers will face are not, the working environments and combinations in which they are found create unique challenges. New technologies or working processes associated with wind energy will also lead to new hazards, which call for new combinations of skills to deal with them (EU-OSHA, 2013). Wind energy is a relatively 'new' industry, and some of the workers may not be fully aware of the hazards that exist in this work environment. In addition, the speed at which the EU wind industry is expanding could lead to skills gaps, with inexperienced workers involved in processes for which they have not been trained, and who therefore put their safety and health at risk. Although wind energy is considered 'green' and good for the environment, it does not necessarily mean it will be good for the health and safety of workers. Wind energy workers can be exposed to hazards that can result in fatalities and serious injuries during the various phases of a wind farm project. The objective of this report is to provide an in-depth and comprehensive overview and analysis of the OSH challenges in the wind energy sector in order to raise awareness and thereby support good OSH, so that the jobs in this sector are jobs that provide safe and healthy working conditions. This review considers the OSH issues in the wind energy sector, both onshore and offshore, within the EU Member States. The activities associated with wind energy — from the design and manufacturing of wind turbine parts, through the transport, installation and maintenance, to emergency rescue and waste treatment — are explored. OSH issues associated with working in remote areas, extreme weather conditions, confined spaces, awkward postures, electrical risks, falls from height, musculoskeletal disorders, physical and psychosocial loads, various aspects of work organization and exposure to dangerous substances (e.g. at the production stage but also during maintenance operations) are included. Other aspects, such as subcontracted work, worker training and characteristics of the workforce (e.g. gender, age), are also addressed where relevant. Further, the possible conflicts between OSH and environmental requirements are explored.

2. METHOD

The researchers used a desk-based method to source the information and data used in the report. They decided on the inclusion and exclusion criteria to determine the data to be used. In order to be included, the information and data had to (i) relate specifically to the health and safety of workers within the wind energy sector or the health and safety of workers in other sectors where work is carried out in difficult climates or environments and (ii) have been published within the last 10 years. During the search for relevant data, the researchers found a significant amount of information on company websites that provided useful background information on the wind energy industry. However, the potential commercial bias of this information meant that much of it had to be discounted from the initial sift when reviewing documents and then for classification into the database that was used to record the extracted information.

The documents were ranked as listed below, that is articles from peer-reviewed journals rated as the most robust research:

peer-reviewed journals;
government reports and non-governmental organizations;
trade associations and trade unions;
newspapers and magazines; and
Pressure group information.

Owing to the shortage of papers that refer specifically to OSH issues within the wind energy industry, the researchers used their discretion in deciding which documents to include or exclude. Moreover, if the researchers felt that the data presented were not very robust, they were not included in the report.

The researchers devised search terms for the review. After several refinements, the researchers decided on the following primary search terms:

Onshore wind energy
Offshore wind energy
Onshore wind farms
Offshore wind farms
Renewables or emerging energy technologies

The search terms were used in combination with other relevant ones in order to retain focus on OSH issues likely to be faced by the wind energy sector both on- and offshore at different phases of the life cycle. A list of the terms used can be found in Appendix 1. The resources included those available on the Internet that were found through Google and Google Scholar search engines; the grey literature; and Ebsco, Oshrom, Oshupdate, Proquest, Science Direct, Web of Science and STN research databases. In addition, the European Agency for Safety and Health at Work (EU-OSHA) provided access to its network of national focal points ([1]). Information was received from 10 Member States (Austria, Denmark, Germany, Finland, France, Ireland, Lithuania, Norway, Slovakia and Spain); this included anecdotal observations from these countries' experience of the industry and links to peer-reviewed journal articles and wind energy industry trade bodies. This use of grey literature ([2]) allowed reports and research output which may not have been covered during regular searches of electronic databases to be assessed, thereby allowing a broader, and more comprehensive assessment of the various topics under discussion. The data in this report, while mainly EU focused, include research from outside the EU to supplement the information and practices in this area to ensure that the most relevant data have been accessed and assessed for their relevance to the topic. The researchers systematically captured the key information in the documents in line with the objective of the research. General summaries were used to capture key points from the articles. The short descriptions of good-practice examples included in this report were found partly through EU-OSHA's focal points, desk-based research and any contacts the authors might have had from within the industry, including trade associations.

3. DISCUSSION — FUTURE CHALLENGES

Europe's ambitious programmer to increase wind energy capacity so that it represents 25 % of EU electricity consumption by 2030 (EWEA, 2010) will require further efforts to consolidate and further improve OSH within the industry. Many of the OSH risks faced by the industry are not new as such, but are found in new, different situations or combinations that bring along new, different challenges.

