East African Scholars Journal of Engineering and Computer Sciences
Abbreviated Key Title: East African Scholars J Eng Comput Sci
ISSN 2617-4480 (Print) | ISSN 2663-0346 (Online) |
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-2 | Issue-3 | March-2019 |

Review Article

The Principle of Compliance with Requirements of Directive 2009/104/Ec: Risk Assessment of Work Equipment in General Use

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Abstract: The risk assessment is a key element in ensuring compliance of professional use products with, both legal and technical requirements. The study is an analysis undertaken to identify the necessary measures to be taken to increase the compliance rate in the use of work equipment and new electricity generation technologies in Romania. The paper aims to identify the professional risks that can be generated by the wind turbines, with are included in machinery, in order to conformity assessment, certification and adoption of the measures necessary for safe use, as well as to ensure the safety of the working environment and the environment itself. The risk assessment, under the principles set out in Directive 2006/42/EC and the SR EN ISO 12100:2010 standard, is essential to prevent the hazards and to guarantee the safety of work equipment in use, taking into account the new technological challenges in the energy sector. The necessity to comply with the essential safety requirements and to perform periodic safety tests on wind turbines commissioned in Romania aims to eliminate the risk of accidents at work during the installation, commissioning, in use, verification and maintenance operations.

Keywords: risk, evaluation, security, turbines, machinery, electricity production.

INTRODUCTION

An important objective at the national level is to ensure the conditions for the competitiveness of the producers of work equipment on the market and to guarantee the free circulation of Romanian products within the European Union (EU), taking into account the status of Romania as a member state, by ensuring the essential requirements for safety and health applicable to all work equipment in order to implement the policies for the free movement of products contained in the EUROPA 2020 strategy (Buica, G. *et al.*, 2011; Leba, M. *et al.*, 2014). At European level, guaranteeing a safe and healthy work environment for over 217 million EU employees is a strategic goal for the European Commission, which is working closely with the Member States, the social partners and the other EU institutions. One of the priorities of the Europe 2020 strategy is "inclusive growth: promoting a high-employment economy that ensures social and territorial cohesion". In correlation with this priority, the European Commission set the following objectives: 75% of the 20-64-year-old population should have a job; the number of people threatened by poverty should be reduced by 20 million. (European Commission, 2010).

EU primary legislation is for general application, it is entirely binding and applies to all Member States. Within the EU, workers are protected against the risks of injury and occupational disease through the Framework Directive 89/391/EEC, its basic principle is accident prevention, which implies the risk assessment by the employer and imposes an obligation to ensure safety and health for workers in all aspects of work. The Framework Directive is complemented, at EU level, by Specific Directives laying down minimum health and safety requirements for employees. As a result, it is ensured compliance with the essential health and safety requirements set out in Annex 1 of Directive 2006/42 / EC, in conjunction with the requirements of

