WORK SAFETY IN THE WIND ENERGY SECTOR: STATE OF THE ART, PROBLEMS AND FUTURE PERSPECTIVES

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ABSTRACT

The wind sector is a relative "new" work activity, if we consider that in the national context the first power plants have been built in the mid-90s, and for this reason the main processing phases of the wind farm construction and management involve risks to the health and safety of workers not yet fully known and properly managed. Many researchers and safety professionals operate in this sector and search for solutions that could reconcile production efficiency with the need to mitigate the risks associated with the work, through the risk assessment and the identification of appropriate prevention and protection measures.
25 years after the first installations, the issue of the advancing age of wind energy technicians appears as one of the main risk factors so far little taken into consideration, and on which it is therefore necessary to intervene.
Our work focused on the identification of risk assessment criteria and on the search of innovative mitigation measures, through a methodology based on the work experiences we have lived in the Company in over 25 years of activity. We have analyzed the current legislation, identifying gaps and the need for adjustments according to the emerging work needs, and explored the most recent evolutions of the technology, which provides increasingly sophisticated tools to guarantee a level of comfort and safety to workers that are involved in installing and doing maintenance at height on wind turbines which in the meantime in the last two decades have come to have nacelles mounted on towers over 100 meters high, with rotors over 150 meters in diameter and increasingly complex equipment to manage.
The result of our study demonstrates that the risk to health and safety deriving from the aging of technical personnel engaged in the wind energy sector can be correctly mitigated thanks to the targeted implementation of innovative tools made available by scientific and technological progress and through organizational models that take care of staff training and specific health surveillance protocols.
We have also highlighted that there are some gaps at the regulatory level that should be filled, in particular through the recognition of "strenuous work" for the technicians of the wind sector, and we continue to cooperate with the Institutions, also through our participation in the HSE Work Group (Health, Safety & Environment) established at the National Wind Energy Association (ANEV), so that these legislative adjustments can be achieved as soon as possible.

INTRODUCTION

The development of wind energy in Italy constitutes one of the cornerstones of the turning point towards the environmental sustainability that the new Ministry of Ecological Transition has decided as a condition, also thanks to the growing attention worldwide, public opinion and Institutions are placing in climate change and the now imperative need to reduce emissions into the atmosphere.
The workers of the sector are exposed to dangers that can cause death and serious injuries during all the phases of a wind farm project.
In particular, the most relevant activities for the assessment of health and safety risks are:

- installation of the turbine;
- installation of the cables;
- commissioning of the turbine;
- maintenance of the turbine;
- dismantling of the wind farm.

Once operational, wind farms are unmanned structures where specialized technical personnel access only for the time strictly necessary to carry out maintenance and repairs.
A well-designed wind farm, built and subject to careful periodic maintenance, has an average lifetime of 20 years, during which some parts of the plant need to be repaired or replaced due to mechanical or electrical faults, due to wear of the components and operation in conditions of strong "stress" such as mechanical stress and frequent power variations linked to the stochastic nature of the anemometric resource.
The installation phase of a wind farm can last a few months, during which the technicians are engaged on average for 9-10 hours a day in the activities of pre-assembly of the components, erection of the wind turbine and electromechanical completion.
During operational activities, a typical team consists of two / three technicians who work in the turbine for a period of 7-8 hours per day, to carry out scheduled maintenance or repairs.
In both phases, the time that workers spend on the wind turbine takes up almost the entire working day, increasing the probability of exposure the an health and safety risk.
Moreover, the safety risks during the installation and maintenance of wind turbines are connected to the technological aspects of complex machinery and to the environmental and meteorological conditions the workers are exposed to.

General risks	Specific risks
Sliding	Work at height
Lifting and transport of loads	Electrical work
Ergonomics	Work in restricted spaces
Drugs and alcohol	Work Abroad
Business travel/Working hours	Work in hot conditions

Tab. 1 - *main risks in a wind farm*

The main risk factors in the wind sector are:
- Ergonomics (Prolonged uncomfortable positions in tight spaces)
- High physical load for the ascent to the turbine
- Works carried out at height
- Emergency Management and Evacuation from the Turbine
- Hard-to-reach area in an emergency
- Extreme weather conditions
- Electrical risk

They can be classified into general and specific risks as per the table below

The assessment of these risks and the identification of appropriate prevention and protection measures are currently being studied and reviewed by various working groups, also in collaboration with the relevant Institutions, in order to adapt the production processes and make them increasingly safer. Among the most important results, in which we participated directly through ANEV, we like to mention the collaboration with INAIL which in 2019 issued the guidelines for the operation of wind farms, an important signal of regulatory compliance for an innovative and rapidly expanding professional sector in our Country. Much remains to be done to improve the comfort and safety conditions of workers in the wind sector, especially in anticipation of a general phenomenon of aging of the technical staff who, having started their career in the mid-90s, are largely in the range between 50 and 60 years old.
To understand the problems and risks of this particular category of workers, and to have the necessary elements to identify the prevention and protection

