

Protocol

# A Protocol of Prevention and Protection Measures on New Occupational Risk Factors in Green Jobs in Italian Workplaces

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**Abstract:** The Green Transition aims to protect the health of our planet through changes at the economic, political, and social levels while also having a significant impact on the world of work through the creation of sustainable occupations, referred to as 'Green Jobs'. The aim of our research was to identify the new emerging occupational risks associated with Green Jobs and to propose a protocol to promote the adoption of more appropriate prevention and protection measures. Starting with a few keywords chosen by the authors, we conducted a narrative review of the scientific articles published in the literature. The results obtained show that the new occupational risks emerging in the activities involved in the green transition are mainly related to the introduction of new materials or new technologies and to modes of production processes. These risks may pose a danger to those exposed to them on a daily basis, causing damage to health. Our protocol proposal calls for a more careful and adequate risk assessment for Green Jobs, providing specific training on these issues for new professionals in the sector and introducing specific prevention and protection measures for the different occupational risks analysed in the workplace. By adopting these recommendations in the workplace and conducting in-depth research on these issues, it will be possible to contribute to the improvement of prevention and protection for these new emerging occupational risks, achieving a positive economic impact and better safety conditions for workers.

**Keywords:** green jobs; protocol; prevention and protection measures; workplace; emerging risks; occupational medicine; green transition



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## 1. Introduction

The enormous transformation and exponential development of the world of work in recent decades have brought about countless changes in terms of occupational risks in the workplace. Despite numerous advances in occupational medicine and related branches, today, many workers are still exposed to unacceptable occupational risks and are often victims of occupational diseases and serious accidents.

The topic of occupational safety is highly topical, all the more so considering the historical moment we are living through of targeted transformation of production processes in an increasingly sustainable vision [1].

The ecological transition, also known as the 'Green Revolution', aims to develop major themes such as sustainable agriculture, the circular economy, energy transition, sustainable mobility, energy efficiency of buildings, safeguarding water resources and reducing pollution in order to improve the sustainability of the economic system and ensure a fair and inclusive transition to a zero environmental impact society. An example of such a revolution is the US administration, which has already committed itself to ambitious climate targets, seeing the transition to zero net emissions as an opportunity to protect the

environment and create new 'green' jobs. However, this shift in the labour market, from activities considered traditional to more innovative, is not easy to achieve. A 2022 study by Bergnant et al. made it clear that Green Jobs tend to be more skilled and relatively less vulnerable to automation, suggesting that the green transition must certainly require a shift in the workforce, involving the acquisition of new and higher worker skills, and in which policy must play a crucial role by helping workers become more competitive in the new labour market [2].

The need to protect the health of our planet has, therefore, also triggered numerous changes in economic, political and social terms, significantly impacting the world of work and the role that each of us can play on a daily basis for the well-being of the environment. The ecological transition has certainly slowed down due to the economic crisis and corporate financial fragility resulting from the historical world events we are currently experiencing, from the post-pandemic period to the current state of political instability, thus increasing economic uncertainty and limiting credit to companies, leading to lower economic and employment growth both in developed countries, and with greater effect, in developing/emerging economies [3]. However, the challenges posed by climate change, natural resource depletion, and environmental degradation have led to an unprecedented demand for a new workforce committed to ecological balance and sustainable practices [4], spurring governments around the world to find solutions to the looming crisis, through policies via internationally supported funding programmes, in order to have a direct effect on the labour market of the beneficiary countries [5,6].

The intersection of economic development and environmental sustainability has, in fact, given rise to a growing employment sector known as 'Green Jobs' [7]. When talking about Green Jobs, one cannot ignore the concept of the Green Economy, which, according to the definition given by the European Commission, refers to an economy that focuses on the survival of the planet through the use of sustainable human activities, in particular by focusing on a low-carbon economy, the efficient use of resources, and taking the form of a new socio-economic model that pays equal attention to the productive world, economic growth and the social [8].

These new sustainable jobs represent all those professions related to sustainability, well-being and the protection of the planet. Specifically, they are innovative jobs with a focus on the environment and sustainability, offering brilliant opportunities in agriculture, construction, public administration, and services and contributing decisively to preserving the quality and integrity of the planet. There are many definitions of "Green Jobs"; the one most often used is identified by the United Nations Environment Programme (UNEP, 2008), which defines such jobs as ". . . agricultural, production, research and development, administrative, and all activities and services that contribute substantially to preserving or restoring environmental quality. . ." [9].

However, it should be made clear that Green Jobs does not only mean those jobs directly associated with specific sustainability issues, such as those related exclusively to the protection of ecosystems and biodiversity, but also those activities related to the efficiency, quality and innovation of goods and services offered, from an eco-sustainable perspective [10].

Indeed, Green Jobs encompass a range of occupations and jobs that prioritise environmental responsibility and contribute to the ecological transition. The emergence of this new occupational type not only responds to pressing environmental concerns but also represents a significant economic opportunity [11].

A study conducted in 2008 by Pollin et al. and reported by the European Agency for Safety and Health at Work [12] divided Green Jobs into three main categories as follows:

1. Direct jobs: First job changes resulting from new results in the target industries;
2. Indirect jobs: Subsequent changes in work resulting from new inputs needed to accommodate new outputs;
3. Income-induced jobs: Additional jobs created by changes in household income and expenditure resulting from items 1 and 2.

These definitions appropriately describe the work areas potentially affected by the 'green' label but also include related work activities, such as administrative activities involved in the implementation and coordination of this inducement.

In order to be able to achieve smart, sustainable and inclusive growth, meeting the objectives of the EU's green transition strategy, the creation of new jobs defined as green must also focus on the importance of anticipating new emerging occupational health and safety risks for workers, with the aim of ensuring adequate, safe and healthy working conditions, offering benefits not only to the environment but also to the workers involved in these activities.