4. LACK OF OSH DATA AND INFORMATION

This review has attempted to bring together relevant OSH-related material in the wind energy industry by using data from national wind energy trade bodies and other stakeholders. However, it was evident that the amount of information available is rather sparse and in some cases extremely vague. This is mainly because of the following reasons:

The existing fleet of wind turbines is relatively young.

There is a lack of research/experimental data on risk exposures to workers — most research focuses on public safety.

Businesses within the wind sector tend to be guarded not only at a recruitment and training level, but also at an operational level. The operational data of turbines are kept confidential by the manufacturer. Some wind energy operators share between themselves (mostly between members of wind energy trade associations) their data on OSH incidents and accidents but do not make this information public, thereby limiting possibilities for OSH actors to contribute to research and action to improve OSH conditions in the sector.

5. STANDARDS AND GUIDELINES

The lack of recognized standards and guidelines for the safe operation of wind farms, particularly for offshore facilities, has also been captured by the review. For a long time, there have been no requirements in many countries for independent verification of the performance, durability and reliability of wind turbine products. It has been identified that, as technologies develop, standards have not always kept up with the pace of development and variations in product design. For example, at present standards are being developed for medium-sized wind turbines, which to date have used the same standards as those employed for large-scale wind turbines. However, this is either restrictive or not appropriate for the medium-scale wind market. It is also claimed that the available international standards for small wind turbines do not fully reflect the technical and economic demands associated with such turbines and their placement (IRENA, 2013). Without clear guidance in place, national trade bodies have tried to improve standards within the industry by producing best-practice OSH recommendations; however, there is a clear need for the development of international standards or guidelines for OSH management that ensure a holistic approach from a life cycle perspective. Best practice and international standards provide a clear ability to provide products that are inherently safe and perform to set standards established by the international technical experts. The European standard EN 50308:2004 'Wind turbines: Protective measures — Requirements of design, operation and maintenance' is currently being updated and it is expected that this standard will ensure that OSH is considered from the start of the turbines' life cycle.

6. SKILLS SHORTAGE AND TRAINING

The rapid development of the wind energy sector over the past few years has resulted in severe skill shortages. TP Wind reports claims that this shortfall in skilled workers could climb to 28,000 by 2030 — nearly 5 % of the entire wind energy industry workforce. Wind energy cannot compete with traditionally higher salaries and opportunities offered by the oil and gas industry because the commercial returns are much smaller. This means that the majority of workers who are prepared to join the industry have little or no experience of working on wind farms and are not familiar with the OSH challenges they will face. It could be said that one of the attributing factors for this shortage in staff is the lack of an industry standard in practical wind energy training — training is an important part of preparing the wind industry to be reliable. There has been significant investment and work done to try and develop wind-specific training in Europe, for example inexperienced staff can now practice their techniques and new skills on dummy turbine masts. However, supplying training

7. OSH THROUGH THE LIFE CYCLE OF A WIND TURBINE

From the offset of the review, the collected data showed that wind energy workers both onshore and offshore will be exposed to OSH risks throughout the entire life cycle of a wind turbine. By using the life cycle model (design and development, manufacture, transport, construction, operation, associated infrastructure, repowering/life extension, decommissioning and recycling) to frame the review, it was possible to visualize the various complexities involved in any of the tasks or activities being undertaken on both onshore and offshore wind farms.

8. DESIGN AND DEVELOPMENT

Design and development is a critical stage in minimizing the potential for OSH issues throughout the life cycle of wind turbines. Discussion between designers and contractors can often result in a number of engineered solutions and more efficient operations that will minimize the amount of time workers spend on activities at all stages of the wind turbine's life cycle, for example employing remote diagnostics to reduce service and maintenance frequency. Minimizing the need to visit turbines decreases the number of operational maintenance hours offshore, and therefore the overall risk to personnel. Some of the newer wind turbine concepts, such as floating platform technologies and airborne wind turbines or kits, can potentially reduce falls from height and musculoskeletal issues because they can simplify some of the more difficult tasks (EWEA, 2010; EERA, 2010; Byon, 2010). Some components on wind turbines have longer design lives, which, again, will improve the OSH of workers simply because they spend less time working in and around wind turbines on unscheduled maintenance tasks.