Fig. 1 - *development and design steps*

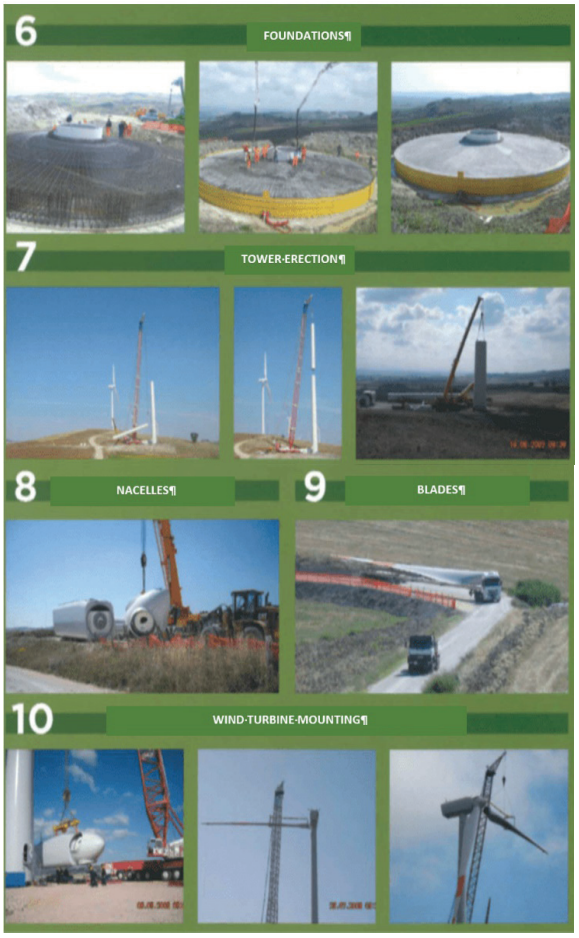

Fig. 2 - *construction steps*

measures, it will be useful to recall in the following paragraph a brief description of the production processes inherent to the installation and maintenance of the wind farms.

How a wind farm is built and managed

The identification of a suitable site for the construction of a wind farm constitutes the first phase of this activity, and is carried out through a series of technical studies and feasibility analyzes, including:
- Anemometric studies to evaluate the availability of the wind "resource"
- Viability and suitability to construction site to evaluate the possibility of building on inaccessible sites and with complex road accesses
- Analysis of the constraints on the area of interest and environmental impact assessment
- Access to the connection point to the electricity grid
- Availability of soils

Subsequently, we proceed to the elaboration of the layout and the geological surveys preparatory to the construction.
The photographic flow chart below schematically represents the evolution of these activities
Once the necessary permits have been obtained, the construction is started, where the civil works for the construction of the foundations, and the electromechanical works for the lifting and assembly of the wind turbines are clearly identifiable.
Finally, after the wind plant has been commissioned, the O&M Companies carry out all the activities nec-

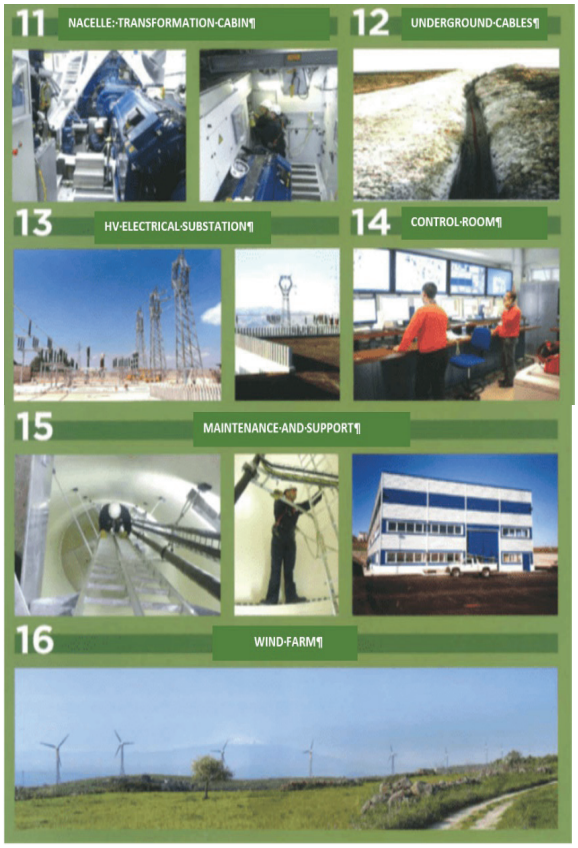

Fig. 3 - *O&M steps*

essary to optimize the electrical production and keep the plants in a correct state of use and maintenance in order to minimize downtime for failure and extend the turbines lifetime, which in industrial models should be at least 20 years.
From this description, it can be deduced that the main activities that the wind energy technicians undertake on technologically complex machinery are those of lifting, installation and maintenance of wind turbines, and it is therefore on these phases that the professional risk analysis is focused and the constant search for solutions to improve working conditions.

Relevant aspects of health and safety risk for wind technicians

Wind energy is a relatively new industrial sector for which the legislator has never regulated in a detailed way and shaped the health and safety requirements applicable to that sector both from the point of view of machine safety requirements and as regards the characterization of specific training.
The operators are mainly classified as "metal mechanics workers", which is limiting as the machines they interact with (Wind turbines) have intrinsic characteristics and dangers that expose them to risks other than those of the generic engineering sector.

Evolving technology

We have gone from older wind turbine installations (although still in operation) to more complex wind turbines in terms of height and size.

Small wind

Even small-sized wind turbines (despite their small size) present problems and criticalities due to reduced operator space for maneuver, lack of mechanical aids and some lack of anchoring points.

Location

A wind farm is generally located in places far from built-up areas, which can be reached with difficulty due to the lack of adequate roads and access is also conditioned by the occurrence of meteorological events; the lack of coverage of the telephone network and often of radio links can further aggravate the working condition.