Quick Response Code

Journal homepage:
http://www.easpublisher.com/easjecs/

Article History
Received: 15.02.2019
Accepted: 01.03.2019
Published: 20.03.2019

DOI: 10.36349/easjecs.2019.v02i03.002

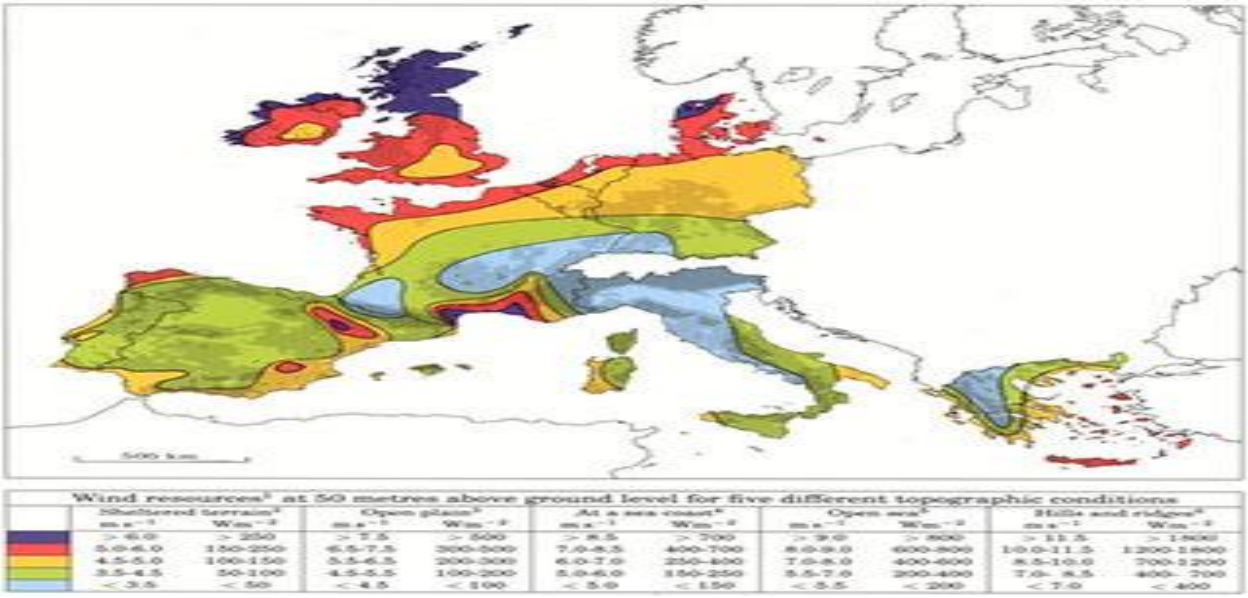
Directives 2009/127 / EC, 2006/95 / EC and 2014/30 / EU , and the guarantee of the minimum safety and health requirements of the Directive 2009/104 / EC. This study focuses mainly on the analysis of identifying the measures to be taken to increase the compliance rate of Work Equipment (WE) in use and the new technologies for the production of electricity in Romania (Gaman, A. *et al.*, 2012; Romanian Government. 2011). The used methods are:

- identifying the professional risks for wind turbines, which fall into the machinery directive, and which are the subject of this analysis;
- establishing the essential safety and health requirements applicable to wind turbines, according to the legal provisions set out in Annex no.1 of GD no.1029/2008, which adopts the Machinery Directive 2006/42/EC (Machinery Design Directive);
- establishing the safety and health requirements applicable to wind turbines, according to the legal provisions set out in Annex no.1 of GD no.1146/2006, which adopts Directive 2009/104 / EC (Work equipment directive);
- establishing the safety and health requirements applicable to wind turbines, according to the legal provisions set out the specific security standards analyzed in this paper.

GUIDELINE ON WIND ENERGY

In December 2008, the EU adopted an ambitious and long-lasting package on “climate change and energy” that obliges EU-27 countries to increase the share of renewable energies to 20% of Europe's total energy production by 2020. Wind energy is a clean and renewable electricity source, which is meant to make a significant contribution to achieving the 20% target over the last decade, wind energy having a rapid growth in Europe. (European Union, 2011) In 2008, it represented around 4, 8% of the total EU electricity consumption, assuming that this percentage will increase at least three times by 2020. The number of wind farm facilities in the EU is expected to increase considerably in the short and medium term, one of the reasons why wind energy is so rapidly expanding is that the technology has considerably evolved over the last 20 years (Buica, G. *et al.*, 2011; European Commission. 2011). Thus, the size of terrestrial turbines has increased from less than 50 kW in the 1980s to more than 3 MW at present; the rotor diameter rising from an average of 15m to 100 m or more.

At present, upstream turbines are predominant, with a 3-blade variable speed control system, generating between 750-3000 kW, accounting for about 90% of the EU market (eg small and very small turbines are used to fulfill specific needs, for example, as a traditional part of rural electrification systems, to power isolated homes, boats and telecommunication installations). The cost of installing wind turbines has declined considerably in recent years, wind farm construction becoming more cost-effective and more attractive to investors, with average wind turbines in Europe costing 1.23 million/MW on land and 2-2.2 million/MW offshore. (European Union, 2011). Fig. 1 presents the wind energy production resources at European level, in five different topographic conditions.