Ultimately, there will be situations when a visit is unavoidable; the design should therefore allow technicians to safely and quickly deal with any issues. However, in an effort to make efficiencies, some potential OSH implications may have been overlooked. The use of nanomaterials in smart paint is a case in point. Smart paints were developed to help reduce weathering effects on wind turbine components. Owing to the conductivity of the paint it has also allowed for the use of remote control sensors and remote robots that can closely inspect the integrity of wind turbine blades from a remote control room. However, the use of nanomaterials raises potential issues for workers involved in manufacturing and at any other stage where repairs or decommissioning work might result in exposure to the paint or dusts containing carbon nanotubes or other nanomaterials. Although anecdotally there is some debate about the long latency of nanomaterials, there is some evidence that some types of carbon nanotubes may have asbestos-like effects. Another potential issue that is discussed within the industry but has not yet been tested to any significant extent is the change in turbine blade design that uses two or even one blade and produces higher noise levels as a result of higher speeds at the wind tip. As this illustrates, designers and developers need to consider fully the long-term impact of their designs and the materials they use on workers. Such is the fast pace of change in technology in the wind industry that health and safety risk assessments need to be dynamic and flexible enough to respond to these changes (Wood, 2009; United States Department of Labor, Occupational Safety & Health Administration).

9. MANUFACTURING

Manufacturing of wind turbines also presents some interesting issues for OSH. Exposures to chemicals, particularly epoxy-based resins, are not new hazards (O'Neill, 2007; Rasmussen et al., 2005; Safety and Health Practitioner, 2009; Health and Safety Bulletin, 2009; Wood, 2009), but as other materials are introduced into the manufacture stage the impact of technology on workers' OSH will need to be continually reviewed. The long latency of such chronic exposure should be fully considered during health surveillance and risk assessment. Newer manufacturing plants may invest more in up-to-date production processes such as robotic spraying booths that will reduce the exposure and immediate contact of workers to dangerous substances; however, the manufacturing processes will continue to have other OSH issues that need to be addressed. With wind turbines increasing in size, the impact of these larger and heavier components on the OSH of manufacturing workers needs to be assessed, especially with regard to the physical load on the body (manual handling, awkward postures, etc.). The trend for the manufacture of wind turbine components for offshore wind farms to be sited at key ports is an interesting development. Workers may potentially be fitting larger components together, so that they can be lifted directly onto specialist wind turbine installation vessels. There is further work that could be done to assess the musculoskeletal issues that may occur with the increased size of these components.

10. TRANSPORT

The movement of enormous wind turbine components for hundreds of miles is more than a substantial logistics challenge for the wind energy sector. It also poses a number of OSH concerns for the workers involved. According to statistics reported up to 31 March 2013, there were 113 transport-related accidents reported — including a 45-m turbine section ramming through a house while being transported. Although most road accidents involve turbine sections falling from transporters, accidents can also involve vehicles rolling over, loads shifting forward and causing serious injuries to the driver and collisions with other vehicles, particularly on smaller off-roads. In the case of offshore transport, additional issues are introduced, such as the transportation of larger and heavier turbine components or even a fully constructed turbine, exposure to weather, stranding or collisions and being subjected to different motions such as rolling or pitching. To ensure the safe transportation of turbine components both onshore and offshore, the risks mentioned above need to be taken into consideration as early as possible in the design phase of the project. This would identify the type of provisions, such as the provision of escorts, contingency planning, restricted access routes, steep gradients, confined road corridors, road traction, limited turning points or forms of communication that will be needed. The changes towards the manufacture of components at ports will reduce some of the road transportation issues; however, as offshore wind turbines are being sited further away from the shore, the travelling distance required by workers on sea is increasing. It is not just the OSH implications of transporting components that requires consideration.

11. CONSTRUCTION — CONTROL OF CONTRACTORS

Construction is seen as the most complicated and possibly the most dangerous stage of a wind turbine's life cycle, as it involves the installation of major components, among them the foundation and transition piece, and the assembly of the wind turbine. Although the number of workers involved in the installation phase will depend on the size of the wind farm, this is the most personnel-intensive phase in its development and operation. During the construction period (which could take more or less than a year depending on the project size, location and weather conditions), construction workers, engineers, surveyors, turbine installers, electrical contractors, administrative employees and managers would all be working on site. In the BARD offshore project in Germany, for example, approximately 500 workers were involved on the offshore construction and installation of the wind turbines. This change in balance of contracted and in-house work, together with an increased proportion of the work being on longer-term contracts, changes the emphasis of safety management effort. As with any other construction work, the management of OSH in the supply chain is paramount. However, for the wind energy sector this is even more vital because most of these workers would have never worked in the wind energy industry, particularly offshore. The majority of works, for example design, construction, installation and commissioning, are generally undertaken by contractors. Successful management of the project will therefore depend on:

the appointment of suitable competent persons for key safety-related roles;

appropriate contractor selection, considering their safety culture and ensuring that the contractor's investment in developing competent people and safe methods brings a competitive advantage, rather than just a consideration of the initial cost;

effective communication of safety information to the relevant personnel, including between contractors and phases of a project;

agreement of suitable contractual arrangements, which promote safe working and define relevant key performance indicators; and

Effective monitoring of contractor performance according to key performance indicators and compliance with method statements.

