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CONSIDERATIONS ON PROFESSIONAL RISKS AND PREVENTIVE MEASURES IN THE GREEN TECHNOLOGIES SECTOR

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Abstract: *For all green technology jobs, the employers must provide workers with safe and healthy working conditions. For this purpose, ecological workplaces must be subject to occupational risk assessment. This paper presents the occupational risks and measures to be taken for a representative job in the field of green technologies: wind turbine maintenance electrician. Thus, the analysis of classic occupational risks is updated alongside the new and emerging risks in the green technology sector through the EVA-RISK method, the necessary systems for mitigating and eliminating these risks are presented, as well as the need for employers and workers to be aware of the importance of safety at work in current conditions.*
Key words: *green technologies, occupational risk, preventive measures, sustainability, renewable sources*

1. INTRODUCTION

The sector of green technologies is associated with the protection, conservation and recovery of the environment and natural resources, but it is also associated with sustainability, compliance with the principles of circular economies - recycling, reuse, reduction. The alternative to fossil fuels is renewable energy sources - wind energy, solar energy, geothermal energy, hydroelectric energy, ocean energy, biofuels and biomass [1]. They help reduce greenhouse gas emissions and reduce dependence on volatile and uncertain fossil fuel markets, particularly oil and gas. European legislation regarding the promotion and use of renewable sources has changed significantly in the last 15 years [2-4].

If in 2009, the EU leaders decided that by 2020, 20% of energy consumption should come from renewable energy sources, in July 2021, it was established that, by 2030, this percentage should increase to 40. However, as a result of the invasion of Ukraine by Russia and the energy crisis that followed, the EU decided to quickly reduce dependence on Russian fossil fuels before 2030, and accelerate the transition to an ecological energy [4-5]. This aspect causes a series of changes in the work process Thus, the work environment changes, new substances and work processes appear, the structure of the labor force changes, new forms of employment and work organization appear. New work situations generate new risks and challenges for workers and employers, which require new types of political, administrative, technical and regulatory approaches to ensure a high level of safety and health at work [5,7].

The assessment of professional risks in the case of ecological technologies must become an integral part of the activity of safety and health at work in conjunction with the economic activity. These assessments are also an effective way to determine whether or not a technology that has been labeled as green has a minimal level of impact on the environment.

The occupational health and safety problems that arise in these new technologies are relatively little studied at the European level. There are no systematic studies of the implications of the development of non-polluting technologies on the safety and health of workers, only information provided by the manufacturers of the respective technologies. The need to identify

and assess the new risks that appear at workplaces within these technologies and, on this basis, the development of preventive measures is all the more significant as there is already a sudden increase in their weight in the global economy [8]. It should be stated that, at workplaces within this sector, the occupational safety and health knowledge assimilated from classic trades is currently used [9-12]. Therefore, we aim to develop the knowledge base on occupational health and safety issues that must be considered when using green technologies.

The proposed goal is to identify classic risks along with new and emerging risks generated by ecological technologies, to provide tools for their assessment, as well as to create mitigation-elimination systems that help design places of future jobs in this burgeoning field.

This paper presents the assessment for a representative job in the field of green technologies: wind turbine maintenance electrician.

2. METHOD

The methodology is comprehensive [13-15], consisting of two important stages:

- assessing of occupational risks through a method complies with the requirements of the legislation; the evaluation will take into account the following elements: worker, workload, means of production and working environment.
- establishing the mitigation-elimination systems for the identified risk factors.

The European Agency for Safety and Health at Work considers green technologies as part of the category of new technologies that generate new and emerging risks in the work process [5,8]. Emerging occupational risks, according to the European Agency for Occupational Safety and Health at Work (EU-OSHA), is an occupational risk that is new and increasing. A new risk is considered a risk which was previously unknown and is generated by new technologies, processes, or workplace types. Also, new risks can be determined by changes of the social perceptions or scientific advances related to a long-standing issue [5,6,16]. If the number of the hazards which are determining the risk is increasing, the risk is increasing. Also, the risk is increasing if the likelihood of the hazard exposure is increasing by growing the exposure level and/or the number of exposed people, or the consequences of the hazard on the worker's health become more significant by increasing the severity of health effects and/or growing the number of affected people. As a result, we consider that the most appropriate evaluation method in this case is EVA-RISK, because this, in addition to the list of identification of traditional risks, also contains a list of identification of new and emerging risks, presented in Table 1 [7,14,17].