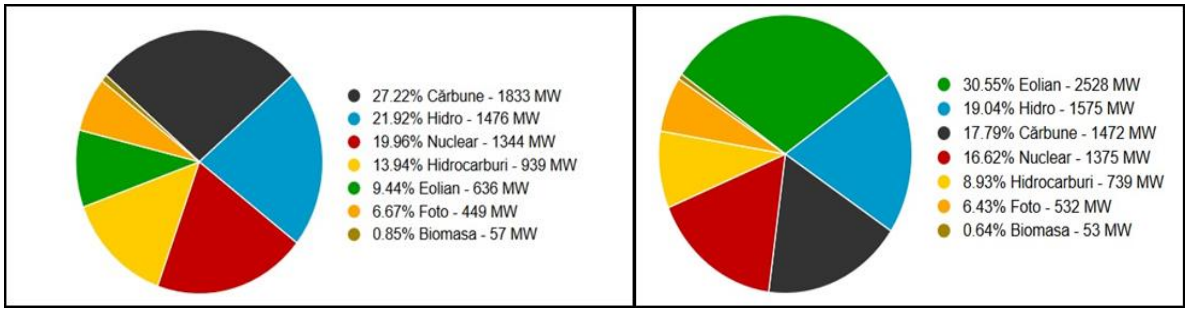


European Wind Atlas

Source: Risø National Laboratory, Roskilde, Denmark, 1989 (internet)

The EU has committed to reduce greenhouse gas emissions by 80-95% by 2050 compared to 1990 levels, in the context of the need to reduce emissions by developed countries as a group. In the Energy Perspective 2050 (Buica, G. *et al.*, 2011; SR EN ISO.12100:2010), the European Commission examines the challenges of meeting the EU's decarburization target, while ensuring security of energy supply and competitiveness.

The share of energy from renewable sources increases substantially in all scenarios, reaching at least 55% in gross final energy consumption in 2050, 45% more than the current level, about 10%. At the national level, the programmatic document elaborated by the Romanian Government on "Romania's Energy Strategy for the period 2007 - 2020 updated for 2011-2020", establishes the need to improve energy efficiency and promote renewable energy sources in order to diminish the negative effects of the process energy production on the climate and alignment with European actions that promote the Lisbon. In fig. 2, is shown the renewble energy production, by category, in Romania.



* Data taken from the operational report of National Power Dispatch

The production of renewable energy in Romania

In order to limit the projected increase in global temperature and greenhouse gas emissions, Romania is set to act to promote energy efficiency and renewable energy sources. These actions will contribute both to reducing the negative impact on the environment, as well as to increase the food security, diminishing the degree of Romania's dependence on energy imports. The most suitable renewable resources (depending on the cost of use and the volume of resources) and technologies used for electricity production are hydroelectric plants including micro-hydropower, wind and biomass cogeneration turbines and biomass and energy for the production of heat solar. At national level, tools have been developed to evaluate the most appropriate renewable energy system for different areas and uses. Overall, the evaluation is done. In general, the evaluation is done using an expert system (ES) based on general rules. Expert systems are designed to provide "expert-quality" performance on domain-specific problems (Gaman *et al.*, 2012). The expert system based on QFD is validated by evaluating the most suitable types of wind turbines for several different areas, the main advantage of using this QFD implementation method is that it provides a global assessment tool for the more appropriate renewable energy system, based on the specified requirements and the quality characteristics of the available systems (Leba *et al.*, 2013, Leba *et al.*, 2014). In order to prevent the risk of injury and occupational disease, studies were carried out, in which were calculated the cost of an accident at work and the cost of occupational safety. In this regard, the identification of risk factors, analysis and elimination or reduction of these factors has been carried out, allowing for the estimation of the cost of work accidents. In addition, it is important to note that in order to reduce the risk of accidents and occupational diseases (Buica *et al.*, 2011, Buica *et al.*, 2012).

RESULTS AND DISCUSSIONS

Issues concerning the essential safety and health requirements for wind turbines

This paper has focused on the analysis of the essential health and safety requirements that wind turbines have to guarantee, which are fall into machinery category. Wind turbines are of several categories, depending on the various criteria that can be divided, vertical-axis turbines, horizontal, medium-sized or high-capacity turbines.

