Foresight Study on the Circular Economy and its effects on Occupational Safety and Health

Phase 1: Macro-scenarios

European Agency
for Safety and Health
at Work

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Abstract

This study was carried out against the background of an EU policy shift towards more environmentally sustainable practices, with several policy initiatives driving efforts in the circular economy (CE) arena. These initiatives, and indeed the CE as a whole, are widely considered to be critical and influential developments that will be beneficial to the action against climate change and will ultimately impact on the future of work and on occupational safety and health (OSH). In response, this study aims to explore different ways in which work and jobs may be impacted by efforts towards implementing a CE, and what consequences this may have for OSH. The core element of this study, which is phase 1 of the full foresight study on the CE, was the development of four macro-scenarios focused on the CE and its potential effects on OSH in 2040. The four scenarios were generated via a key-factor-based scenario methodology drawing from an extensive literature analysis and expert interviews. For each scenario, a narrative was developed that describes the world in 2040, including how the respective development pathways came to be, and levers and turning points. Special emphasis was placed on the effects on working conditions, as well as a first look at potential implications for OSH. The four scenarios and the underlying research showed that the potential pathways for the CE in Europe and their effects on working conditions could vary widely, with a similarly wide-ranging set of first implications and opportunities for OSH and associated future policy. Notably, the study also showed that a window of opportunity currently presents itself for advancing the CE while at the same time realising OSH improvements. This is attributable to several factors, among them a recently increased focus on the interconnectedness of the social and environmental pillars of sustainability, and a growing awareness that an integrated view of efforts in those areas will clearly benefit the third pillar of sustainability, the economic sphere (a 'just transition'). Phase 2 of this foresight on the CE will focus on the dissemination and tailoring of the scenarios via stakeholder dialogue and workshops.

For the purposes of this project, the circular economy 'is based on pillars that question operating modes that are well-rooted in today's economy: sustainable supply, eco-design, industrial and territorial ecology, functional economy, sustainable consumption, extended use duration and recycling' (INRS, 'A circular economy in 2040').

For this project we have also followed the definition of a circular economy put forward by the Ellen MacArthur Foundation, a foundation devoted solely to developing and promoting the idea of a circular economy: 'a circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems'[1] (Ellen MacArthur Foundation, 'What is the circular economy?')

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[1] While definitions of the circular economy vary across publications, for this project we have used these two definitions as a starting point to map the territory of the term and concept.

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Executive summary

The European Agency for Safety and Health at Work (EU-OSHA) has for several years been applying foresight approaches as part of its mission to contribute to safer and healthier working conditions in the EU. Its foresight approach looks at changes that may take place in the future and considers what their consequences could be for occupational safety and health (OSH), with the aim of supporting policy-making and raising awareness to reduce work-related accidents and ill health. Within its new foresight cycle, work is focused on the circular economy (CE) and its effects on OSH, primarily within the European context.

This report is part of phase 1 of this project, the development of macro-scenarios, which was carried out against the background of an EU policy shift towards more environmentally sustainable practices, with several policy initiatives driving efforts in the CE arena[2]. These initiatives, and indeed the CE as a whole, are widely considered to be critical and influential developments that will be beneficial to the action against climate change and will ultimately impact on jobs and on OSH. Thus, this study aims to explore different ways in which future jobs may be impacted by efforts towards implementing a CE, and what consequences this may have for OSH in the future. This was achieved through the development of four macro-scenarios focused on the CE and its effects on OSH.

The four scenarios were generated by Future Impacts, together with the EU-OSHA project team, via a key-factor-based scenario methodology drawing from an extensive literature analysis (which included significant parts of earlier foresight work done by EU-OSHA) and expert interviews. For each scenario a narrative was developed that describes the world in 2040, including how the development pathways came to be, and levers and turning points. Special emphasis was placed on the effects on working conditions, as well as a first review of potential implications for OSH. The scenarios were supplemented with visuals and an illustrative vignette depicting daily life in 2040 to aid communication. They illustrate four distinct alternative future pathways in the CE and their implications for OSH, considering risks as well as opportunities.

The four scenarios on the circular economy in 2040

Scenario 1: The Roaring 40s — fully circular and inclusive

Working conditions across all sectors are significantly better than they were two decades ago, pollution has been reduced to a minimum, businesses find that keeping a small footprint is good for the balance sheet, and public trust in policy-makers and national and European leaders is greater than ever. Implementing serious sustainability and realising the principles of 'reduce, reuse, recycle' across all sectors takes a lot of collaborative fine-tuning, as does keeping workers safe and secure in a multifaceted labour environment with myriad platforms and forms of employment. But one key difference compared with the situation in 2020 is a palpable sense of optimism: with so many challenges successfully met, the future cannot be anything other than bright.