Table 1

New and emerging risk factors identification list

Crt. No.	Risk factors
	Means of production
1.	nanomaterials - penetration into the human body etc.
2.	new technologies - the functional movement of some equipment used in new technologies
	Work environment
3.	microorganisms - new viruses, viruses that have undergone mutations, pandemics
4.	climate changes - continuously increasing high temperature, prolonged drought, heavy rainfall in a short time, violent storms
5.	international armed conflict (war) - accidental bombing
	Workload
6.	psychic request - extended work schedule, variable work schedule, unpredictable work schedule, lack of balance between professional and private life, high emotional demands at work
7.	digitization - lack of social interaction, solitary and monotonous work; artificial intelligence – the takeover of leadership by super-machines
	Worker
8.	vulnerable persons – persons with disabilities, people with chronic diseases etc.
9.	old people - aging workforce
10.	young people - insufficient level of skills and training, lack of physical and emotional maturity
11.	immigrant workers - difficulties to understanding the Romanian language
12.	gender- harassment, discrimination, underestimation at work (especially of women)

The EVA-RISK method is the result of the collaboration between OSH specialists, professors, researchers and doctors. This method complies with the requirements of the OSH

legislation, modified and updated [18-20]. The advantages of using this method are also given by the EVA-RISK electronic evaluation application in Excel - rapidity, precision, accessibility.

Occupational risk, approached as a component of the risk in an enterprise, is characterized by the probability of occurrence and the consequences of a risk of injury [21-24].

The EVA-RISK method includes the following steps [14,25-27]:

- Identification of occupational risks at the workplace proposed for evaluation;
- Establishing the maximum foreseeable consequence (damage) on the human body;
- Determining the severity class and the probability class of the consequence;
- Establishing the level of risk for each risk;
- Completing the risk assessment sheet and the prevention measures.

The central instrument of the method is the risk assessment sheet and includes [14,19,20]:

- The identified professional risks;
- The maximum foreseeable consequence on the organism and the severity of the consequence – Table 2;

Table 2

Quotation of severity and probability

Severity Class	**Severity description**	
1	Minor	Incapacity for work up to 3 days
2	Medium	Incapacity to work for 3-45 days, requires medical treatment
3	High	Consequences with incapacity for work between 45-90 days
4	Majority	Invalidity class 1, 2 or 3, irreversible consequences.
5	Fatal	Death
Probability Class	**Probability description**	
1	Very rare	The hazard is not observed, very low risk exposure time
2	Rare	The danger could be very difficult to detect during OSH inspections/checks, short exposure time
3	Unlikely	The danger could be noticed during workplace controls and/or OSH inspections, medium exposure time
4	Likely	Easily noticed during workplace controls and/or external OSH inspections/audits, high risk exposure time
5	Very likely	The danger is easy to notice during the controls carried out at the workplace level, very long exposure time

- The probability class of the consequence- Table 2;
- The level of risk determined based on the severity and probability;
- The risk/safety level quotation (Table 3)

Table 3

Quotation of risk/safety level

Risk level		**Safety level**	
1	Minimum	5	Very high
2	Low	4	High
3	Medium	3	Medium
4	High	2	Low
5	Very high	1	Minimum

- Proposed measures – mitigation - elimination systems;
- Deadline for carrying out the measures;
- Responsible for implementing the measures (technical, organizational, hygienic-sanitary, others).
- According to the methodology, the Level of Job Risk (Lr) is calculated as a weighted mean of risk level values determined for all identified risk factors [14,15,24], using the formula:

$$Lr = \frac{\sum_{i=1}^{n} r_i \bullet l_i}{\sum_{i=1}^{n} r_i} \quad (1)$$

where:

- l_i is the level of risk determined for the risk factor i;
- r_i – weight for the risk factor i;

by definition, $r_i = l_i$;

- n – number of identified risk factors.

3. RESULTS AND DISCUSSION

The results of Analysis and evaluation of professional risks for "Wind turbine maintenance electrician" are presented in this chapter.

