

Scenario Summaries

Win-Win

High economic growth

Looking back from 2025, after a slow start in 2012, growth across the EU and OECD returned to the levels prior to the economic crash of 2008. Developing countries also experienced high growth similar to that in the first decade of the century.

High green values

Advances in climate science started to show how vulnerable we are becoming to climate change. Growing public concerns encouraged governments to introduce green policies, including those leading to deep and progressive cuts in carbon emissions.

There was strong approval for green behaviour by corporations and individuals. This was reinforced by concerns over resource shortages (food, commodities, minerals, water and energy.)

High level of innovation in green technologies

Green growth has increasingly been seen as vital for a sustainable future. Corporate profits and access to finance have supported high levels of investment in new business opportunities and infrastructure. The rate of technological developments has accelerated with high levels of innovation. A high proportion of the innovation has been aimed at achieving a green outcome and generating future profits.

Society and work

Most people in the EU now feel prosperous and place a higher value on the preservation of the environment, human life and well-being. The strong economy allows governments to address the increasing demands for welfare and to invest in education.

There is high employment and many new jobs and new products are now being created over ever-shorter timescales, which can lead to new hazards and risks if not designed with OSH taken into consideration.

Occupational safety and health

Overview

In a buoyant economy, funds are available for investment in safety, but the high pace of innovation and the rapid roll-out of new technologies and new products, and the creation of new jobs requiring new skills mean that a wider population faces new risks over shorter timescales. It is, therefore, important that OSH assessments are undertaken early in the development cycle of a technology or product so that the pace of development doesn't leave OSH behind.

Wind energy

The risks are multiplied many fold in offshore wind farms, which have the potential to become very dangerous worksites. With so many large turbines in ever-deeper water, ever further from safe haven, access issues are the dominant OSH consideration. Working sites are more widely dispersed, with lower profit margins to pay for safety than in the oil and gas industries. Construction is hazardous and with the large numbers of turbines come skill shortages as wind competes with other technologies for qualified staff. Specialist vessels are required to handle large turbines in deep water, and there are still issues over foundation strategies (especially as the seabed is different for each turbine in a wind farm), transport of foundations from yards, and longer-term issues over removal of foundations. Novel turbine designs have brought engineering unknowns. In the hostile environment, maintenance is demanding, although more

reliable electronic infrastructure monitoring devices help to minimise unpredicted maintenance and improved quality of equipment has helped reliability. The need for workers to live so far offshore is leading to work organisation issues and psychosocial problems. New composites and nanomaterials used for the manufacture of wind turbines have possibly introduced new health hazards for workers involved in manufacturing, maintenance, decommissioning and recycling.

Green construction and building retrofitting

Off-site automated construction of modular buildings has improved on-site safety as far fewer tasks are undertaken on site. However, as building moves into factories, new risks emerge as workers are exposed to novel substances increasingly used in construction material (e.g. phase change materials, heat storage chemicals, novel surface coatings, nanomaterials and fibrous composites).

On-site issues arise from mixing automated with traditional, manual activities. There are risks during the connection of services (e.g. water and electricity) to prefabricated modules but, with the correct design, these should be negligible. There are also electrical risks as old and new buildings have to be integrated into the smart grid, incorporating smart appliances, energy storage technologies, etc. In increasingly crowded cities, the trend of developing basements has led to increasing underground congestion with associated OSH implications due to working in confined spaces, the risk of collapsing structures or drilling into existing cabling.

Combinations of new energy sources in buildings (e.g. photovoltaics (PV), geothermal and biomass) bring new hazards and unexpected accidents — in particular as there are many new players entering the sector.

With a high level of new build, there is a large quantity of old building materials from demolition to deal with, exposing workers to hazards. Retrofitting of existing buildings exposes workers to increasing roof work as they install solar panels and small-scale wind turbines, with the risk of falls and exposure to lead and asbestos as they disturb old structures.