Aging of staff

It should also be considered that in recent years the problems associated with the aging of personnel have been emerging also in relation to all the risks set out above since the companies operating in the sector, most of which have been established since the 1990s, will have to confront with a workforce that is no longer young and without a precise protocol to be adopted to address the problem.

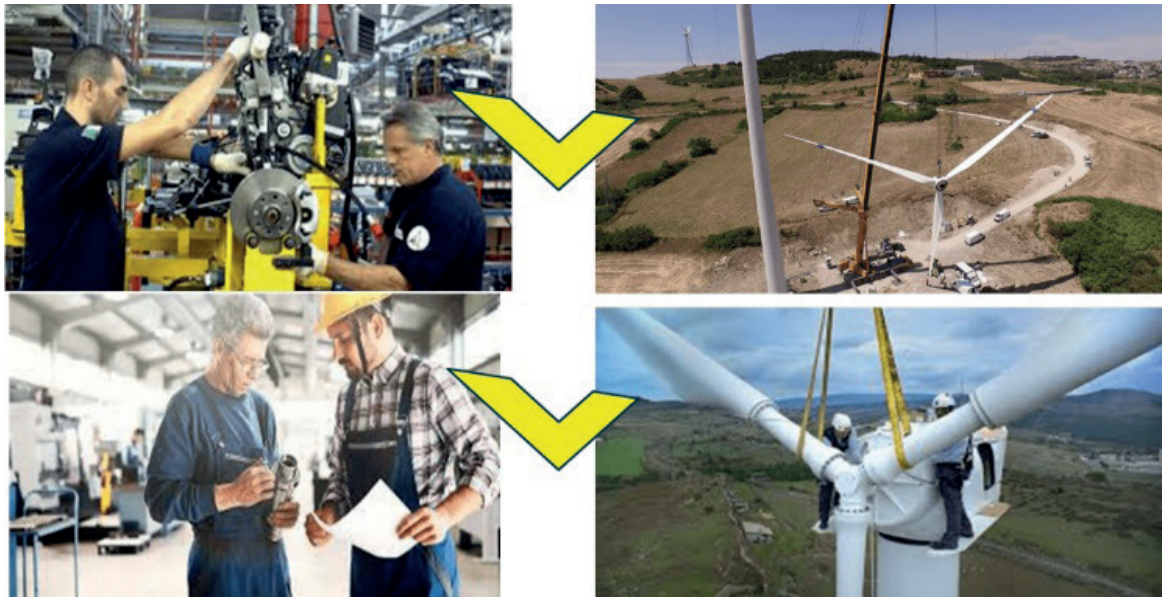

Fig. 4 - *traditional metal workers and wind workers*

Fig. 5 - *90s wind turbines and latest generation models*

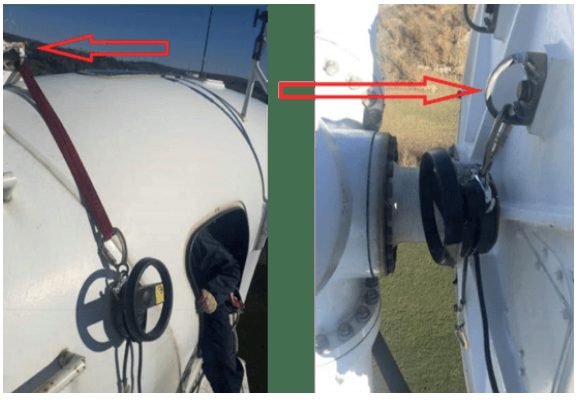

Fig. 6 - *small wind turbine*

Wind Sector Analysis

The fatal cases in the wind sector from 1970 to 2016 were 144: 87 victims were involved in the construction and management of turbines, while the other 57 cases involved people not directly employed in the production of wind energy.
In 2018 alone (INAIL data) there were 149 deaths in the agriculture sector. This is to say that, despite the wind sector has not yet been fully taken into consideration under the specific and peculiar regulatory and contractual aspects, it has, over the years, equipped itself with a management system made up of procedures, work instructions, voluntary training protocols, which has reduced intrinsic problems to a minimum, making residual some relevant risks such as work at height, electrical and mechanical. In fact, despite the high level of risk in the wind sector, the attention paid to safety by the companies in the sector allows the number of accidents to be far lower than that of other working sectors.
Since the problems are transversal and concern all companies, the operators of the sector have joined in A.N.E.V. (National Association of Wind Energy) which, thanks to its specific experience and the high professionalism of the members, is the privileged interlocutor in the hoped-for process of collaboration with the Institutions for the definition of sector legislation and with all the bodies of information sensitive to environmental issues and interested in the dissemination of correct information based on the scientific analysis of the disseminated data.
In 2016 ANEV signed a framework agreement with INAIL which led to the drafting of the first National Guideline concerning standardized procedures and a Safety Management System applicable to the wind sector. Although voluntary, the Guideline has traced the first real path for reflection on the peculiarities of risks in the wind sector in Italy.
Without prejudice to these necessary premises regarding the sensitivity and attention to health and safety issues by the companies in the wind sector, one cannot ignore the issue of the progressive aging of personnel, which could be an element of risk for the health as well as representing a risk management factor for the companies that will have to face it. Since the problem has no historical background to work on, as in Italy the first major companies began to hire staff in the nineties, the discussion in the following document covers a very delicate and difficult to solve issue. As no bibliographic data or comparative elements are available, the study was based starting from a census and a photograph of the risks also in view of the progressive aging of the staff compared with a risk reduction curve thanks to the implementation of all the possible preventive measures referred to in this document.