Wind power is the process of creating electricity using wind or air currents that occur naturally in the earth's atmosphere. Modern wind turbines are used to capture the kinetic energy from the wind and generate electricity. They can be placed in open spaces to capitalize on the wind, Figures 1 and 2 [28]:

Fig.1. Wind farm

Fig.2. Wind turbine

Wind power generation has experienced spectacular growth over the past decade and is expected to continue to grow. The types of jobs related to this sector are found in the design, production of turbine components, construction, installation, operation and maintenance of wind turbines.

The work process for the "*Wind turbine maintenance electrician*" consists in ensuring the good functioning of the electrical equipment in the wind turbines and the power station and performs specific activities of supervision, control, maneuvers, recording the values of the work parameters, light interventions etc.

The elements of the work system:

1) means of production
- 100 wind turbines, with an installed capacity of 2.5 MW each;
- main electrical station 400/110/20 kV transformation;
- the 110/33KV electrical secondary stations
- LES 33 kV cable routes;
- PC system;
- SCADA monitoring system (Supervisory, Control and Data Acquisition);
- work kit;
- vehicle.

2) to the work environment
- natural and artificial lighting;
- strong wind (Vmax=23.4m/s) when traveling on land;
- variable temperatures, depending on the season;

3) the workload
- maintenance of the equipment;
- draws up and submits to verification and approval internal technical instructions and procedures on the electrical side, for carrying out the operation of electrical installations;
- participate in the pre-reception phase, reception of electrical installations and propose measures, deadlines and responsible for eliminating non-conformities;
- participate in various trainings in the electrical field;
- ensures the training of the operating operational personnel;
- participates in commissioning, guides the operational staff in order to correctly apply the electrical technical regulations in force;
- supervises the development in good conditions of the exploitation activity of the operational team, during the execution of the commissioning.

In this case, the analysis and assessment of professional risks will be done for the specific risks and the new and emerging risks of the worker's activity. Applying the EVA-RISK method, we identify the risks, establish their severity and probability, determine the risk level

of each risk and complete the mitigation - elimination systems for each risk. The results are centralized in evaluation form, Table 4. The meaning of the notations in Table 4: Lr - level of job risk - is a weighted average of the levels of risk factors identified for a job; l - level of risk of the risk factor - is given by the probability and severity; S – severity; P – probability.

- Replacing the quantities in formula (1), obtain the risk level of the job: Lr = 2,86
- 21 risks specific to the workplace were No risks with a risk level above 3 were identified
- Measures specific to the use of wind turbines have been developed in Table 5.
- Identified and 4 are new and emerging risks, total 25 risks, Figure 3.
- The level of risk in the workplace does not exceed value 3 - tolerated value.

Table 4

The risk assessment form

Economic unit: ABC	**ASSESSMENT FORM Lr=2,86**			**Work time: 8**h/shift		
Department: WIND FARM				**Assessment team**		
Workplace: Wind turbine maintenance electrician						
Risk factors	S	P	l	Measures	Dead-line	Responsi-ble
Means of production						
1.Hit by vehicles, CF when traveling on the normal route between home and unit, when traveling in the wind farm towards the turbines	5	1	3	periodic training and testing	quarterly	worker
2.Free fall of parts, tools, materials, ice, in the case of carrying out revision and repair works or while climbing the turbine ladder	5	1	3	equipping and using appropriate PPE	quarterly	manager and worker
3.*The functional movement of wind turbines produces wind turbine syndrome* – new risk	3	3	3	periodic training, testing	quarterly	manager and worker
4.Design of bodies or particles in special situations: at the explosion of the power transformer	4	2	3	equipping and using appropriate PPE	quarterly	manager and worker
5.Direct contact of the epidermis with overheated surfaces – when working on the transformer in case of checking or taking oil samples, etc.	3	1	2	equipping and using appropriate PPE	quarterly	worker
6.Surprise by the electric arc when handling the earthing separator on site; electric arc spontaneously occurring in live electrical installations	5	1	3	equipping and using appropriate PPE	quarterly	worker
7.Electrocution by direct contact, by indirect contact or the appearance of step voltage in case of: damage to the protections	5	1	3	periodic training and testing	quarterly	manager and worker
8.Working with flammable substances (transformer oil) or in the vicinity of places with a risk of fire	4	1	3	equipping and using appropriate PPE	quarterly	manager and worker
Work environment						
9.*Increasing air temperatures, from one year to another (climate changes)* – new risk	3	1	2	equipping and using appropriate PPE	semester	worker
10.Strong wind especially when working outdoors in winter	3	1	2	equipping and using appropriate PPE	semester	manager and worker
11.Natural calamities – earthquake, lightning, blizzard, etc.	5	1	3	periodic training and testing	quarterly	manager and worker
12.Physical aggression from some turbulent people, when traveling on the field	3	1	2	periodic training, testing	quarterly	worker