Key message: 'The Roaring 40s' is a best-of-all-worlds scenario — not only do policy-makers and stakeholders (having realised the gravity of the situation) make bold decisions to achieve real, far-reaching sustainability, but worker safety and health is also a key concern and is fully realised. This scenario demonstrates that one does not have to come at the expense of the other, and that both can be achieved in a competitive economy. But, even in this positive situation, OSH will always come up against new challenges, and constant improvement remains necessary.

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[2] The key related policy initiative is the European Green Deal initiative, which has the overarching aim of making Europe climate neutral by 2050 (see https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en). Alongside the Green Deal initiative sits the Commission's 2015 CE package, comprising - an EU action plan for the CE ('Closing the Loop') with 54 concrete actions to achieve a CE, many with significant policy and regulatory implications for the EU's waste and recycling sector (see https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52015DC0614).

Scenario 2: Carbon neutrality — of a hazardous kind

In the early 2020s, a warming climate, extreme weather events and habitat loss took centre stage in the public mind. Eco-consciousness reigned, leading to a surge in environmental regulation and environmentally friendly industry practices. However, with the bulk of funding spent on renewable energy infrastructure and CE initiatives, social concerns fell by the wayside. Social infrastructures and services, social rights, inclusion and job quality have declined for many.

Key message: 'Carbon neutrality' is a 'mixed bag' scenario — it demonstrates that, given the right incentives, Europe would be able to kick its addiction to fossil fuels in an incredibly short time span and become a world leader in green technologies, but also that this speed would come at a cost for workers. Unless measures are taken to secure a 'just transition', during which workers receive all the (organisational) support and develop all the skills necessary to work new jobs safely, accidents and work-related diseases will increase, even with the use of new, safer technologies. In addition, regional challenges will vary much more widely in a localised economy: areas that sourced much of their employment from fossil fuel energy generation would find themselves faced with rapidly growing unemployment and an exodus of workers with outdated skills, while the OSH-relevant knowledge necessary for the safe dismantling of old energy infrastructures may be lacking. If OSH must take a back seat to a speedy transition to carbon neutrality, the human cost could be considerable, and stakeholders are challenged to not let this happen.

Scenario 3: Staying afloat — amid economic and environmental crises

Recessions, cuts in public spending, environmental crises and rising unemployment: headlines in 2040 make for grim reading. In the business community, it is everyone for themselves; competitiveness and profits are all that count. New technologies, rationalisation and digitalisation have created an ever-growing pool of workers who lack the qualifications, as well as the supporting working conditions, that are necessary to make it in this new, cut-throat economy. Platform work brings rewards to only a few, and, even in the sectors where it is booming, the 'Russian doll effect' of sub-contracts within sub-contracts means that workers never see their fair share. The CE remains a distant dream, and the transition everyone went through was neither green nor just.

Key message: in 'Staying afloat', the millennium's second decade never delivered on its promises. Policy-makers and stakeholders never dared to make the 'big jump' and failed to grasp the opportunity offered by public support for a green transition and the shake-up provided by the COVID-19 pandemic. Now, economic success often comes at the expense of both worker safety and health and the environment, putting OSH institutions and other actors in the OSH field (policy-makers, etc.) under enormous pressure to improve the situation workers find themselves in, and are less and less able to address core issues comprehensively.

Scenario 4: Regional circularities — with European divides

For both policy-makers and the public, a safe, growing economy was the overriding concern of recent decades. The environment fell by the wayside, but not everywhere. Richer European regions could afford to outsource disposal of waste and pollution to other world regions or poorer EU Member States, and now boast some sort of localised CEs, but the loops are never fully closed — problems are simply offshored. Social inclusion was also neglected. With good jobs available to only a minority of well-trained, highly skilled individuals, a growing number of workers are driven towards the informal economy and to unregulated, underpaid and increasingly precarious employment.

Key message: 'Regional circularities' emphasises the dangers inherent in regional and social disparities. Not only is responsibility for disposal of waste and polluting practices shifted from the rich to the poorer regions, but the working population is also divided between those who enjoy safe working conditions and good social protection and others who must make do with very little in both respects. In this environment, realising high OSH standards for everyone will be challenging and require broad political coalitions, forcing OSH institutions to reach out and encourage other stakeholders to increase pressure on decision-makers.