Assessment of the main risks related to the safety aspects of workers in the wind sector
R= Px I (Damage) P = Probability of the event - I Impact/Damage Level

Given the R assessed, the following table indicates the actions to be taken necessary to mitigate the risk.

Using this assessment tool, we can compare the risk levels of a wind technician in ordinary conditions and in old age.

Fig. 7 - *installation site of a wind farm*

Risk level	Type of Action
1-2-3	Ordinary surveillance
4	Surveillance actions on existing activities
5	Adoption of management actions for risk mitigation (e.g. drafting of procedures, training, and more)
6	Adoption of urgent interventions for risk prevention and mitigation with highest priority) (e.g. technical interventions, process replacement or modification)

Tab. 2 - *type of action to mitigate the risk*

Ordinary conditions

Conditions of aggravation due to the risk of aging
In general, advanced age involves an increase in the estimated risk level, which can still be mitigated through the implementation of targeted and effective prevention and protection measures.

Proposals for intervention

Original and innovative activities and future challenges to resolve critical issues and compensate for technical and regulatory gaps are to be found in the activities listed below.

- Business best practices
- Cooperation and sharing between operators in the sector
- Establishment of working groups to share common sector problems and synergistically identify solutions
- Continuous training shaped on the particularities of the wind sector
- Better implementation and knowledge of the GWO Industry Standard
- Memoranda of understanding between sector operators and Institutional Bodies
- Collaboration and exercise between operators in the sector and emergency operators (in particular Saf of the Fire Brigade and the National Alpine and Speleological Rescue Corps - CNSAS)

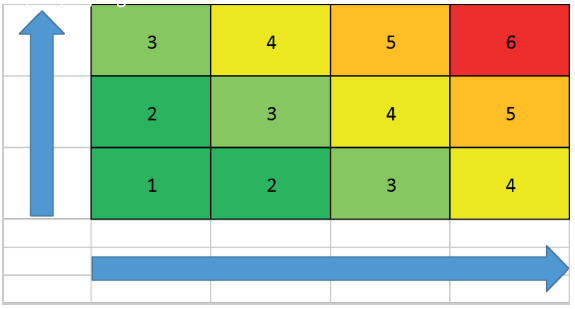

Fig. 8 - *matrix of risk (R) = damage x probability*

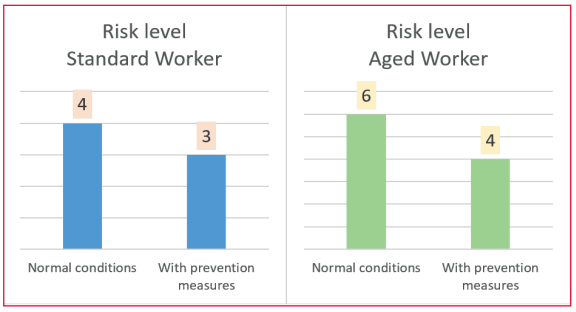

Fig. 9 - *assessment of risk levels with and without prevention measures*

Risk factor	P=Probability	I=Impact	R=Risk
Work at height	high	high	6
Mechanical	high	high	6
Electrocution	low	high	4
Isolated jobs	low	high	4
Evacuation from the turbine	low	high	4
Slipping	low	high	4
Ergonomics	low	high	4
Manual handling	low	high	4
Vehicle accidents	low	high	4
Vibrations	low	high	4
Posture	low	high	4
Microclimate	low	high	4

Tab. 3 - *risk assessment of a wind technician in ordinary conditions*

- Engineering drawings of the machines more inclined to the comfort and ergonomics of the operators
- Health protocols that take age differences into account
- Enhancement of experiences with attention to the intergenerational climate in companies in the sector
- Secondary prevention activity aimed at researching preclinical alterations
- Technological innovations regarding equipment, mechanical aids, rescue vehicles and Personal Protective Equipment.
- Study on the aid of the exoskeleton to favor ergonomics and the manual handling of loads by the operators.
- Study on the use of virtual augmented reality to allow remote assistance and surveillance of the activities carried out by operators locally
- Technological tools to assist the ascent to altitude in wind turbines completely without lifts.

Based on the considerations set out above about the risks of the operators in the wind sector, especially in

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Slipping	low	high	6
Ergonomics	low	high	6
Manual handling	low	high	6
Vehicle accidents	low	high	6
Vibrations	low	high	6
Posture	low	high	6
Work at height	low	high	6

Tab. 4 - *risk assessment in aging conditions*

view of the aging of the staff, it becomes necessary to ask up to what age they will be able to:

- Work at height
- Go up and down the stairs of the tower
- Work in confined spaces
- Work in extreme conditions (temperature, microclimate, etc.)

It is clear that with advancing age the risks of wind energy operators increase exponentially, and therefore the problem arises of how to manage the aging of the technical staff involved in the installation and maintenance of wind turbines in the coming years, addressing the following topics:

- Will they work at height until retirement age?
- Will they all undergo a job change?
- Will they all be fired?