Bioenergy

The storage and handling of biomass expose workers to physical, chemical and biological risks and to risks from fire and explosion. High temperatures, and sometimes high pressures, are used in pyrolysis (350–550 °C) and gasification (over 700 °C). There is also a potential issue with the increased variability in the constitution of gas derived from biomass compared to fossil fuels. Third-generation biofuels have the potential to give rise to new biological risks. There may also be operational risks associated with the scaling-up of third-generation biofuel production from demonstration plant to commercial scale.

With the widespread adoption of bioenergy, many workers are potentially at risk. Agriculture increasingly turns to biomass production and work in forestry is likely to intensify. Waste products from biomass can be toxic (e.g. wood ash contains heavy metals and is strongly alkaline).

Waste management and recycling

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The political pressure to recycle means that workers are potentially exposed to a very large range of materials: increasing volumes of waste result in difficulties in identifying the provenance and composition of waste. However, improvements in labelling, tracking and auditing of materials are helping in the identification process.

Workers have to deal with hazardous waste, not just valuable waste, including material from urban mining and recycling of industrial waste. Nanomaterials are also increasingly appearing in waste as their use in manufacturing becomes more widespread. However, the increasing use of robots to sort and handle waste helps improve workers' health and safety.

The zero-waste economy entails dealing with the most difficult tail end of the waste stream: such wastes in concentrated form are hazards that need special handling.

Green transport

Maintenance of complex networks coupled with skills shortages presents an important OSH challenge. Most new vehicles are electric or hybrid. Rapid recharging or battery swaps may present hazards, as will the maintenance of electrified vehicles (EV). As electric vehicles are increasingly maintained by independent garages rather than specialists, there are electrocution risks since workers are not familiar with the high voltages involved. Risks of fire or explosion are particularly high during quick charging of EV and after accidents. Driverless vehicles and platooning (the grouping of vehicles that behave effectively as one) have improved safety for those who travel as part of their work. However, there is a risk of over-reliance on the technology. Absolute reliability is therefore crucial, with fail-safe modes in the event of accidents, problems or failures.

Green manufacturing, robotics and automation

Increased automation has improved OSH, in some respects, by removing workers from some hazardous tasks but, at the same time, the growth in the use of collaborative uncaged robots has introduced other potential risks.

Growing complexity and increasing ICT in automated manufacturing has brought human-machine interface issues. Some types of robot malfunction may be difficult to detect until it is too late and may, therefore, put workers' safety at risk. Growth in 'just-in-time' and 'lean' approaches facilitated by flexible manufacturing systems have put additional pressure on workers, leading to

psychological risks. Workers are resorting to enhancement technologies in order to keep pace with developments and with their colleagues as well as with robots. There are potential unknown long-term health effects of new green materials and nanocomposites with a lower carbon footprint.

Domestic and small-scale renewable energy

The speed and diversity of change has resulted in skill shortages and, therefore, competency issues for work in renewable energy technologies. There are many new energy technologies where specific knowledge is needed but has not yet been fully developed, and where 'old' OSH knowledge and safe working practices are not always directly transferable. New entrants to the industry are not always sufficiently familiar with the risks and new combinations thereof. Small and medium-sized enterprises (SMEs) are increasingly using their land to produce electricity as a sideline and may use their own workers, or subcontractors, to install or maintain their renewable energy systems ad hoc, although such workers are not skilled in this type of work. The increasing adoption of solar PV has introduced risks for emergency workers accessing roof spaces that remain live even after the mains supply has been cut.

Batteries and energy storage

Hydrogen has grown in popularity as an energy carrier, including its use as a fuel for vehicles, bringing transport and storage issues. Batteries are the main means of electricity storage, with potential risks of fire and explosion, exposure to hazardous chemicals and electrocution from high voltages. Based on their experience from lead-acid batteries, people generally have a false perception that new batteries are safe. As for large offshore installations, specific OSH regulation is in place for deep-sea energy storage, which, although a relatively low-tech concept, involves high voltages and power levels in a complex environment, complicating installation and maintenance work.