13.The appearance of toxic gases, especially in the premises, when certain insulations are pierced, followed by combustion with or without flame in the absence of fire detectors in the wind turbine	4	2	3	equipping and using appropriate PPE	quarterly	manager and worker
Workload						
14.*Physical effort when climbing the wind turbine ladder, during the summer, in the absence of a ventilation system* – emerging risk	3	1	2	the use of appropriate tech.equipment	quarterly	manager and worker
15.Works requiring attention in the conditions where there is no fire detection and signaling system in the wind turbine, the lighting system is non-compliant, the elevator/elevator has non-conformities, and the only communication system is the mobile phone	5	1	3	periodic medical check-up	quarterly	manager and worker
Worker						
16.Execution of unforeseen operations in the work load	4	1	3	periodic training, testing	quarterly	worker
17.Erroneous identification of installation parts or electrical equipment connections that are the subject of the intervention	5	1	3	periodic training and testing	quarterly	worker
18.Approaching live parts at a distance smaller than that allowed by regulations or dismantling fences, respectively exceeding their assembly plan with parts of the body	5	1	3	equipping and using appropriate PPE	quarterly	worker
19.Nonverification of the provided electro-insulating protective means (voltage indicator, electro-insulating poles), individual protective means (high-voltage electro-insulating boots and gloves) and protective equipment for working at height	5	1	3	-periodic training, testing -equipping and using appropriate PPE	quarterly	worker
20.Actions through erroneous identification of cells and/or equipment elements	5	1	3	periodic training, testing	quarterly	worker
21.Falling from a height during height interventions: when working on transformers (oil sampling), in the wind turbine tower (provided that the connecting piece – carabineer – between the complex belt and the sliding fall arrester model Haca is not blocked) -emerging risk	5	1	3	equipping and using PPE for working at height	quarterly	worker
22.Interventions in the turbine in adverse weather conditions (strong wind, lightning etc.)	4	1	3	periodic training, testing	quarterly	worker
23. Acceptance of omissions and/or errors in the equipment: current paths, contacts, switches, separators, protections, measuring transformers.	5	1	3	periodic training and testing	quarterly	worker
24.Omitting operations that ensure his own safety (e.g. not checking the voltage with the voltage detector/indicator, relying on the electronic or mechanical indications of the equipment)	5	1	3	periodic training and testing	quarterly	worker
25.Non-use of the protective means provided (bbc coveralls, electrically insulating boots and gloves, helmet with visor) and other protective means provided (voltage indicators, mobile scc)	5	1	3	periodic training and testing	quarterly	worker