In a few years, companies in the wind sector will have internal organizational problems as they will have to manage a staff with an average age that does not allow them to carry out the same activities in a safe and risk-free way. The problem could also have social repercussions since, as a change of duties or a different relocation within the Company is not practicable for everyone, there could be dismissals and mobility procedures for those who are no longer suitable for the job.

This work therefore aims to identify possible solutions to the problem, with legislative interventions, through the use of the most modern technologies and thanks to an organization of work aimed at protecting the weakest categories, such as wind workers in old age.

We will also report the results we have obtained by applying the working methods suggested within our company, and we will draw the conclusions of our study.

Proposal of solutions and interventions to mitigate the aging risk

Regulatory adaptation

One of the measures that could be more effective and decisive for the protection of the figure of operator in the wind sector would be the recognition of the 'hard work' and therefore of a national collective agreement for the sector which provides for all the conditions relating to the related risks.

Reference legislation:

- D.Lgs 11 August 1993 n.374
- D.M. 18 May 1999
- D.Lgs 67/2011
- Decree of 05/02/2018

In order to include the activity of the wind sector as demanding jobs, the trade associations should instantiate the application to the Government. At the moment our Company is collaborating with ANEV on this topic.

Innovative technologies

Other solutions and risk mitigation interventions of more immediate application are related to the use of technology, and in particular of mechanical aids for climbing and operating at height. Furthermore, the manufacturers of wind turbines can make their important contribution through a design of the machines that takes into account the right level of comfort and ergonomics of the operators.

Hand in hand with the aging of staff, technology also advances and provides innovative tools that companies can use to protect their staff.

Very interesting in this sense are various types of personal protective equipment, such as exoskeletons to give relief to workers who perform physically demanding tasks.

Wrist support

It is a support derived from a medical device aimed at treating conditions such as wrist inflammation. It uses

Fig. 10 - *wrist support in mechanical processing*

Fig. 11 - *exoskeleton*

Fig. 12 - *neck support*

a preventative approach and supports the wrist in numerous applications where the wrist may be fatigued, such as: riveting, welding, moving or installing generators and starters.
The advantages at a glance:

- it relieves tension in the wrist joint when lifting and holding objects
- it can be mounted with one hand
- it regulates the temperature of the wrist thanks to the innovative material tested in space
- it is suitable for both left and right wrists

Exoskeleton

A passive exoskeleton supports people who perform physically demanding activities with their arms raised every day. Relieves strain on the shoulder joints and upper arms, for example when working on maintenance lines.

The advantages at a glance:

- it relieves strain in the shoulder area by over 50% when working above chest height
- it is quick to put on or take off in less than 20 seconds
- it weighs 1.9 kg (4.1 lbs) with full freedom of movement
- it is individually adjustable according to the user's height from 160 to 190 cm

Fig. 13 - *lumbar support*

Support of the cervical spine

A neck support that relieves the neck region and the cervical area of the spine when working over the head. The shoulder and neck sections can be individually adapted to each user thanks to the different adjustment possibilities. This makes the neck support very comfortable to wear and usable during all types of overhead work, such as installing false ceilings or performing visual inspections.

The advantages at a glance:

- flexible neck support for excellent comfort
- easy to put on in seconds, and perfectly adaptable
- rugged, yet featherweight design
- it can be worn together with the exoskeleton for effective relief of the neck and shoulders

Fig. 14 - *climb assistant*

Fig. 15 - *application of augmented reality to wind maintenance*

Support for the lower part of the spine

It can be used when standing or lifting light loads, providing a high level of support for the lower back. It supports an ergonomic body posture when standing and lifting loads.
Possible applications include handling lighter loads and lifting packages.
It also supports the lower spine when standing during prolonged assembly activities.

The advantages at a glance:

- it supports an upright posture when standing and promotes an ergonomic posture when lifting objects
- very quick to put on and take off
- discreet design, adjustable with 5 different sizes
- it can be combined with the Shoulder exoskeleton for effective lower back relief

Climb assistant

A device that helps operators in climbing the towers of wind turbines allowing to give relief and less burdening of the cervical spine.

Augmented reality for maintenance support

This new type of technologies based on the principle of remote support is undergoing strong development in recent years and provides simple, fast and secure visual assistance based on augmented reality to identify and solve problems anywhere in the world.
This technological implementation allows on-site technicians to enjoy the direct support of industry experts through whom they can remotely view the plant and participate in the production process, as if they were present together with the technician.
The visualization through the camera of the smartphone supplied to the technician, allows the experts who are in the control rooms to see the problem and help the person on site to solve it.
In this way, field service technicians can be supported in resolving critical issues quickly and efficiently.
Through these innovative technologies, operators can be guided in the field worldwide, in real time, with hands-on training courses for more efficient knowledge transfer.

Organization, training and specific health surveillance protocols

Particular importance and relevance with respect to risk mitigation measures are to be reported in the context of the Organizational Models of company management with reference to the application of training protocols that take into account the specific needs of the sector and secondary health surveillance that looks for clinical alterations of the workers.
In fact, in recent years, many companies in the sector have implemented the GWO standard in their training protocols and therefore in their corporate training plans.
GWO (Global Wind Organization) is a non-profit association, founded by representative members of the brands producing wind turbines such as Ge-Vestas-Senvion-Siemens-Acciona-Eon-Enercon-Innogy -etc, established to standardize international the training course that the technician of the wind sector must receive with training programs drawn up and shaped according to the particularities and peculiarities of the wind sector which, as already expressed, contemplates different risks than those of the other industrial sectors.