Energy transmission and distribution

The complexity of the SuperSmart Grid (SSG) makes it difficult to maintain top-down control of the grid and, consequently, of related OSH issues. The key OSH risk arises from increased live working to cope with the rapid pace of change. The dangers from electric shock, burns, fire and explosion are well known, but now involve different people in different situations. The increase in electricity storage is an added dimension. The pressure of work can lead to the use of inexperienced staff.

Scenario Summaries

Bonus World

High economic growth

Looking back from 2025, after a slow start in 2012, growth across the EU and OECD returned to the levels prior to the economic crash of 2008. Developing countries also experienced high growth similar to that of the first decade of the century. High growth has led to high prices for natural resources, including energy.

Weak green values

After 2012, economic growth was the priority and some environmental degradation was considered to be an unavoidable consequence of strengthening EU economies. When faced with the costs, people have not valued greenness sufficiently for governments or business to have an incentive to deliver it. Government support for green practices is limited to charging for the visible externalities of production (noise, pollution, landfill, traffic congestion, etc.).

Medium levels of innovation in green technologies (directed towards profits)

Most consumers and businesses choose green products and services only if they are better or cheaper than the alternatives. Innovations in green technologies are limited to those areas that show a positive financial return.

High total levels of innovation

There are continuing advances in technology that are adopted into new products and processes. High levels of capital investment mean that capital-intensive technologies can be rolled out quickly. Corporate profitability and access to finance have supported high levels of investment in infrastructure. The environmental consequences of increased use of resources are seen as acceptable and necessary.

Energy sciences continue to deliver improvements in efficiency and low-carbon energy, but it is now clear that serious and unacceptable compromises would be needed to achieve a zero-carbon future.

Society and work

Most people in the EU now feel more prosperous than in 2012. They value economic well-being more than the environment, but are prepared to pay for a pleasant environment in the vicinity where they live.

Businesses are focused on generating current and future profits. New jobs are being introduced at a relatively fast rate and there are high levels of employment. There is also high mobility of workers, while inequalities mean that low-skilled workers are readily exploited.

Higher income levels and corporate profits have provided the tax revenues that allow European governments to pay for sustainable welfare programmes.

Human performance-enhancing drugs are being routinely used in work settings.

Occupational safety and health

Overview

In a healthy economy, funds are available to invest in OSH and make infrastructure and business processes safe, but OSH is of relatively low

importance to most governments. Employers see OSH as important in terms of its impact on profits.

New jobs and new products may bring new hazards and the rapid roll-out of new technologies means that a wide population is exposed to these with short timescales for determining their possible health and safety impacts.

OSH by regulation is more effective than OSH by education.

As in Win-Win, there are skills shortages associated with the high pace of innovation. This leads to a polarisation of the workforce with regard to skills, with less-skilled workers more readily found in jobs with poorer, more hazardous working conditions.

Wind energy

With smaller turbines, predominantly located onshore, construction and maintenance are not as hazardous as in the other two scenarios; however, the proximity to population centres brings potential risks to a larger population, including workers. Much of the maintenance work is contracted out, so it is more difficult to keep an eye on work organisation and there is a risk of passing of blame and no due diligence by the ultimate owner. Cost pressures may lead to increased risk-taking. Many of the workers are migrants with low skill levels and a poor OSH culture. The decommissioning of old wind farms that were not designed to enable safe dismantling puts workers at high risk. New composites and nanomaterials used in the manufacture of wind turbines have possibly introduced new health hazards for workers in manufacturing, maintenance, decommissioning and recycling. On the plus side, the use of standardised designs has reduced complexity and made maintenance more straightforward.

Green construction and building retrofitting

Off-site automated construction of modular buildings has improved on-site safety as far fewer tasks are undertaken on site. There are risks during the connection of services (e.g. water and electricity) to prefabricated modules but, with correct designs, these should be negligible. However, as building moves into factories, new risks emerge as workers are exposed to novel substances.

On site, there are electrical risks as old and new buildings have to be integrated into the smart grid, incorporating smart appliances, energy storage technologies, etc. In increasingly crowded cities, the trend of developing basements has led to increasing underground congestion.