Key messages across the four scenarios and the underlying research

The four scenarios showed that the potential pathways for CE in Europe and their effects on working conditions could vary widely, with a similarly wide-ranging set of first implications for OSH and possible future policy areas. These may include increased risks from repeated recycling processes and opportunities around a socio-ecological transformation approach that includes the integration of OSH considerations from the very first stages of product development and design[3]. From the scenarios and the underlying research, a number of cross-cutting and overarching key messages were identified:

- As yet, there is no widely shared or common definition and understanding of what a CE is. This contributes to a certain 'fuzziness' around existing assumptions and expectations of potential future developments regarding CE and opens the door to the term and its concepts being used for the purpose of greenwashing.
- Any reflection on CE perspectives in Europe will need to take into account global repercussions as well as value and production chain effects. A paradigm shift towards CE principles could be implemented sensibly and ethically, but only if the approach integrates global production chains and elements over the whole life cycle of any product and material.
- The European waste sector will need to play a pivotal role in the development of any future CE. The integration of new technologies while meeting new challenges will be a complex undertaking, but the reskilling offensive necessary offers opportunities to considerably improve OSH practices and outcomes for workers — if OSH considerations are made an inherent part of this process from the beginning.
- Digitalisation is a key enabler and accelerator for the CE. A high standard of OSH in a CE will be achieved only if digitalisation processes, such as building a universal information ecosystem (a safe data space that minimises manipulation risks) or creating a monitoring system to prevent illegal imports of products that may be hazardous during recycling, are well managed. Accordingly, OSH measures will need to keep pace with these rapid digital changes.
- A fundamental shift towards a CE seems possible only if driven by robust regulatory efforts and policy mechanisms. Circularity can be achieved only if life-cycle responsibility rests with the manufacturer, and measures are taken to internalise external costs of any material and product life cycle.
- Any fundamental shift towards a CE would probably have to involve the far-reaching reorganisation of the value chain and the emergence of new actors. This would probably lead to second- and third-order effects on infrastructure to accommodate new feedback loops and more collaborative material streams.
- Large-scale implementation of a CE would — based on the principle of a 'just transition' — come with a significant opportunity to advance OSH conditions, but could also lead to the emergence of new risks and undesired side effects (especially around repeated recycling). From another perspective, emerging risks also have the potential to be used as growth opportunities — but only if there are clear cost incentives and suitable markets.
- The range of progress in the CE and the integration of OSH measures could differ widely between regions, EU Member States and sectors, and the risks as well as opportunities for OSH could similarly vary widely. Making sure that there is sufficient support for all regions, sectors and countries, especially those with comparatively fewer resources, will be a major factor in ensuring that OSH is advanced alongside any kind of progress towards a CE.
- A window of opportunity currently presents itself for advancing the CE with a view to OSH improvements being realised in synergy. There are several reasons for this, among them a recently increased focus on the interconnectedness of the social and environmental pillars of sustainability, and a growing awareness that an integrated view of efforts in those areas will clearly benefit the third pillar of sustainability, the economic sphere (a 'just transition'). Ensuring that OSH perspectives and solutions are included or even pushed within the context of these transformation efforts could be a lever to bring about fundamental progress along the lines of both the CE and OSH goals.

Lastly, it should be noted that work on the scenarios will continue in phase 2 of this project, which centres on the dissemination and tailoring of the scenarios via stakeholder dialogue and workshops. Thus, it

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[3] The key messages from the project are covered in more detail in section 7: Conclusions and outlook.

needs to be stressed that these scenarios are not to be interpreted as any type of prediction on what the future may or may not hold. They are instead designed to encourage dialogue and reflection with stakeholders around future possibilities, and identify drivers and barriers as well as cross-cutting implications for OSH, with the aim of informing today's decision-making, enabling a more future-oriented policy and making tomorrow's work healthier and safer.

1   Introduction

This report presents the results of phase 1 of the European Agency for Safety and Health at Work's (EU-OSHA's) foresight study on the circular economy (CE) and its effects on occupational safety and health (OSH) up to 2040. At the methodological level, this report begins by outlining the project context and background; it presents the project aims and provides more information on the overall project concept and approach. When describing the project results, the report details the analysis undertaken for the literature review and expert consultation, before putting forward a set of key messages from the translated synthesis report produced from the 2019 report 'Économie circulaire en 2040' by the French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases (INRS) (2019a), to which this project owes gratitude. In the subsequent section, the project's selected key factors that formed the basis of the scenario construction are presented (including short descriptions and expected developments). The four scenarios are then laid out for the reader to reflect on, along with illustration visuals and a first look at the implications for OSH in each scenario. The report also presents 'spotlights' on digitalisation (a key enabler and accelerator of a shift to a CE) and the waste sector (given its critical role in any potential future CE). In the final section of this report, concluding reflections and key messages are presented, as well as a look towards the next steps in the overall project, including options for stakeholder engagement for phase 2, which centres on the dissemination and tailoring of the scenarios via stakeholder dialogue and workshops.