In the following, there are the main changes introduced by the GWO Standard:

- standardized training on sector risks
- continuous updating (all courses must be updated within two years from the first issue)
- training programs constantly reviewed by industry experts
- advertising of the skills of the operators through the GWO's "Winda" portal.

The GWO training, being of a non-mandatory and purely voluntary nature, is considered the Golden Standard of the training of the wind energy sector operator which, integrating in accordance with the training program of the Italian legislation, continuously and constantly improves the skills and awareness of workers.
Another aspect of primary importance among the risk mitigation tools with respect to the aging of the workforce in the wind sector is an effective primary

and secondary health surveillance whose purpose, in addition to being to assess the specific suitability for work, is to discover in good time clinical or preclinical anomalies (early diagnosis) to prevent worsening of the health of the worker. It should be emphasized the importance assumed by the many early diagnosis indices available that can allow interventions aimed at preventing the progression of the disease (secondary prevention). In fact, in order to be able to carry out to the maximum of his competences those activities aimed at a health surveillance that takes into account the "age" risk factor, and with the support of the Company Prevention and Protection Services, prescribes internal company protocols, diagnostic and instrumental tests such as the exercise ECG, for particular categories of workers.

About us - IVPC Group

The IVPC Group, Italian Vento Power Corporation, was founded in 1993 from an idea by Oreste Vigorito, one of the pioneers in the renewable energy sector, and within a few years it established itself as the first and still today one of the main national players for the development, construction and management of wind projects.
The activities of production and sale of electricity from renewable sources are managed within the Group by IVPC SERVICE Srl, a specialized company with 25 years of experience in plant maintenance, operated by highly qualified technicians trained in the culture of quality, protection of the environment and safety in the workplace. The Company Management considers the protection of the health of workers and the prevention of risks to be an absolute priority, and for this reason it has put in place and constantly updated an organizational model strongly oriented towards safety, even when dealing with significant investments.
With this in mind, the Organization has adopted an Integrated Management System for Quality, Environment, Health and Safety, Energy and Anticorruption according to the standards UNI EN ISO 9001: 2015, UNI EN ISO 14001: 2015, UNI ISO 45001: 2018, UNI CEI EN ISO 50001: 2018 and UNI CEI 11352: 2014, which gives all areas the mandate to continuously and systematically improve the quality of the product / service offered, reduce the environmental impacts, pursue the prevention of pollution , ensure health and safety performance including risk reduction, improve energy performance, engage in the prevention of corruption. IVPC SERVICE S.r.l undertakes not to supply or manufacture products / services if the work activities cannot be carried out in full safety for the staff, for the environment and for the rights and dignity of people.
The competence of the staff is the basis for ensuring compliance with the requirements of the product / service.

It is therefore necessary that all personnel are always involved in the growth process which includes refresher courses, information seminars and everything that contributes to the understanding of the impact that the phases in charge of individual resources have on the overall conformity of the product / service achieved, on the safety of workers and on the state of the surrounding environment.

What we have done - the work done by the IVPC Group for safety and the results obtained

With regard to all the above discussion and the focus of the paper aimed at the problem of aging staff in the wind sector, we report below the innovative prevention activities implemented by our company and the results achieved thanks to the implementation of risk mitigation measures. Employee accident data and information on company performance were measured through rigorous registration procedures and processed also making use of standard performance indicators (KPI - Key Performance Indicator), in order to make them readable and comparable with standards of the sector (benchmarking).
The most relevant innovative activities implemented by IVPC starting from 2018 are related to advanced training, enhanced health surveillance and the use of latest generation technologies in the industrial field.

Advanced Training (Ex Standard Gwo)

The continuous training to which all IVPC employees are subjected is borrowed from the GWO standard and oriented towards continuous updating aimed at a level of involvement and awareness of the workers well beyond the minimum requirements imposed by the national legislation in force pursuant to Legislative Decree 81 / 08.
Below there is a detailed description of the significant effort that the Company makes annually to achieve the objectives set by the Company Management.

Health Protocol Strengthened With Stress Ecg

IVPC collaborates with a team of occupational doctors, appointed as "competent doctors" pursuant to Legislative Decree 81/08 at the various company offices and coordinated by a "coordinating competent doctor". As part of this collaboration, the Head of the Company Prevention and Protection Service (RSPP) analyzes and discusses health surveillance plans with these doctors, which are reviewed and updated according to work variations and in the light of the accident data that occur and are recorded during the activities.
In recent years, driven by the greater attention that the Company has placed on the issue of aging staff, the occupational health service has revised the health protocol by strengthening some medical examinations and visits that are considered more effective to prevent risk of accidents, injuries and occupational diseases.
The "strengthened" sanitary protocol adopted by IVPC for all wind technicians is shown in the table below.

Technological Aid Tools

The IVPC Group is an industrial company with a high technological content due to the very nature of its production process, based on the use of continuously evolving wind turbines and electromechanical and electronic equipment.
The culture of technological innovation has also been developed in the context of the Prevention and Protection Service, where the RSPP Manager constantly checks the state of the art and submits the use of the latest generation devices to the attention of the Company Management aimed at accidents prevention and workers protection.