With a high level of new build, there is a large quantity of building materials from demolition to deal with. Compared with Win-Win, newer buildings are being demolished – exposing workers to new hazards from modern materials. Demolition waste is sent to landfill rather than recycling. Retrofitting of existing buildings exposes workers to increasing roof work as they install solar panels after they became economically viable, with the risk of falls and exposure to lead and asbestos as they disturb old structures. The lack of adequate ventilation when retrofitting insulation has become an issue, as this type of work may attract construction workers who are used to outdoor work and, hence, not aware of the need for proper indoor ventilation.

Bioenergy

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As with Win-Win, storage and handling of biomass exposes workers to physical risks, to chemical and biological risks, and risks from fire and explosion: these may be mitigated by automation. Even where biomass is handled automatically, the boilers it fuels are a source of smoke and dust. With small subcontractors working under price pressures, work has intensified with a resulting increase in risks. Third-generation biofuels produced from organisms created by synthetic biology are a potential source of biological risks.

Waste management and recycling

With a high level of innovation, but a lack of attention to recyclability, the waste-handling process can be dangerous. There is some use of automation for handling waste, but only where it is cheaper, rather than for OSH considerations. The rapid rate of innovation means that new materials appear and find their way into waste before OSH can be considered. This is a throwaway society, so a high number of workers are involved in handling waste and are, therefore, potentially exposed. In an increasingly complex world driven by profit, combined exposure can be an issue. High charges for waste disposal may lead to more in-house efforts by the waste producer to deal with waste, transferring risks from professional waste operators to the waste producer: for example, business owners (including microenterprises and SMEs, as well as private individuals) using small-scale digesters, waste compactors or incinerators.

Green transport

As with Win-Win, maintenance and recharging of electric vehicles have become important hazards as they have become increasingly widespread and work has moved away from specialist suppliers and maintainers to independents. The risks arising from the growth in electric vehicles is not confined to the vehicle itself. Vehicle batteries that have reached the end of their life for vehicle service are being used to store electricity in buildings. As well as the normal fire and explosion risks associated with batteries, there is, therefore, the added complication of batteries used for energy storage that are degraded, decaying, unlabelled and of unknown provenance and design. Automation of vehicles is proving to be positive for the OSH of drivers, although there is an issue of over-reliance on the technology. The technology needs to be absolutely reliable with fail-safe modes in case of incidents.

Green manufacturing, robotics and automation

As in Win-Win, increased automation has improved OSH by removing workers from some hazardous tasks. At the same time, the growth in the use of collaborative robots has introduced other potential risks. Increasing complexity and increasing use of ICT in automated manufacturing has brought human-machine interface issues. Safety (as opposed to health) is increasingly engineered into processes, driven by the desire to avoid lost production, while employers are less interested in

longer-term health issues. Decentralised manufacturing systems such as 3D printing or other rapid manufacturing techniques can lead to new groups of workers being exposed to manufacturing hazards (e.g. harmful dusts, chemicals or laser light) yet not being adequately trained to deal with them. There may be new occupational diseases caused by exposure to new materials. Without exposure registers, diseases are difficult to trace back to jobs as no one stays on the same production line for their entire career any more.

Domestic and small-scale renewable energy

In the period before solar PV reached grid parity, the sudden withdrawal of subsidies led to panic in the rush to meet deadlines, resulting in work done in a hurry thus introducing OSH risks including work-related psychosocial risks. The use of cheaper imported products, sometimes of poorer quality or even counterfeit, has led to increased risks, especially when installation is carried out by new entrants to the sector or by householders themselves.

Batteries and energy storage

Novel battery designs continue to appear, bringing potential risks from chemicals, carcinogenic metals, dusts, fibres, nanomaterials and fire. The waste treatment of batteries raises issues around recycling, degradation and fire risk. It is challenging to determine the precise contents of any particular battery type as this information is often treated as a trade secret. Batteries used as building energy stores are a hazard as people don't recognise the risks of overcharging. Hydrogen is used as an energy carrier but it is difficult to handle and there are risks of fire and explosion and risks from its cryogenic liquid form.