Specifically, the development of this large production sector is, for the most part, characterised by a high level of innovation, both in terms of the technologies employed and the production processes adopted, from which the emergence of new potential critical issues for the protection of workers' safety.

Between 2019 and 2023, there has been a significant growth in demand for certain figures related to these production sectors, and it is estimated that this increase will continue in the years to come. Green Jobs are, therefore, jobs that we will increasingly see on the rise in the coming years as a genuine new economic and production sector to focus on [13,14].

In 2008, Pollin et al. drew up a list of production activities that best identify the sectors in which Green Jobs are expanding: building redevelopment, mass transport/rail freight, intelligent network, wind energy and solar energy [15].

In Italy, the labour market is gradually aligning with the new Green Economy trends in Europe, with companies increasingly oriented towards investing in green skills.

The data processed by the Excelsior Information System, created by Unioncamere in collaboration with the National Agency for Active Employment Policies (ANPAL), reveal that between 2023 and 2027, the Italian labour market will require almost 2.4 million employees with green skills at least at an intermediate level and over 1.5 million at a high level. The demand for green skills will therefore concern 65% (intermediate level) and 41% (high level) of the entire projected occupational requirement, respectively, transversally involving the majority of workers who will be increasingly sought after in the agricultural, industrial and service sectors, including the Public Administration [16–18].

According to further studies by ANPAL, in Italy, the sectors with the highest share of companies investing in Green Jobs, broken down by industry and services, are as follows:

#### Industries

- Public utilities (energy, gas, water, environment);
- Chemical, pharmaceutical and oil industries; construction;
- Automotive, equipment and transport industries;
- Rubber and plastics industries, services;
- Transport, logistics and warehousing;
- Accommodation and catering;
- Tourism;
- Health, social care and private health services;
- Education and private training services;
- Advanced business support services.

In light of this, highlighting how the constant pressure associated with environmental, economic and political factors has sometimes led to the neglect of worker safety issues in Green Jobs, the aim of our research is to identify emerging risks in Green Jobs by assessing a stratification of occupational risk with the aim of constructing a thorough and comprehensive protocol to improve the assessment of these new risks by promoting the adoption of suitable prevention and protection measures for their prevention and reduction.

## 2. Materials and Methods

Our work began by conducting a narrative review of the scientific literature, selecting several studies that dealt with various aspects of Green Jobs, particularly those related to the identification of emerging risks and the impact these activities have on working conditions

and standards. In addition, documents and data released by various international agencies on the extent of the effects of the Green Transition and how it will affect action strategies and policies related to occupational safety and security, as well as proposed recommendations in terms of prevention and protection at work, were examined and analysed.

The analysis involved the identification of more than 100 articles published and indexed on two primary sources to select the articles deemed most relevant for our analysis: PubMed and SCOPUS (last accessed via PubMed and SCOPUS in January 2024) [19].

From a methodological point of view, in accordance with the research objective, our work involved the selection of several scientific articles that were compared and synthesised on the basis of the authors' expertise, theories and existing models.

Specifically, the analysis involved two stages: the identification of recently published studies indexed in the Web of Science-Core Collection and Scopus databases pertaining to the topics of our research and the selection of the works deemed most relevant to our research by means of a critical analysis of the selected articles from the point of view of defining the concept of 'Emerging Occupational Risks in Green Jobs'.

In the first phase, articles published since 2008 in the Web of Science-Core Collection and Scopus databases were scanned using as search criteria the presence of keywords chosen by the authors in the title or abstract of the article to be selected: emerging occupational risks, green jobs, green economy, environmental sustainability and safety at work, ecological transition, innovative materials and technologies, green ergonomics.

The choice to conduct our narrative review on these two databases was dictated by the well-known appreciation of the majority of the scientific community of these sources of scientific literature, as they are considered valuable for the rigorous and competent review process of the submitted articles prior to their publication.

The choice of the reference period of the research, 2008, is due to the fact that the first explicit definition of the concept of 'Green Jobs' dates back to this specific year [20].

Information on the number of articles identified following the application of the search criteria in the two databases per publication period is briefly presented in Table 1.

**Table 1.** Articles published worldwide on Green Jobs selected in a narrative review conducted from October 2023 to February 2024.

Article Selection Key	Articles [n]
Keywords—published from 2008 onward	
emerging occupational risks	14
green jobs	25
green economy	96
environmental sustainability and occupational safety	45
ecological transition	21
innovative materials and technologies	30
green ergonomics	5
Topic—published after 2015 onward	
emerging occupational risks	5
green jobs	10
green economy	11
environmental sustainability and occupational safety	2
ecological transition	3
innovative materials and technologies	2
green ergonomics	1

Having identified more than 200 articles, we focused our analysis on articles published after 2015 to ensure that the data in the selected papers were as relevant, current and easily accessible to the academic community as possible. Furthermore, as our analysis focuses on defining specific occupational risks in sustainable activities, we further narrowed the search field to articles that addressed the topic of occupational risks by eliminating duplicate articles, i.e., those selected with more than one keyword.

At the end of our selection, the articles considered valid for our search are shown in Table 1.

Subsequently, in the second phase of the study, once the emerging occupational risks related to Green Jobs were identified from the analysis of the scientific literature, we proposed prevention and protection measures in relation to the legislation currently in force in Italy in order to design a safety protocol that, in our opinion, can safeguard the health of workers involved in Green Jobs.

### 3. Prevention and Protection

Prevention and Protection are the two pillars on which occupational health and safety management is based, according to current Italian legislation (Legislative Decree 81/08). On these two concepts, following the assessment of risks detected in the workplace when carrying out certain activities, adequate and sufficient prevention and protection measures must be defined and applied in order to minimise or, if possible, totally eliminate these risks [21].