Training course	Minimum duration (hours)	Course recipients	Legal requirements	Refresh rate
General training	4	All workers	Agreement for the training of workers, pursuant to article 37, paragraph 2, of the legislative decree 9 April 2008, n ° 81	Permanent training credit
Low risk specific training	4	Administrative clerks	Agreement for the training of workers, pursuant to article 37, paragraph 2, of the legislative decree 9 April 2008, n ° 81	6 hours every 5 years
High risk specific training	12	Technical staff Technical employees	Agreement for the training of workers, pursuant to article 37, paragraph 2, of the legislative decree 9 April 2008, n ° 81	6 hours every 5 years
Low Risk Fire Awareness	4	Firefighters in office	D.M. 10/03/1998	2 hours every 3 years
Medium Risk Fire Awareness	8	Technical staff	D.M. 10/03/1998	5 hours every 3 years
First aid course for Group A Companies	12	First Aid Officers	D.M. 388/2003	6 hours every 3 years
PES or PAV Personnel training	16	Technical staff working on wind turbines and / or electrical substations	CEI 11-27 ED2014	not applicable
Training course for workers driving self-propelled forklifts with driver on board.	12	Forklift operators	Agreement for the identification of work equipment for which specific operator qualification is required pursuant to article 73, paragraph 5 of legislative decree 81/2008	4 hours every 5 years
Training “Supervisor”	8	Personnel appointed with the appointment of a supervisor	Agreement for the training of workers, pursuant to article 37, paragraph 2, of the legislative decree 9 April 2008, n ° 81	6 hours every 5 years
Training “Management”	16	Executives pursuant to Legislative Decree 81/08	Agreement for the identification of work equipment for which specific operator qualification is required pursuant to article 73, paragraph 5 of legislative decree 81/2008	6 hours every 5 years
Work in confined spaces or environments under suspicion of pollution	8	Personnel carrying out work activities in confined spaces or suspected of pollution.	DPR 177/2011	8 hours every 5 years
R.S.P.P. Module C	24	People appointed RSPP	Agreement 128 State-Regions Conference of 2019	40 hours every 5 years
Workers’ safety representatives	32	RLS elected or designated persons	D.lgs. 81/2008	8 hours a year
Safety trainers training	24	Safety teachers	Decree of 6 March 2013, qualification criteria for the figure of the occupational health and safety trainer	24 hours every 3 years
Fire Awareness GWO	4	Technical staff	GWO Standard	4 hours every 2 years
First Aid GWO	16	Technical staff	GWO Standard	8 hours every 2 years
Manual Handling GWO	4	Technical staff	GWO Standard	4 hours every 2 years
Working at Heights GWO	16	Technical staff	GWO Standard	8 hours every 2 years

Tab. 5 - *matrix of the training protocol applied in IVPC*

Medical service	Rate
Medical examination with clinical-functional evaluation of the cervical spine and attention to the stresses transmitted to the hand-arm system.	half yearly
Audiometric examination and balance tests	half yearly
Spirometry	half yearly
Normal ECG before age 45	yearly
Exercise ECG over 45 years of age	biyearly
Laboratory tests also to verify the absence of an alcohol-dependent condition (complete blood count, glycemia, azotemia, cretatininemia, transaminase, QPE, urinalysis, CDT, triglycerides, gamma GT)	yearly
Tetanus vaccination	decennary

Tab. 6 - *"strengthened" health protocol IVPC*

Starting from 2018, the Company has given the authorization to purchase "EXOLIFT" uphill aids as already represented in the previous section "Innovative Technologies", in order to allow technicians to reduce effort and fatigue of the cervical spine during the ascent on the turbines installed more recently and characterized by a greater height of the tubular. This of course also in view of the possibility of involving workers over 45 on these turbines.
Additional technological supports such as exoskeletons or software platforms for augmented reality are currently being evaluated in collaboration with the team of competent doctors.

Results And Kpi Analysis

The average age of the IVPC staff is 43.2 years while that of the only technical staff is 38.5, with 30 workers between 45 and 60 years old.
Since 2019, IVPC has organized 180 training sessions dedicated only to the GWO standard involving 515 profiles of participants, and also in 2020, despite the pandemic, the Company organized 438 events involving staff for 630 hours.
The main objective is that Security is seen as a strategy, and not just as mere legislative compliance, with the aim of measuring and monitoring results in a rigorous and managerial approach.
The information and data were recorded and processed in the logic of measuring the results obtained in a clear and objective way, also making use of performance indicators (KPI) necessary to verify the achievement of the strategic objectives expected by the Company Management by virtue of the actions put in place and useful for benchmarking with similar production realities and with literature data.
Below there is the matrix of information and KPIs developed by IVPC according to the strategic objectives.
More generally, IVPC has perfected a list of reactive indicators, through which it monitors the accident and near misses phenomenon (recording of accidents, near misses, medications), and a list of proactive indicators used to monitor investments and efforts aimed at safeguarding safety and continuous improvement (training carried out, inspections and maintenance, etc.).