Energy transmission and distribution

There are risks from power cuts as cost pressures have led to a reduction in spare generating capacity. The risks arise from sudden darkness and the loss of power, especially with moving machinery, and other safety-critical situations. The pressure to squeeze more capacity out of the system leads to novel solutions, but this reduces safety margins. Substitution of copper cabling with aluminium, again driven by cost as copper becomes increasingly expensive, has introduced an increased risk of sparking and joint failure.

Scenario Summaries

Deep Green

Low economic growth

Since 2012, there has been little economic growth within the EU and some countries are still facing sovereign debt problems. The BRICs have not returned to the former high growth rates and are currently growing at about 5 % per annum. Other developing countries are growing at a rate broadly in line with the growth of their populations.

Strongly green values

Green values have strengthened over the last decade and there is widespread and strong approval for green behaviour by corporations and individuals. This has given governments a mandate to legislate for deep and progressive cuts in carbon emissions. Reduced growth is seen as a price worth paying for a green future.

Advances in climate science have shown just how vulnerable the human race will be to climate change. There are growing public concerns about the loss of ecosystems and resource shortages.

Medium innovation in green technologies (directed toward greenness)

The concerns about a green future have driven progress on improvements in efficiency and the target of a zero-carbon future. There are continuing advances in technology, but restricted levels of capital investment mean that capital-intensive technologies have been slow to be rolled out. Commercial success depends on having appropriately green products and services. There have been significant local small-scale innovations to address green issues, many directed toward self-reliance.

Energy sciences continue to deliver improvements in efficiency and low-carbon energy, but it is clear that serious compromises will need to be made to achieve a zero-carbon future.

Medium total innovation

The priority has been to direct innovation towards achieving a green future.

Society and work

Over the last decade, the key priority has been to move towards a green future, at the expense of growth and other social objectives. As a result, there is now higher unemployment and lower corporate profits. The reduced tax base has restricted the ability of EU governments to pay for increasing welfare demands.

The greening of the economy and society has introduced many new processes and enterprises, creating new green jobs. Businesses are focused on survival and reducing costs, and workers are

concerned about joining the significant number of the unemployed.

Innovation continues to deliver improvements in efficiency and reduced carbon outputs but it is clear that serious compromises need to be made to achieve a zero-carbon future. Despite the difficulties, a green future is generally seen as worth the sacrifices.

Occupational safety and health

Overview

Low economic growth has tempted employers to cut corners, making investment in safer and healthier infrastructure more difficult. A tendency towards decentralised, more local and smaller enterprises (in particular microenterprises and self-employment) makes it more difficult to reach workplaces to disseminate good OSH practices and to control OSH conditions. With emphasis on reduced consumption of energy and physical goods, most new jobs are in the service sector. Many new small businesses, often with skills deficits, are set up to meet these needs. A make-do-and-mend approach leads to refurbishment rather than replacement, so there are risks associated with the use of old equipment. In this scenario, there are more difficult 'dirty' manual jobs (in repair, maintenance, waste sorting, etc.) than in the other scenarios with more innovation and automation. But the relatively slow roll-out of some new technologies and products gives more time to assimilate new hazards and risks. There are many new green processes and enterprises, all of which require new OSH procedures and training.

Wind energy

End-of-life issues and maintenance are the key OSH considerations. The economy requires the upkeep of older installations and there is pressure to keep systems running whatever the weather. Older wind turbines have not been upgraded with safety or ergonomic features, such as lifts, because of cost pressures: as a result, the physical risks associated with climbing and working in towers has become significant, especially as increasing numbers of older workers are unable to retire.

Green construction and building retrofitting

With relatively little new build, the main risks to workers come from exposure to new materials during refurbishment and the handling of waste from refurbishment (including asbestos), and from the retrofitting of renewable energy technologies, involving work at height and electrical connections to the grid. Retrofitting also exposes workers to dust and hazardous chemicals. The lack of adequate ventilation may be an issue, in particular as this type of work may attract unskilled workers, including 'do-it-yourself' installers, unaware of the risks.