Prevention is identified as the set of provisions, measures and good practices necessary, also in relation to the type of work activity, experience and technique, to avoid or reduce occupational risks while respecting the health of the population and the integrity of the external environment. Prevention thus acts by decreasing the probability that an injury may occur (reference to the concept of Risk as a combination of probability  $\times$  magnitude).

In light of this, it is the duty of the Employer, in collaboration with the other safety figures envisaged by the legislation, i.e., the Head of the company Prevention and Protection Service, the Competent Doctor and the Workers' Safety Manager, to carry out a correct Risk Assessment, useful for defining all the risks that the work activities may generate, and to define all the necessary prevention measures.

Among the most common prevention measures applied are the system of information, education, and training of workers; the design, construction, and correct use of machinery, equipment, and facilities in the workplace; and the adoption of appropriate behaviour and operating procedures [22].

Protection measures, on the other hand, are represented by all those defensive actions that are implemented to protect personnel from any damage caused by residual risks that cannot be reduced by prevention. Such actions are capable of further reducing the extent of possible damage to property and persons [23].

Where prevention measures fail to achieve an excellent result in terms of safeguarding workers' health, it becomes necessary to adopt further protective measures, which can be identified in this order, through the use of Collective Protection Devices (CPDs), which protect a group of persons from a risk (e.g., a fume hood that protects a group of people from a risk; a fume hood that protects all the workers present in a laboratory), or Individual Protection Devices (PPE) that protect the individual person and in particular the target organ of the risk (e.g., a face mask that protects the worker's respiratory system). Finally, it should be emphasised that protection only comes into play when it is not possible to partially or totally eliminate a risk through the use of preventive systems [24].

### 4. Emerging Risks

Emerging occupational risks are defined by the European Agency for Safety and Health at Work as all occupational risks that are identified as 'new' and 'increasing'. The term 'new' refers to an occupational risk that did not previously exist and is therefore not present in the relevant regulations, which is caused by new processes, new technologies, social or organisational changes due to a change in social or public perception; or a risk that has emerged as a result of new scientific knowledge. Newly emerging risks are also to be understood as those conventional occupational risks to which, however, workers are exposed under nontraditional conditions. The other aspect present in the definition of an emerging risk is its trend in terms of the number of exposed workers; a risk should be understood as 'increasing' if there is a large number of exposed workers with a high

probability that this condition will lead to a hazard; or if the effect of the hazard on the health of workers is increasing exposing more and more of them to serious consequences from such exposure [25].

It is common to associate the word ‘green’ with safety, but what respects the environment does not necessarily also respect the health and safety of the workers who carry out such work. History has shown us in the past how new regulations and technologies intended to protect the environment have not always had the same effect on those exposed at work, leading to an increased risk to health and safety.

The speed at which the ecological transition is expanding and the emergence of new technologies and new work processes related to ‘green’ jobs may, in fact, entail several new specific risks, requiring innovative combinations of worker health and safety skills that cannot simply be transferred from traditional work contexts, in order to avoid scenarios characterised by skill shortages, and the possibility of hiring inexperienced workers involved in performing new procedures for which they have not been adequately trained.

For Green Jobs to be truly sustainable, from the point of view described above, it is necessary to ensure that such activities do not pose a risk to the safety and health of workers or the environment. In fact, they may prove to expose workers to different types of specific risks between the emerging ones and the traditional ones but are carried out under new working conditions [26].

Specifically, the innovativeness of the materials used and the production processes adopted in work activities, the introduction of more modern technologies, and the new forms of employment and work organisation involved in the ecological transition can certainly determine new risk profiles for workers’ health and safety, which combined with the traditional and regulated specific risks can favour the occurrence of occupational accidents or illnesses. An example of such a condition concerns the work activities of the renewable energy sector and, in particular, the wind energy sector, which combines traditional safety risks such as electrical risk, the risk of falls from heights or working in confined spaces, with newly emerging health risks such as the use of newer, more innovative and resistant materials to make up wind blades, such as resins and solvents, or the manual handling of loads on ropes in unfavourable environmental conditions [27].

In short, Table 2 lists some of the green activities that have greater prominence in the ecological transition process, in which all these types of occupational risks are combined.

**Table 2.** Green activities, with greater prominence in the ecological transition process, where all these types of occupational risk are combined.

Sector	Risks/Dangers
Wind energy	<p><u>Safety Risks</u>: electrical, falls from height, working in confined spaces.</p> <p><u>Health risks</u>: manual handling of loads, noise, vibration, micro- and macroclimates determined by unfavourable microclimatic conditions, exposure to new, more innovative, and resistant materials such as resins, solvents, etc.</p> <p><u>Cross-cutting risks</u>: organisation of work teams and shifts, work-related stress.</p>
Waste handling/recycling	<p><u>Safety hazards</u>: electrical, falls from height, accidental ingestion (contaminated hands).</p> <p><u>Health risks</u>: manual handling of loads, noise, vibration, inhalation of aerosols, cuts, punctures, contact, exposure to toxic/harmful substances.</p> <p><u>Cross-cutting risks</u>: organisation of work teams, night shift, work-related stress.</p>

Table 2. Cont.