1.1   Project context and background

EU-OSHA has for several years been applying foresight approaches as part of its mission to contribute to safer and healthier working conditions in the EU by developing, analysing and disseminating OSH information. Its foresight approach looks at changes that may take place in the future and considers what their consequences could be for OSH, with the aim of supporting policy-making and raising awareness to reduce work-related accidents and ill health. Within its new foresight cycle, work will focus on the CE and its effects on OSH, primarily within the European context. Future Impacts realised phase 1, the development of macro-scenarios, for and in conjunction with EU-OSHA.

While definitions of the CE vary across publications, this study interprets the CE as 'based on pillars that question operating modes that are well rooted in today's economy: sustainable supply, eco-design, industrial and territorial ecology, functional economy, sustainable consumption, extended use duration and recycling' (INRS, 2019b). It further assumes that the CE 'is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems' (Ellen MacArthur Foundation, 2017a).

Against the background of an EU policy shift towards more environmentally sustainable practices, several policy initiatives are driving efforts in the CE arena. The key related policy initiative is the European Commission's European Green Deal initiative, which has the overarching aim of making Europe climate neutral by 2050[4]. Alongside the Green Deal initiative sits the Commission's 2015 circular economy package, including an EU action plan for the circular economy ('Closing the Loop') with 54 concrete actions to achieve a CE, many with significant policy and regulatory implications for the EU's waste and recycling sector (European Commission, 2015).

These initiatives, and indeed the CE as a whole, are widely considered to be critical and influential developments that will be beneficial to the action against climate change and ultimately impact on jobs and OSH. While seen by some as an opportunity to create good-quality jobs (see, for example, WHO, 2018), others point to the rise in hazardous working conditions in the areas of maintenance and repair, disassembly and recycling (see, for example, EPSU, 2017, 2020). However, it is widely agreed that future jobs will be changed and reshaped as a consequence of adapted processes and the use of different (reused) materials, with impacts felt across almost all industries — from transport to the care sector.

Thus, this study aims to explore the different ways in which working conditions, work and jobs may be impacted by efforts towards implementing a CE, and what consequences this may have for OSH in the future. This was achieved through the development of macro-scenarios focused on the CE and its effects on OSH. These were generated by Future Impacts, together with the EU-OSHA project team,

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[4] For further information, including the Green Deal Action Plan, see European Commission (2019a).

via a key-factor-based scenario methodology drawing from literature analysis ands well as expert interviews.

1.2 Project aims, concept and approach

Phase 1 of this project aimed to develop macro-scenarios centred around possible developments in the CE up to 2040 to highlight potential implications for OSH in the EU context. The initial basis for the study was a review of existing future-oriented knowledge and insights on the topic, using existing knowledge (from work by EU-OSHA as well as other sources) as much as possible. The underlying aim of the project is to support policy-makers at European and national level in the development of strategies, regulation, enforcement, guidance and support measures. An additional objective of highlighting knowledge gaps in the current discourse and literature to identify priorities for further research was pursued.

The project also aimed to capitalise as much as possible on existing work by EU-OSHA and other sources. These elements included:

To meet these aims, and in particular to provide value for and facilitate phase 2 (dissemination and tailoring of phase 1 scenarios via stakeholder dialogue and workshops), four factors were regarded as critical, and the project methodology was conceptualised accordingly. These factors were:

1. a tailoring of the approach and outputs to the specific context and aims of EU-OSHA, with a focus on OSH-specific implications and taking into account its learnings from previous foresight projects;
2. a smart strategy to identify existing research, resources and initiatives on the topic, and to analyse them;
3. an attractive and adaptable form of outputs that lends itself to the activities of phase 2;
4. the inclusion of a variety of different perspectives, aimed in particular at identifying blind spots and acting as a sounding board, in addition to the use of existing research.

The approach used paid tribute to these factors and followed several steps to arrive at the expected outcomes, which was achieved in close coordination with the team on EU-OSHA's side. The detailed step-by-step methodology is described in section 2 of this report; we highlight below only the principle of the key-factor-based scenario approach followed in this study.