Bioenergy

Scenario Summaries

The risks from fire and explosion and exposure to chemicals and biohazards are similar to those in the other scenarios, but the emphasis on local production and use — with many small-scale producers — creates risks that are more difficult to regulate. New players, less familiar with the risks of handling fuel (e.g. farmers producing low quantities, or companies starting to use their own waste as an energy source, for example in the textile or food industry) may be particularly at risk. There may also be problems with the quality of their products and, therefore, safety issues, as well as the impact on gas network pipelines from biogas or syngas not meeting the required gas specification.

Waste management and recycling

Overall, waste volumes are down as a result of strong green values and the economic situation, but there is still legacy waste to deal with and construction waste volumes from refurbishment are high. There is an emphasis on local handling of waste at the small-scale — meaning a potentially weaker culture of OSH and more difficulties in controlling OSH risks in a decentralised system — and there is a high manual component, with a relatively low level of automation. The quality of the waste stream has improved, but landfill mining is increasing as the costs of raw materials climb, so workers risk being exposed to safety hazards as well as unknown health hazards. Greater use of biomass in this scenario brings exposure to dust, allergens and other toxins. Reused items may compromise safety and health (e.g. steel made from recycled metals containing lead).

Green transport

As in Win-Win and Bonus World, the maintenance and charging of electric vehicles are key OSH concerns. However, driven by the need to economise and by strong green values, there has been an increase in two-wheeled vehicles for personal transport and goods as well as for service deliveries, exposing those who travel for their work to risk of injury and accidents. Many 'mobility self-entrepreneurs' have seen a job opportunity in this growing area of the transport sector. However, the self-employed tend to have less of a culture of OSH and less access to OSH services such as OSH medical surveillance, labour inspectorate services; in addition, they are generally not covered by worker protection legislation.

Green manufacturing, robotics and automation

There has been less adoption of automation than in the other scenarios, so old OSH issues may persist as manufacturers make do with ageing infrastructure and machinery. The increasing tendency to outsource maintenance services to small companies has increased risks to maintenance workers who have to deal with a wide range of equipment to extend its life. The intermittent nature of renewable energy (reliant as it is on wind and sunlight, for example) means that shift working has increased, resulting in increased

health and psychosocial issues and other risks such as accidents. Exposure to new materials in SMEs and microenterprises involved in decentralised manufacture (e.g. 3D printing) has brought potential exposure risks to more workers. Process integration means that industrial processes previously performed in different locations (e.g. manufacturing and recycling) are brought together, increasing the range of risks on a single site. This requires new skills and technical knowledge. However, there is a lack of skills as manufacturing is brought back into the EU as a result of global changes, and the loss of corporate memory and experience is exposing new workers to risks.

Domestic and small-scale renewable energy

A diversity of distribution systems and non-standard installations is resulting in electrical risks to maintenance workers. The combination of technologies (e.g. combined heat and power (CHP) and solar thermal) is adding to the complexity and, therefore, the risk. Similarly, unsophisticated, perhaps do-it-yourself, domestic installations are also potentially hazardous. Small-scale bioenergy generation gives rise to risks of fire and explosion and exposure to toxic substances. Distributed supply, especially from small clusters of houses or small businesses, is difficult to regulate. The emergency services are at risk when they attend non-standard installations. Emerging technologies generally may be responsible for long-latency effects, yet to emerge.

Batteries and energy storage

Batteries give rise to electrical risks and risks from toxic chemicals and fire. Greener batteries may be more hazardous as environmental regulations limit the range of materials allowed. Interconnected mixtures of energy storage technologies devices, especially those assembled by do-it-yourself enthusiasts, bring unexpected risks in themselves, to maintenance workers and to the emergency services. Hydrogen is used for energy storage, introducing risks of fire and explosion and risks from its cryogenic liquid form.

Energy transmission and distribution

OSH issues include the difficulty in maintaining top-down control of the grid as distributed generating sources increase. Major work to upgrade the grid has been undertaken, introducing increased live working. Life-extended systems bring more risks than new systems. Biogas distribution has brought risks of intoxication, suffocation, explosion and quality issues.