Sector	Risks/Dangers
Photovoltaic	<p><u>Safety Risks</u>: electrical, falls from height, working in confined spaces, burns and scalds.</p> <p><u>Health risks</u>: manual handling of loads, noise, vibration, micro and macroclimates determined by unfavourable microclimatic conditions, exposure to solar cell components and semiconductors such as cadmium telluride.</p> <p><u>Cross-cutting risks</u>: organisation of work teams, night shift, work-related stress.</p>
Biomass	<p>Safety hazards: fire, explosion, electrical.</p> <p><u>Health risks</u>: manual handling of loads, noise, vibration, micro- and macroclimates determined by unfavourable microclimatic conditions, exposure to carcinogens, heavy metals, hazardous gases, volatile organic compounds, dust, mould, endotoxins.</p> <p><u>Cross-cutting risks</u>: organisation of work teams, night shift, work-related stress.</p>
Solar thermal	<p><u>Safety hazards</u>: electrical, falls from height, confined spaces, burns.</p> <p><u>Health risks</u>: manual handling of loads, noise, vibration, micro and macroclimates determined by unfavourable microclimatic conditions.</p> <p><u>Cross-cutting risks</u>: organisation of work teams, night shift, work-related stress.</p>

The transition to a green economy, therefore, poses new challenges in terms of workers' health and safety, which, in addition to traditional work-related risks, could include emerging risks related to the introduction of new technologies, new substances, new production processes and changes in the workforce. In addition, the rapid expansion of the green economy could pose additional training needs, leaving some unskilled workers involved in procedures for which they have not been adequately trained.

In this regard, EU-OSHA is implementing a series of foresight projects aimed at assessing the possible effects of newly emerging occupational risks that can be divided into two broad categories:

- new materials and technologies
- new ways of working

#### 4.1. Exposure to New Materials and Technologies

Work activities involved in the ecological transition are often considered innovative or next-generation due to the increasing use of materials considered sustainable.

This is the case with the so-called 'technical or synthetic marbles or quartz agglomerates or artificial stones', materials composed of marble agglomerates obtained by aggregating marble flakes with polyester resin or cement, subjected to vacuum compaction to create cohesive and homogenous blocks.

In recent years, the stone-processing sector has seen the introduction of these new synthetic materials consisting of quartz agglomerates, in which silica is used as the main component in a mixture with substances (resins) used as aggregants in excess of 90 per cent and resin (usually polyester) as a binder. For this reason, the cutting and processing of artificial stone gives rise to the formation of silica dust, to which workers performing these tasks are exposed.

Artificial stones, such as those mentioned above, can now be defined as 'articles' within the meaning of the REACH Regulation, i.e., objects composed of one or more substances or preparations which, during production, are given a particular shape, surface or design that determines its end-use function to a greater extent than its chemical composition [28].

From the point of view of the health of exposed workers, numerous scientific articles have shown that cases of silicosis in companies working with these artificial materials

with high silica % are on the rise. Already in 2009, the Spanish Institute for Silicosis (INS) reported the first three cases of silicosis in young workers installing quartz agglomerate surfaces in buildings (decorations, bathroom and kitchen countertops, etc.) and exposed to high concentrations of silica during their work [29]. In 2010, another paper was published, also in Spain, on the prevalence of silicosis in a stone materials processing workshop. In particular, six cases were reported to be related to exposure caused by the processing of new synthetic materials with a high silica content (quartz and resin agglomerates). The prevalence found within the small group of 11 workers, of whom four were cutting workers and seven assemblers, was 54.5% overall. The prevalence was, however, higher in the group of assembly workers, where five out of seven workers performing this task fell ill, underlining the fact that the greatest risk was related to the work, often performed at the customer's home, without any respiratory protection. Also striking in this case was the young age of the subjects, the advanced degree of the disease and the presence of a case of progressive massive fibrosis in a 32-year-old subject. The article demonstrated the danger posed by exposure to silica in work processes hitherto not considered from this point of view, such as the handling of quartz agglomerates [30].

This scientific evidence allows us to state that the use of these innovative man-made materials, designed to reduce environmental impact and have a more sustainable approach in the construction sector, does not always correlate with greater safety for workers employed in the various processing stages such as assembly/cutting/sanding, leading to a high risk of developing historical occupational diseases such as in this case silicosis in young subjects [31].

Similar to the previous concept is that inherent in the use of nanotechnologies, which are little known in terms of health risks for exposed workers but are increasingly used for their countless innovative and environmentally friendly features [32].

Nanotechnology has applications in various economic sectors, including healthcare, biotechnology, clean energy production, information and communications, chemistry, the food, electronics and military industries, agriculture and construction. They use nanomaterials (NMs), i.e., materials with innovative characteristics at the nanoscale (1–100 nm). In 2022, the European Commission defined nanomaterials as natural, derived or manufactured materials consisting of isolated solid particles or constituent particles identifiable in aggregates or agglomerates and in which 50 per cent or more of the particles in the number size distribution meet at least one of the following conditions:

- external particle size in the range from 1 to 100 nm;
- elongated particle (such as a stick, fibre or tube) with two outer dimensions of less than 1 nm and the other dimension greater than 100 nm;
- platinum-shaped particle with one of its outer dimensions less than 1 nm and the other dimensions greater than 100 nm [33].

The use of NMs and related nanotechnologies is currently in great demand. Specifically, these materials are included in the broader group of so-called advanced materials, i.e., extremely versatile materials with new functionalities and increasingly high-performance characteristics. These are materials that are already known and suitably modified or entirely new materials designed to have specific characteristics, such as the ability to modify their physicochemical properties, combine two or more materials, be applied to a biological system or be derived from a biological source, or be materials obtained by advanced methods of adding/removing material through virtual geometry, without the use of pre-forms or moulds [34].

However, it should be remembered that the widespread use of nanotechnologies has aroused great interest due to the obvious economic and social benefits of their use, but due to the limited knowledge of the long-term effects of some of these materials on human health, it has raised many justified concerns about the possible negative effects on the environment and human health, leading to a possible limitation of their use [35].

The use of nanomaterials, in fact, may represent an emerging health and safety risk, which must be assessed and managed through a specific approach, particularly within the



complexity of work environments. It has, therefore, become necessary to properly assess and manage the potential risks of these new types of materials and to study and analyse the hazardous properties that these substances may have on humans in order to ensure their safe use.

To this end, the scientific community and regulatory authorities are working to establish whether the current methods for assessing the safety of chemicals, as laid down in the REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) regulation, are also applicable to nanomaterials, or whether new methodological approaches are required. In fact, regulations within the European Union stipulate that all chemical substances and their use in products for which there is no other specific regulation are subject to EC Regulation 1907/2006 concerning REACH [36].