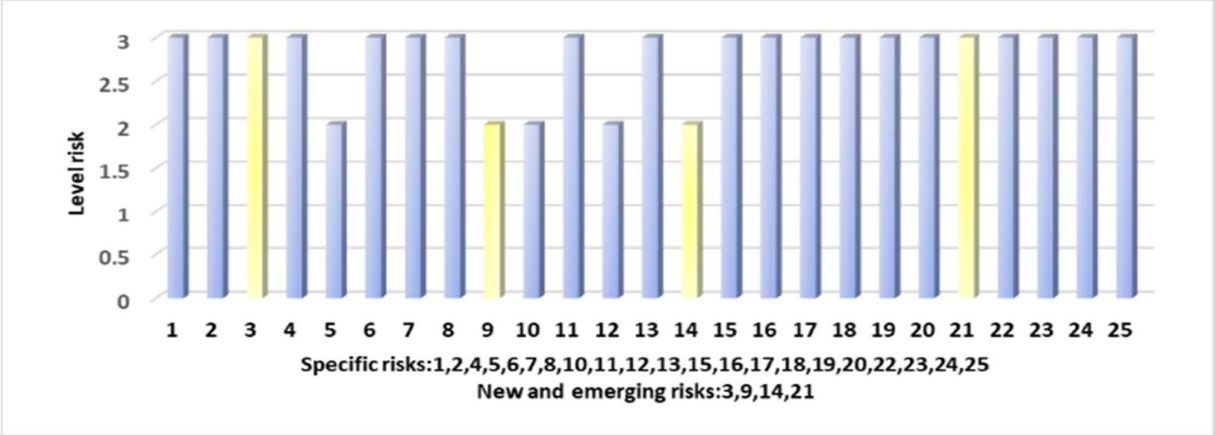

Fig.3. Risk levels by specific risks and new and emerging risk

Table 5

Crt. No.	Prevention and protection measures
1.	Arrangement of traffic routes in the wind farm according to the types of means of transport used
2.	Ensuring an appropriate lighting system both in the wind turbines and in the transformation substations
3.	Ensuring a fire signaling system in wind turbines
4.	The warnings, markings and labels on the technical equipment are written in Romanian
5.	It is recommended to mount and use an access rail/line and fall arresters on the nacelle
6.	Maintenance of the turbine elevator according to occupational health and safety requirements
7.	Ensuring an efficient communication system between the control room staff and the maintenance staff
8.	Periodically and before starting the intervention, checking the condition of the safety belt and other means of protection against falling from a height, as well as not using those that show defects
9.	The use of the safety belt whenever working at a height greater than 2 m from the ground or other reference surface considered stable up to the soles of the worker's feet;
10.	Use of all safety devices provided for working at height;
11.	Capacitive load discharge of the installation to be worked on;
12.	Establishing the work area taking into account the possibility of the accidental occurrence of the electric arc in the vicinity of the intervention point;
13.	Deenergizing the potential source of electric arc, if the work area cannot provide protection against the arc;
14.	Ensuring the appropriate personal protective equipment (helmets, gloves, safety belt, protective shoes etc.).

4. CONCLUSIONS

Jobs in the sector of non-polluting technologies, although they have a beneficial effect on the environment, involve new risks for the safety and health of workers, as seen in this case study.

- The risks were evaluated with the EVA-RISK method, a complete, accessible method and in accordance with the legislative amendment and update in the field, which takes into account the current challenges in the field of OSH. It is the only method that has an identification list for new and emerging risks, and the electronic application in Excel makes it adaptable, simple in application and complex in content, on the same form we find both the evaluation and the mitigation-elimination systems.

- In order to keep these risks under control, measures to prevent accidents and occupational diseases were proposed. By means of these measures, the action of risk

factors on the human body is eliminated, avoided or reduced.

- Organizational measures are mainly aimed at the executor and the work task, and technical measures are mainly related to the means of production and the work environment.
- The measures aimed at the performer are aimed at eliminating the risk factors specific to him: omissions and wrong actions or their causal substrate, lack of physical and mental skills, lack of safety knowledge work, inappropriate attitude towards risk etc.
- In the working conditions of wind farms, prevention and protection measures contribute to the reduction the incidence of occupational diseases and work accidents,
- This paper aims to be a useful tool for both wind energy workers and occupational health and safety appointees in the sector to increase the effectiveness of workplace safety, health and well-being and developing a culture of occupational safety and health at the organizational level and of social responsibility.
- The needs to identify and assess the risks that appear at workplaces within these technologies are increasing with the massive expansion of green energy production capacities (wind turbines, photovoltaic panels) due to the invasion of Ukraine by Russia and the energy crisis that followed. A boom is anticipated, a super-accelerated increase in the share of these renewable sources in the global economy.

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Considerații privind riscurile profesionale și măsurile de prevenire în sectorul tehnologiilor verzi

Pentru toate locurile de muncă din domeniul tehnologiilor verzi, angajatorii trebuie să asigure lucrătorilor condiții de lucru sigure și sănătoase. În acest scop, locurile de muncă ecologice trebuie să facă obiectul evaluării riscurilor profesionale. Această lucrare prezintă riscurile profesionale și măsurile care trebuie luate pentru un loc de muncă reprezentativ în domeniul tehnologiilor verzi: electrician întreținere turbine eolienne. Astfel, se actualizează analiza riscurilor profesionale clasice alături de riscurile noi și emergente dintr-un sector al tehnologiilor verzi prin metoda EVA-RISK, sunt prezentate sistemele necesare pentru atenuarea și eliminarea acestor riscuri precum și necesitatea conștientizării angajatorilor și lucrătorilor privind importanța siguranței la locul de muncă în condițiile actuale.

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