Identifying the professional risks that can be generated by wind turbines

In order to assess the risks of wind turbines, wich are consideredmachinery, it is necessary to identify the professional risks in order to assess the conformity, certification and adoption of the measures necessary for safe use, as well as to ensure the protection of the working environment. The risk assessment, under the principles laid down in Directive 2006/42/EC and SR EN ISO 12100: 2010, is essential to prevent hazards and to guarantee the safety of work equipment in use, taking into account the new technological challenges in the energy sector. The identification of the professional risks applicable to wind turbines, which are subject of design analysis, was

based on the analysis of the main parts of the turbines: rotor hub, blades, nacelle, pillar, main shaft (low speed), spindle speed with spike wheels, braking device, electric generator, cooler, swivel system, weathervane, anemometer and controller.

Wind turbine with horizontal axis
Source: INCDPM study ; Photo: dr.eng.Georgeta Buica

The identification of the risks in these categories of machinery was aimed to ensure the necessary conditions for establishing the essential safety and health requirements applicable that are subject to the design analysis in accordance with the legal provisions set out in Annex no.1 of GD no.1029/2008, which adopts the Machinery Directive 2006/42/EC (Machinery Design Directive).

Identifying the essential safety requirements applicable to wind turbines

In order to guarantee the safe use of machinery, the designer and manufacturer of a wind turbine, must confirm the fulfillment of GD no.1029/2008 provisions, which is the legislative document by which the Directive 2006/42/EC is adopted. The provisions of Directive 2006/42/EC apply to the major electrical risk (machinery and equipment covered by the Machinery Directive, except those covered by the LVD 2015/35/EU Directive), and for the emission and immunity characteristics of equipment in an electromagnetic field, the provisions of the 2014/30/EU Directive on Electromagnetic

Compatibility apply. In order to ensure the essential safety and health requirements applicable to the machines from the design, manufacturing and marketing stages, the provisions of GD no.1029/2008 and GD no. 1446/2006, regarding the use of work equipment, have to be fulfilled cumulatively. In this study, the professional risks generated by wind turbines were identified and the relevant safety and health requirements were established, based on the assessment of the risks arising from the analysis of the underlying causes of the hazards in the process of production renewable energy. Risk analysis provides information required for risk assessment, which in turn allows judgments to be made on whether or not risk reduction is required. (European Commission, 2017; SR EN 12100:2011). Risk assessment and any qualitative and quantitative analysis shall include, as appropriate, the following: machine limits, machine life phases, design documentation or other means of defining the nature of the machine, power related information, the history of any accident or incident, or any information related to health hazard.

Table 1. Extracted list of mechanical and other hazards identified on the machines

adaex	Risk name	Annex no.1 of GD no. 1029/2008	Annex no.1 of GD no. 1029/2008	SR EN ISO 12100:2011
1	Principles of safety integration	1.1.2, 1.7.4	Art.4	6.2.2.1, 6.2.2.2 6.2.3 a), 6.2.3 b) 6.2.6, 6.2.10 6.3.1, 6.3.2 6.3.3, 6.3.5.2 6.3.5.4, 6.3.5.5 6.3.5.6, 6.4.1 6.4.3, 6.4.4, 6.4.5
2.	Risk of breakage during operation	1.3.2	2.7	
3.	Risks due to dropping or ejecting objects	1.3.3	2.5	
4.	Risks due to surfaces, edges or angles	1.3.4	2.7	
5.	Lighting	1.1.4	2.9	6.2.8
6.	Power supply	1.5.1	2.19 3.3	6.2.9, 6.3.2 6.3.3.2, 6.3.5.4 6.4.4, 6.4.5
7.	Extreme temperatures	1.5.5	2.10	6.2.4 b), 6.2.8 c) 6.3.2.7; 6.3.3.2.1 6.3.4.5
8.	Explosion	1.5.7	2.17, 2.18	6.4.4.b), Annex B
9.	Emissions of hazardous materials and substances	1.5.13	2.5 2.17	6.2.2.2, 6.2.3 b) 6.2.3 c), 6.2.4 a) 6.2.4 b), 6.3.1 6.3.3.2.1, 6.3.4.4 6.4.5.1 c), 6.4.5.1 g)
10.	Risk of slipping, unbalance or falling	1.5.15	2.3.1	6.2.6, 6.2.11.11 6.3.2.1, 6.4.5.1.b)
11.	Lightning (atmospheric overvoltage)	1.5.16	2.3.1	
12.	Machinery maintenance	1.6.1	2.13, 2.16	6.3.2.4, 6.4, 6.4.5
13.	Access to workstation and intervention sites	1.6.2	2.1.16	6.3.4.5
14.	Operator intervention	1.6.4, 1.7.4	2.1.13	6.3.2.4, 6.3.5.6 6.4, 6.4.5
15.	Risks for people near or on the access areas' of cabins	6.3	2.16	6.3.5.6