According to the European Chemicals Agency (ECHA), nanomaterials are not explicitly mentioned in the REACH framework, but since these requirements apply to chemicals in any form and configuration, they are considered to be covered by this regulation anyway [37].

The ECHA has also published different guidelines on information requirements and safety risk assessments for nanomaterials, according to REACH. These include data on physicochemical properties, toxicology and toxicokinetics, as well as appropriate safety assessment measures, including occupational exposure and recommendations on personal protective equipment for personnel to be used if residual exposure cannot be avoided through the application of other preventive and protective measures [38].

The specific occupational risks, therefore, vary depending on the type of nanomaterial. Exposure to insoluble or poorly soluble nano-fibres is considered to pose the greatest risk, but in fact, all activities involving the handling of nanomaterials in a dry state outside of closed facilities or when using closed facilities that are not functioning properly, such as in the case of leaks or during cleaning and maintenance activities, may be associated with a high risk of exposure for workers [39].

Among the activities at greatest risk for workers' exposure to nanotechnology, the primary sector, and agriculture in particular, should certainly be mentioned, as with an ever-growing population, high agricultural yields and more efficient strategies to optimise farming practices are increasingly in demand [40].

In this area, nanotechnology has seen significant growth, and these practices have been shown to make agriculture increasingly sustainable, providing innovative solutions to protect and restore water and soil, thus increasing global food production and quality while respecting the environment [41–48], and improving seed germination, plant growth and protection through the reduced and controlled use of traditional chemicals, partly replaced by new generation pesticides that are less harmful to the environment [49].

However, the emerging and massive uses of nanotechnology in agriculture continue to raise questions and concerns about the possible implications for human and environmental health for both the general and working population. In this regard, although organic farming is generally considered healthier for both consumers and the environment, it may not be so for the working population involved [50,51]. From the point of view of occupational health and safety, in fact, this seems an even more pressing issue since the first intensive and chronic exposures concern workers in the sector, who may manifest long-term adverse health effects earlier than the rest of the general population [52].

In light of the potentially great variety of nano-substances used in different sectors, but not yet fully known from a toxicological point of view, it must therefore be considered that despite the presence of regulatory and standardisation measures in the area of occupational exposure, their use requires adequate analytical capacity, which is still under development for some applications [53,54].

More generally, occupational safety and health concerns related to the increasing use of new, potentially harmful materials, based on the current reduced scientific knowledge of the effects of chronic exposure, encourage a more cautious approach to their use and subsequent

comprehensive assessment in order to achieve optimal alignment of the key objectives of occupational safety and health, sustainability and the concept of Green Chemistry.

Green chemistry is understood as the commitment of the entire chemical industry to reduce or eliminate the use of hazardous substances that are harmful to the environment or human health in order to reduce the negative effects of the chemical industry and safeguard future generations. In addition to the search for better material yield, which is only one of the many characteristics a production process must possess to be considered efficient, this industry aims at the need to redesign existing chemical processes considering first and foremost worker health safety, pollution prevention, waste minimisation and energy optimisation [55].

Despite these assumptions, to date, there are still many uncertainties about the health effects related to the nature and scale of nanotechnologies and other materials that are widely used in the environmental transition; indeed, the recommendations converge towards the implementation of a preventive approach for safe and sustainable use in the workplace [56,57].

#### *4.2. New Ways of Working*

In the course of the ecological transition, there are several economic sectors in which new ways of working are practised on existing production processes in order to have a better output and a lower environmental impact. This can often result in workers being simultaneously exposed to specific types of occupational hazards that are considered traditional but carried out under new working conditions, as in the case of aggravated ergonomic risk, work carried out in remote or lone mode, or even in activities carried out under extreme climatic conditions.

Today, 'ergonomic risk' is rightly among the most highly evaluated aspects in terms of prevention when designing interventions to improve the safety and well-being of workers in the workplace. In the context of Green Jobs, ergonomic aspects, also referred to as 'green ergonomics', are considered essential to ensure the development of safe and healthy sustainable jobs [58].

An example of a growing sustainable work activity in which the workers involved are exposed to specific emerging ergonomic risks concerns rope work. This work mode is often used in the field of renewable energy, as well as in sustainable construction, to reduce the use of polluting conventional elevation equipment such as cranes, baskets or other mechanical platforms. The ergonomic risk in this work mode is combined and amplified with new work modes that may involve the manual handling of non-traditional loads and the prolonged assumption of incongruous postures, leading, as shown by different studies in the literature, to a greater onset of musculoskeletal disorders of the cervical spine, scapulohumeral girdle and upper limbs, which are not frequent in workers exposed to the same specific risks and with the same task but performed in traditional work modes [59].

Green ergonomics, therefore, aims to create work environments that prioritise the health and safety of workers by designing ergonomic workspaces for various activities, assessing the harmful effects that new practices may cause in performing tasks for which specific occupational risks considered traditional have previously been assessed.

Specifically, the use of adjustable workstations and equipment that can be adapted to different builds and individual preferences to reduce the risk of musculoskeletal disorders, together with specific training programmes on ergonomic practices, could improve awareness of these hazards by reducing the likelihood of accidents at work and instil a culture of safety and well-being in all the professionals involved. This should be considered not only a benefit for the worker but, above all, for the employer and the company, fostering an increase in profit in terms of a reduction in the number of errors, accidents and sick days, with a virtuous growth from which the entire company benefits.

Among the traditional risks most commonly assessed in green activities in open spaces, and particularly in this historical period, we must mention those determining 'climate change' caused by long-term variations in temperature and weather patterns. Current

legislation considers micro- and macro-climatic conditions as a risk to workers' health and safety, which are to be assessed according to four different parameters: air temperature, humidity, airflow velocity, and radiant temperature.