The complex measurement and monitoring system set up by the Prevention and Protection Service allows the IVPC Group to systematically monitor company performance in terms of workplace safety and changes over the years.
The first and most important result we record is the '' ZERO '' injury data from 2020 to today, unlike previous years where there was 1 injury in 2019, 5 in 2018 and 1 in 2017.
The following is the annual trend of the main injury indices of the IVPC Group.
It is clearly recognizable from these data a progressive improvement trend which has led, after a peak

Strategic target	KPI
Eliminate fatal injuries in the industrial process	· Number of deaths due to accidents at work · Progress of projects aimed at eliminating the causes of serious injuries (eg falls from a height, serious electrocution, investments)
Reduce psychosocial factors and improve organizational well-being	· Results of analyzes of organizational climate or job satisfaction · Cases of work-related stress symptoms reported to the competent physician
Reduce road accidents	· Frequency of road accidents per km traveled · Hours of road safety training per employee

Tab. 7 - *IVPC Group - strategic objectives for safety and performance indicators*

Reactive indicators	Proactive indicators
· Frequency Index (number of injuries x 10^6 / worked hours) · Severity Index (number of days lost due to injury 10^6 / worked hours) · Incidence Index (number of injuries / number of employees) · Number of reported incidents without injuries · Number of dressings administered by healthcare personnel · Number of spills · Disease rate	· Hours of safety training carried out · Progress on projects concerning safety improvement · Number of safety-relevant inspections · Number of maintenance interventions · Number of observations and security dialogues · Investments dedicated to improving safety

Tab. 8 - *IVPC Group - performance indicators*

in injuries in 2018, to a reduction of the same up to zero in 2020 and 2021, in a time window perfectly superimposable to the implementation by IVPC of the prevention and protection measures discussed above and implemented starting from the end of 2018.
It is interesting to see in detail the trend between worked hours and recorded injuries, comparing the 2017-2018 period prior to the implementation of risk mitigation actions versus the subsequent two-year period 2019-2020.
Despite the fact that in the two-year period 2019/2020 there were about 94,000 worked hours more than in 2017/2018, thanks to the measures taken, seven fewer injuries were found by a percentage decrease of 90%.
Finally, the figure for absences due to injury is also comforting, since it shows that thanks to the implementation of the above mitigation actions, the number of days lost due to injury has practically halved in the 2019-2020 two-year period compared to the previous one.

CONCLUSIONS

The issue of health and safety at work in the sector of installation and maintenance of wind power plants is highly topical in the industrial scenario of the moment, since the analysis of the operational phases highlights

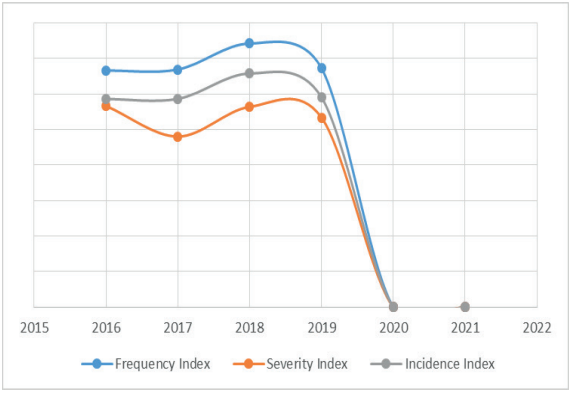

Fig. 16 - *IVPC Group - annual accident index trend*

that the workers in this sector are daily exposed to a list of risk factors that must be adequately assessed and treated to ensure "safe" working conditions.
The wind industry, due to its relatively recent history, presents some safety problems that are still outstanding, related to the intrinsic characteristics of the technological systems where the technicians operate, with very different methods and conditions from those of the other working sectors metalworkers.
We have also highlighted that staff aging can increase the likelihood of risk for those companies that, born between the end of the 90s and the beginning of the new millennium, have a staff of technicians with an advanced average age.
The IVPC Group, pioneer and leader in the wind sector in Italy, is structurally committed to the search for reliable solutions to mitigate the risk to which its workers are exposed, and the Company Management has adopted a policy of involvement and collaboration with all the figures interested, from managers to the prevention and protection service head, from competent doctors to operational staff, so that effective actions can be identified and implemented.
In this work, we have presented the innovative activity carried out in the last three years by the Prevention and Protection Service of the IVPC Group, which is operating on various fronts, including: regulatory

Year	Frequency Index	Severity Index	Incidence Index
2016	4,50	0,46	0,72
2017	4,87	0,06	0,73
2018	26,09	0,43	3,74
2019	5,29	0,22	0,80
2020	0,00	0,00	0,00
2021*	0,00	0,00	0,00

Tab. 9 - *IVPC Group - injury rates*
** partial data as of 09/15/2021*

Year	Worked hours	Recorded injuries	Year	Worked hours	Recorded injuries
2017	244.267	2	2019	343.171	1
2018	279.876	6	2020	275.038	0
Total	***524.143***	***8***	***Total***	***618.209***	***1***

Tab. 10 - *IVPC Group - accident monitoring before and after the implementation of risk mitigation actions*

Year	Working days lost due to injury	Year	Working days lost due to injury
2017	39	2019	74
2018	118	2020	0
Total	***157***	***Total***	***74***

Tab. 11 - *IVPC Group - monitoring of days lost due to injury before and after the implementation of risk mitigation actions*

adaptation aimed at recognizing strenuous work; the implementation of an organizational model of excellence based on "reinforced" training and health surveillance protocols; the research and use of devices derived from scientific and technological progress to support operators in the most dangerous and burdensome maneuvers.
We have presented the results of our work, showing that a correct workplace safety management system, based on the application of innovative measures and on the involvement of personnel, makes it possible to significantly mitigate the risks inherent in wind activity with the consequent benefit of reducing the number of accidents. In particular, the Company data and statistics reported in this article demonstrate the effectiveness of the measures implemented and the achievement from 2020 to date of the "ZERO" injury target, which also corresponds to the significant decrease in occupational diseases and therefore in the number of lost working days.

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