Electrical equipment of wind turbine must guarantee the essential safety and health requirements applicable, provided in Annex no.1 of Directive 2006/42/EC and Annex no.1 of Directive 2009/104/ EC (INCDPM 2015).

Table 2. Extracted list of electrical hazards identified on the electrical equipment of the machines

ndex	Risk name	Technical condition according to			
		Annex no.1 of GD no. 1029/2008	**Annex no.1 of GD no. 1146/2006**	**SR EN 12100:2011**	**SR EN 60204-1:2007/AC:2013**
1	Risk of electric shock by direct touch	1.5.1	2.19, 3.3.1	6.29, Annex B	6.2
2	Risk of electric shock by direct touch in fault conditions	1.5.1, 1.6	2.19, 3.3.1	6.29, Annex B	6.2
3	Risk of electric shock by indirect touch	1.5.1	2.19, 3.3.1	6.29, Annex B	6.3
4	Failure of electrical separation devices	1.6.3	2.14	6.29 Annex B	5.6, 11
5	Failure of emergency stop device	1.2.4	2.1, 2.4	6.29, Annex B	10.7, 10.8, 11
6	Failure of control system	1.2	2.2, 2.3, 2.4	6.29, Annex B	5.3, 5.5, 11
7	Failure of control system in the event of a power failure	1.2.6	2.3	6.29, Annex B	5.4
8	Failure of engine protection against abnormal heating or generator protections	1.5.1	3.3.1	6.29, Annex B	7.4
9	Non-operation of protection against accidental grounding and residual currents	1.5.1	3.3.1	6.29, Annex B	7.7
10	Do not operate over atmospheric overvoltage or comutation overvoltage	1.5.16.	3.3.1	6.29, Annex B	7.9
11	Thermal risk due to the occurrence of an electric arc during the maintenance activity	1.5.1	3.3.1.1	6.29, Annex B	-
12	Thermal risk due to thermal radiation during the maintenance activity	1.5.1	3.3.1.1	6.29, Annex B	-

Conformity assessment and technical inspection of wind turbines

The safety and health requirements applicable to wind turbines used as work equipment (WE) for the production of renewable electricity, are laid down in Directive 2009/104/EC, which is adopted in Romanian legislation by GD no. 1146/2006, concerning the safety and health at work for the use of the WE, and the application of these requirements must also be made in the compliance of the WE in use.

Fo

r this purpose, for the wind turbines in use, the initial inspection should be carried out because their safety depends on the installation conditions, the conditions after installation and before being put into service, periodic and special inspections and, where appropriate, examinations/tests of wind turbines exposed to conditions that may cause damage and may result hazardous situations (European Commission, 2010).

CONCLUSIONS AND FINAL REMARK

The research study aimed both at identifying the professional risks for wind turbines, and establishing the essential safety and health requirements relevant to these WE for the prevention of hazards and safety in use, taking into account the new technological challenges in the energy sector.

These identified specific safety conditions both support employers in order to eliminate the risk of work accidents in the installation, commissioning, operation, verification and maintenance of new turbines put into service, and to competent bodies for the purpose of assessing conformity, inspection, certification or, where appropriate, compliance with technical diagnosis.

ACKNOWLEDGMENT

The authors would like to acknowledge the keen support for this work of the Department of Physics, Faculty of Science, University of Tabuk, Saudi Arabia and the Faculty of Exact Sciences and Engineering, University "1 Decembrie 1918" Alba-Iulia, Romania and also University of Petrosani, 20 Universitatii str, Petrosani, România (Adina, Tatar. *et al.*, 2016; Buica, G. *et al.*, 2019).

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