From the integration of these parameters, different thermal indices were identified that make it possible to assess the thermal stress, especially in extreme situations, suffered by the human organism. The limits highlighted for most of these indices relate to the metabolic heat of the body, which is different for each worker, also depending on other variables such as acclimatisation, physical activity, clothing, age, gender, health status, body type, and alcohol or drug intake.

According to the Technical Standard UNI EN 2743:1996, which concerns the evaluation of heat stress for humans in the workplace, the most reliable index for evaluating heat stress in outdoor work in a hot environment is the WBGT (Wet Bulb, Globe and Air Temperature). This index is easy to determine and makes it possible to assess the average effect of heat on humans during a representative period of their work activity [60].

Considering the current ever-increasing climatic variability and the general increase in temperatures at all latitudes, it is therefore evident how these known and considered traditional risks, already provided for by current legislation, in these new ways of performing the various tasks in Green Jobs may have a greater likelihood of leading to an accident.

Among the other sectors involved in the Green Economy, and which, more than others, take advantage of the new working methods outlined above, is the field of wind energy. This industry exploits the renewable energy produced by the force of the wind to produce electricity that is useful for human activities without releasing any pollutants into the air. The work activities in this field are diverse and mainly concern the construction, operation and maintenance of wind turbines. Specifically, the tasks include different jobs: from research workers, such as engineers, to design components and select sites to manage installations and the development of wind farms, to machinists, assemblers, maintenance workers and welders for the production and maintenance of components, ending with construction workers, including those specialised in concrete and steel foundations [61].

The Occupational Safety and Health Administration (OSHA) describes different occupational hazards specific to wind energy, which can be partly compared to other sectors also in the field of renewable energies, that can be aggravated by the performance under new and highly hazardous environmental and procedural conditions [62].

Specifically, this is the case with rope work, carried out outdoors in highly variable climatic conditions from heat above 35 °C to the cold typical of areas at high altitudes, or it concerns the increased safety risk of falls from heights that can occur during the installation and maintenance phases of wind turbines, brought about by working in places exposed to strong winds such as wind farms at sea level; or it is the case of those who carry out their work in confined spaces, such as inside the cramped spaces of turbine rotors, where the typical risk of this activity can be aggravated by the accidental start-up of machinery and equipment or the accidental release of electricity during service or maintenance activities.

Another aspect to be considered in new working arrangements concerns psychosocial risk factors. There is little knowledge in the literature on this topic, but nevertheless already, in 2013, the European Agency for Safety and Health at Work (EU-OSHA) stated that working conditions such as long hours, lone or remote working for prolonged periods should be taken into account when addressing the psychosocial specificities of work [63].

In this regard, among Green Jobs, several activities involve the exploitation of these working methods, especially in the field of renewable energy, such as the installation, maintenance and disposal of planned elements in wind or photovoltaic plants that are frequently located in remote places. Several studies have shown that working alone can lead to an increase in psychosocial risks associated with the restlessness that may develop when working in such conditions, so that in the event of an accident or illness, one cannot be rescued in time or the stress one is subjected to when facing alone scenarios that require situational awareness and immediate decision-making in the face of more or less abnormal events related to the work process and safety; aspects of a psychological and social nature

that may have important chronic repercussions on the worker's state of well-being linked to the specific condition of feeling alone [64].

At a time when psychosocial risk factors and their impact on health are the subject of increasing debate, reflecting on the sustainability of certain jobs labelled as 'green' and therefore favourable to environmental protection, which do not implicitly provide safe and healthy working conditions for workers, is essential for planning a change in safe working conditions.

Finally, among the new modes of work that are booming, especially in the post-pandemic era, distance working should be considered. In recent years, in fact, technological advances and globalisation have profoundly influenced the nature of work, favouring long working hours and making psychological and physical detachment from one's professional obligations more difficult [65]. Specifically, the emergence of technologies such as e-mail, smartphones, and virtual meetings has facilitated the spread of alternative ways of working, which provide workers with greater flexibility in the execution of work activities in terms of time, space, and procedures, but contribute to blurring the boundaries between work and private life [66]. Although the adoption of flexible working arrangements was steadily increasing in the pre-pandemic era, the COVID-19 crisis caused a sharp acceleration in this trend [67].

Various forms of alternative working arrangements are described in the literature [68,69], each with its own peculiarities, including, for example, teleworking, remote working, and smart working (SW). According to the International Labour Organisation, telework "refers to employees who use information and communication technologies to perform their work remotely", usually from home or another location of their choice on a regular or permanent basis [70].

In Italy, SW denotes a form of flexible work organisation that implies a work activity subdivided into phases, cycles and objectives, in which the use of technological tools to perform the task and the absence of time and place constraints is possible, thus enabling remote work [71]. Interestingly, SW was originally proposed to improve competitiveness and foster work-life balance; however, scientific studies to date have shown mixed results between SW and worker well-being [72–76]. Indeed, different scientific studies have reported that SW is a complex phenomenon with profound and far-reaching effects on employees' health and well-being [77]. Specifically, SW can have both favourable and unfavourable consequences [78]; on the one hand, it can help workers maintain or replenish resources (e.g., time, energy) and prevent negative health consequences associated with resource depletion by reducing home-to-work commuting time, encouraging the adoption of healthy behaviours (e.g., improved sleep and a balanced diet) and increasing opportunities for recreational activities; but on the other hand, SW has caused work intensification, as workers may find it difficult to manage their workload effectively and end up devoting more time and effort, both physical and mental, to their work in order to meet work requirements and achieve their goals. Such behaviour appears in the long run to be an unfavourable psychological factor for workers, playing a negative role on homeostatic adaptations to stress that are responsible for the occurrence of various biological and behavioural effects with negative mental health outcomes such as a positive association between workload and exhaustion, a central feature of job burnout, or endocrinological biological alterations on endogenous cortisol balance [79,80].