12. OPERATION AND MAINTENANCE

Once operational, wind farms are essentially unmanned facilities with personnel accessing them only to perform maintenance and repairs. Regardless of whether the wind turbine is onshore or offshore, once the technician is inside the turbine, the operational and maintenance tasks that he or she will undertake are exactly the same. Owing to the pace at which the industry was developed, earlier first-and second-generation wind turbine designs that are still in operation did not have operational and maintenance OSH risks that we are now aware of designed out, for example workers having to make several climbs a day up the turbine or the need to work in confined spaces. Better engineering controls, reduced maintenance cycles and remote inspection on newer designs have improved the OSH of workers. Good management practices, including worker engagement, are key elements in promoting good OSH, but the industry should also be mindful that the pressure to work efficiently in what are often short periods of good weather has the potential to create stress on a workforce with high work demands. The development of offshore platforms in deep water and the requirement for workers to spend periods of time on accommodation platforms may require further investigations into the psychosocial issues associated with working on offshore wind farms.

13. REPOWERING AND DECOMMISSIONING

Repowering has to some extent kept many wind farms beyond their intended life span, and there have been consequences for workers as the earlier generations of wind turbine design were smaller and accessed by ladders. Whilst some decommissioning activity has taken place, wind farms in areas such as Germany, Denmark, the United Kingdom and Spain, where the wind energy industry is more mature, will be faced with an increased number of decommissioning activities. The designs for these installations are unlikely to have considered their legacy, how they will be dismantled and the recycling of their parts. Inevitably these tasks will be undertaken by subcontractors, and duty holders will need to ensure that measures are put in place to oversee their activities and embed them into their OSH culture for the time they are on site. Duty holders will face challenges not just from subcontracted workers; the shortage of trained technicians could also mean that some companies become reliant on temporary agency staff, which makes it harder for managers to develop a culture of good OSH behaviors.

14. WASTE MANAGEMENT

In the life cycle analysis for both onshore and offshore wind turbines, it is assumed that most of the materials of the wind turbine will be recycled at the end of their life cycle; however, turbine blades that are nearly all manufactured from thermoset plastic (the only material currently known that meets reliability standards owing to its relatively high strength and low weight) cannot be recycled once their useful life has expired. There are three possible routes for disposing of dismantled blades: landfill, incineration or recycling. Wind turbine blades are mainly sent to landfill, but in several EU countries it is illegal to send composite materials to landfill. Another common route is incineration. However, the ash that is left after incineration may be considered as a pollutant because of the presence of inorganic materials in composites; furthermore, the flue gases may be hazardous. The last option is recycling as a material or as a product. However, at present there are few established methods for recycling of wind turbine blades. The blades would need to be cut into smaller parts for ease of transport, and this can result in respiratory problems caused by the fine dust produced during the cutting and grinding of the blades. This lack of forward planning means that the future of waste handling for rotor blades and their OSH implications are still unknown.

15. REFERENCES

[1] Albrechtsen, E., ‘Occupational safety management in the offshore wind industry — status and challenges’, *Energy Procedia*, Vol. 24, 2012, pp. 313–321.

[2] American Wind Energy Association and Canadian Wind Energy Association, *Wind turbine sound and health effects. An expert panel review*, 2009. Available at: (accessed 15 November 2013).

[3] Bundesverband WindEnergie, ‘GWEC: wind energy powers ahead despite economic turmoil’, 2012. Available at: (accessed 22 May 2012).

[4] Byon, Y. D, ‘Season-dependent condition based maintenance for a wind turbine using a partially observed markove decision process’, *IEEE Transactions on Power Systems,* Vol. 25, No 4, 2010, pp. 1823–1834.

[5] Casey, Z., ‘No link between wind turbine and adverse health effects’, 2013, EWEA blog. Available at:

[6] Chief Medical Officer of Health (CMOH), *The potential health impact of wind turbines*, CMOH, Ontario, Canada, May 2010.

[7] Clarke, P., Health & safety on wind farms — the PowerGen approach, PowerGen, pp. 25–31.

[8] Department of Health and Human Sciences (National Institute for Occupational Safety and Health), Summary of the Making Green Jobs Safe workshop, 14–16 December 2009, Mandarin Hotel, Washington, DC., 2011, publication number 2011-201, NIOSH.

[9] European Commission, ‘Wind energy generation, Strategic Energy Technologies Information System’, 2012. Available at: (accessed 15 November 2013).

[10] European Energy Research Alliance, ‘The EERA joint programmer on wind energy’, 2010, Available at: (accessed 18 June 2012).