Overall, the literature, therefore, agrees that SW can be seen as a work modality with a dual effect on employee well-being, increasing flexibility in defining the spatiotemporal boundaries of work and the massive adoption of new technologies and generating opportunities for employees to harmoniously integrate work and non-work activities but, at the same time, also contributing to hindering the effective achievement of work objectives through the interruption of employee workflow and information overload, with opposite effects on individual well-being.

## 5. Discussion

The Green Economy is able to generate economic benefits that exceed its costs and is an opportunity for development, innovation and employment in terms of changing the use of renewable energy and protecting the environment [81].

Despite this, it is not easy to adapt all countries through new laws to these changes due to numerous political and economic impediments. While in theory, the transition process seems to be well advanced, in practice, the situation is different. In fact, the Green Economy has had an initial negative social impact on productive sectors, as companies are under great pressure to adopt new and sustainable materials and tools, which inevitably leads to increased costs.

To be able to benefit from this transition, it is necessary to consider the Green Economy strategy in the long run; it provides for the allocation of numerous funds in order to facilitate the use of green materials for both companies and individuals in order to obtain benefits and advantages, such as great opportunities from the reduction of energy purchase costs or the creation of new and additional jobs [82].

In light of the above, and looking at workplace safety in economic terms, it is important to remember, as several studies have already shown, that an ineffective occupational health and safety strategy can have a negative effect, leading to higher costs, and that conversely, good management of the health and safety of workers in a company leads to improved performance and profitability of the company.

Every work environment in any economic sector has general and specific occupational risks for the tasks involved in the various work activities. In Italy, according to the State-Regions Agreement of 21 December 2011, INAIL has developed a classification of company risk based on statistical data on accident events processed in the various years monitored, in the various types of companies divided by risk index, i.e., that value which identifies how much workers are exposed to the dangers inherent to the work activity envisaged by the macro sector [83].

Specifically, companies are classified by the Italian National Institute of Statistics (ISTAT) through the ATECO code, an alphanumeric combination that identifies the economic activity carried out by the company.

Annexe 2 of Legislative Decree 81/08 (published in the Official Gazette on 11 January 2012) contains tables classifying companies according to their level of risk divided into three grades: low, medium or high [21]. Below are some of the industries that fall into the various categories:

Low risk: Wholesale and retail trade, craft activities not similar to the above, such as body shops, vehicle repair, laundries, hairdressers, bakers, confectioners, etc., hotels, restaurants, insurance, real estate, IT, recreational, cultural, sporting associations, domestic services, extraterritorial bodies;

Medium risk: Agriculture, fishing, transport, storage and communication, non-residential social work, public administration and education;

High risk: Mining and other extractive industries, construction, food processing, textiles, clothing,

leather, wood, paper, publishing, printing, non-metallic minerals, production and processing of metals, manufacture of machinery, mechanical appliances, manufacture of electrical and electronic appliances, motor vehicles, furniture, production and distribution of electricity, gas, water, waste disposal, refineries and processing of nuclear fuels, chemical industry, health and residential social work.

This classification is very important in order to be able to establish what specific risks are present in the company and how much these affect the safety of the workers exposed in relation to the possible appropriate prevention and protection measures on health and safety at work applied, and the correct and appropriate training of the various professional figures involved in the management of safety at work required by Legislative Decree 81/08 and the State-Regions Agreement. This distinction of companies by economic macrosectors, however, does not always correspond to the real risks to which the workers involved are

exposed, who often concretely carry out activities that are much more dangerous than what would result from a simple evaluation of the classification tables provided by the regulations, as in the case of the new activities envisaged in the Green Jobs.

Starting from the INAIL classification described above, in our study, we tried to include new criteria to stratify the risk of green enterprises in relation to the number of employees, the use of new substances and materials in the production cycle, and the application of new working methods to perform tasks.

Companies with a low level of risk related to green activities:

- Activity classified by ATECO code by INAIL as low risk for accident probability.
- Number of employees less than three;
- Activities in which the risk assessment revealed only traditional task-specific risks.

Companies with an average level of risk related to green activities:

Activity classified by ATECO code by INAIL as a medium risk for the probability of injury;

Presence of more than three employees;

Performance of an activity in which the presence of specific regulated occupational risks has been assessed, in which work is carried out in a non-traditional manner;

Presence of innovative new-generation materials in the production cycle.

Companies with a high level of risk related to green activities:

Activity classified by ATECO code by INAIL as a medium risk for the probability of injury;

Presence of more than five employees;

Activities involving the use of new materials and new technologies to be carried out in new ways.

Based on the proposed risk stratification, in relation to the new emerging risks present in the production processes of green companies, we have developed new proposals for prevention and protection measures and good practices in order to be able to recognise and prevent any harmful events for exposed workers.

The prevention of the risks involved in these green activities must include sharing knowledge of the development and application of new technologies so that there can be a more careful and adequate risk assessment, as well as broader management, including specific training on green issues for both workers and all other safety figures in the company.

When assessing risks with new materials planned in the production cycle, information on their hazardous properties must be taken into account, which is often still lacking, both in knowledge of the individual components and in systems for measuring the exposure levels of emission sources with objective use and assessment limits.

For the use of new substances, as in the case of nanomaterials, according to our protocol, the approach must involve the implementation of preventive and protective measures that intervene following the common principle of first interacting with the collective of the working population and then focusing on the individual.

The first analysis to be made, once the presence of such an occupational risk has been recognised, is to consider the possibility of substituting the new substance from the production cycle as provided for in Article 224, 'General measures and principles for risk prevention' in Legislative Decree 81 of 2008. This pivotal principle for all occupational risks, however, is often difficult to apply in green activities, as innovative materials are often used due to their often unique technical properties, and therefore their substitution may not be easy. In such circumstances, it is therefore necessary to apply targeted technical, organisational and individual prevention and protection measures, such as:

- Identifying and defining new professional figures experienced in the green economy and sustainable economy who have the necessary skills from the design of energy systems to the use of raw materials, from the analysis of the territory to the operational management of green projects, through to financial advice and the promotion of sustainable materials;

- Carrying out an exposure assessment by inhalation, dermal contact or ingestion, implementing the necessary actions to reduce exposure, and developing a specific emergency plan in case of accidental high-risk events;
- Use of closed encapsulation and ventilation systems in the production process, with particular attention to the phases with the highest risk of exposure, such as the mixing of substances or the cleaning of equipment or waste disposal, in relation to the level of dustiness and emission of the substance used [84]. In particular, this measure is to be applied to nanomaterials that, having a nanoscale mass and a very low kinetic energy, may have a behaviour considered similar to that of gases rather than that of powders;
- Controlling air circulation in closed and open factory environments, using ventilation systems with high-efficiency HEPA particulate filters or ultra-low penetration ULPA filters;
- Reducing waste products and waste from the production process as much as possible, isolating them in designated places with controlled access and appropriately marked;
- Accurately inventorying materials stored and used in the workplace with the relevant health hazard information, usually provided in safety data sheets;
- Organisation of work shifts so as to reduce risk exposure;
- Mandatory use of PPE to protect the respiratory tract and skin surface in relation to the effects on humans that substances may cause, in accordance with the safety data sheet of the respective manufacturer;
- Worker training specific to these new substances, aimed at understanding the monitoring and prevention systems used and the new operating procedures applied;
- Risk assessment for workers considered vulnerable, such as minors or pregnant or breastfeeding workers, determining whether specific actions are needed for their protection.

When talking about risks related to green companies, as mentioned above, one must also consider new ways of working that expose workers to specific risks already foreseen by the relevant legislation but aggravated by new conditions that could increase the risk, such as in the case of adverse weather conditions or solitary or remote working modes.

In the presence of WBGT positive for high temperatures, the most suitable prevention and protection measures to be applied proposed by our protocol are as follows:

- Suspension of work for outdoor or indoor environmental temperatures above 35 °C;
- Organisation of work shifts favouring times of day with milder ambient temperatures;
- More frequent breaks from outdoor activities with shelter from direct sunlight;
- Installation of shading devices in workplaces;
- Use of personal protective equipment that promotes sweating and skin perspiration;
- Use of skin protection shields with a physical mechanism to defend the skin from ultraviolet (UV) rays, such as creams;
- Use of certified eye shields for UV protection;
- Training of workers on the specific risks in such working conditions and on first aid.

Remote and lone working arrangements are often a problem related to the psychosocial sphere. In order to reduce this risk, it is necessary for workers working under such conditions to be adequately familiar with the workplace and its surroundings, in particular, routes to reach busy roads, villages or nearby inhabited places to possibly call for help, but also the work equipment, tools and vehicles they use. The following are, therefore, necessary:

- Use and knowledge of the activity surveillance system employed by the company;
- Information and training on activities that require the presence of a second person (e.g., work in confined spaces or on ladders) or require the presence of a certified specialist (e.g., maintenance technician);
- Creation of an emergency or evacuation plan also for isolated areas, including escape routes, an acoustic alarm system, a visual alarm system and emergency call and emergency management methods in special situations (e.g., electricity blackout, flooding, etc. in relation to the state of the site);

- Use, when possible, of new surveillance technologies such as the use of drones, geolocalisation apps or GPS systems with SOS functionality in the event of an accident that can alert rescue and automatically report the location of the injured person;
- Equipping remote workstations with all the furniture and ergonomic equipment provided at in-house workstations;
- Provide alternating periods between remote or solo work and in-company work in the presence of the public or work colleagues.

## 6. Conclusions

The ecological transition is a phenomenon that is set to increase exponentially in the coming years and trigger strong structural changes in the labour market. The use of renewables and the spread of environmentally related technologies will certainly have positive consequences for our quality of life, but they must not make us forget to pay attention to health and safety at work. When we think of the word 'green', we usually refer to products and services that, in the collective imagination, are safer from all points of view than the products or services they replace, but unfortunately, this does not always reflect the truth in terms of safety in the workplace.

While this revolution ensures the growth of green sectors by strengthening them and creating new job opportunities, thus benefiting highly skilled workers, it can also represent a scenario of possible new emerging occupational health and safety risks that may lead to an increase in adverse events in the workplace.

At present, giving a complete and rigorous answer on the occupational impact of the ecological transition is complex. However, considering the limited knowledge of the specific risks emerging in Green Jobs and the topicality of the topic of occupational safety, our aim has been to try to identify which occupational risks are linked to the most growing activities in the ecological transition process, trying to identify the most suitable prevention and protection measures to safeguard the health of the working population involved and to increase knowledge in the field of health and safety in Green Jobs. The limitation we can recognise in our study is that we have not been able to analyse in detail all the new risks considered to be emerging and all the work sectors involved in the ecological transition due to the meagre bibliographic sources in the literature.

Among the most frequent new emerging occupational risks, we have assessed and analysed those related to the use of new materials, especially innovative nanoscale materials, and we have also examined the most frequently used new types of work methods, such as working at heights on ropes or other elevation systems, locating workplaces in areas far from built-up areas with the consequence of working alone, or adopting remote work methods in order to optimise human resources. In light of the above, we evaluated new criteria for classifying economic sectors that could be added to those already provided for in Italy, and finally, we proposed new specific prevention and protection measures that are better suited to improving safety management in these workplaces.

We hope that by adopting these organisational, environmental and personal measures, which we propose, the management of safety in Green Jobs can improve by ensuring the reduction of occupational injuries and illnesses in the workforce and the population as a whole.

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