The key-factor-based scenario approach employed in this study incorporated the following steps:

- **Information around trends, megatrends and drivers of change were captured as 'key factors'**[5], i.e. the main issues that play a role in the scenario topic, in this case the future of the CE in the EU up to 2040 and its effect on OSH.
  - Key factors are clearly defined, their past development up to the present day is captured and described (with references given), and the impact on/relevance for the scenario issue (here, the CE and OSH) is outlined.
  - The possible future developments for each key factor are described systematically as 'future projections', always lining out alternatives for the future development in the field[6]. This step serves to uncover blind spots in existing research.
- **The different projections are combined into scenarios, the most consistent (or plausible and 'robust') of which are selected.**
  - The consistency of the combinations of projections are evaluated individually, here with the help of a scenario software tool.

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[5] The final naming of the different kinds of information used will be agreed with EU-OSHA and can be adapted to the needs of their context to ensure compatibility with previous work. Here, we follow the established terminology from the key-factor approach for ease of reading, but in fact refer to all kinds of information with these broader terms 'key factors' and 'projections' (e.g. encompassing information on trends, megatrends, drivers of change).

[6] If only one kind of future development is imaginable, only one projection can be covered, and the relevant factor would be categorised as a 'given'. However, this is increasingly rare in view of recent experience and awareness of uncertainty and disruption related to the Covid-19 pandemic.

- o This enables the selection of particularly plausible, highly consistent scenarios from the variety of possible projection combinations and makes it possible to systematically evaluate the consistency of different assumptions (here, from the different studies used as a basis).
- **The selected scenarios are then developed further into appealing and believable narratives that outline different CE futures in 2040, including their pathways and the potential implications for OSH**.

2 Methodology

The following section outlines the overall methodology. The central foresight methodology this project followed was the scenario methodology, specifically the key-factor-based scenario methodology. We provide an overview of this approach in the text below. For definitions of key concepts and terms, please refer to the glossary in section 8.1.

2.1 Overview of the methodology

The key-factor-based scenario methodology uses key factors to capture the main developments and changes in the field in question, in this case the future of the CE and its potential effects on OSH. This approach was selected principally on account of its ability to integrate existing insights from a variety of sources, e.g. information on trends and drivers, and relevant megatrends.

The identification of key factors (as well as later steps in the scenario development) was drawn from two pillars of insights: (1) secondary research via a literature review and (2) feedback and insights via expert interviews.

The literature review was built upon three central pillars. First, a longlist of studies on the topic of the CE, OSH and the future of work was drawn up. Studies were selected if they were future focused and if they covered current and proposed initiatives in EU Member States; sources from a range of organisations; and/or insights from across the STEEP fields (i.e. information on changes, trends and drivers, etc., in the spheres of society, technology, the environment, the economy and politics). For the in-depth review, a shortlist of studies was selected according to the criteria above to ensure a balanced spread across the types and topics of resources available. Second, previously published EU-OSHA foresight resources (and other relevant EU-OSHA resources) were reviewed with the objective of incorporating and building upon their existing findings. In the third and final step, key sections from the report 'Économie circulaire en 2040' (INRS, 2019a) were translated into English (from the original French) and key insights relevant to this project were identified and incorporated into the findings of the literature review (see section 2.2 for further details of the literature review, including lists of sources).

Experts were also identified systematically, again working with a longlist and narrowing it down to a shortlist, using a set of criteria that included coverage of a range of different professional backgrounds, aiming to achieve as much gender balance as feasible, as well as respecting tripartism and including a variety of perspectives from different EU Member States. The expert interviews followed a semi-structured approach, i.e. interviewees were asked a set of guiding questions but some flexibility was allowed for during the interviews. Each interview was written up and shared with the project results (see section 8.3 for the anonymised interview summaries).

Based on the results of the literature review and the first round of expert interviews, a list of key factors was established. These key factors were identified as being both highly relevant for the future of the CE and having an impact on the related traditional and emerging OSH risks (the key factors and their descriptions are provided in section 4). In a subsequent step, projections (i.e. alternative pathways of potential future developments in the field of the key factor) were developed for each key factor, based on the understanding of selected initial conditions and drivers (identified in the literature review and interviews), and mapped against a number of dimensions (e.g. rapid vs. slow adaptation, improving vs. deteriorating conditions) (for further insight into the scenario development, see section 2.4). With the support of a scenario software tool, plausible combinations of different projections were then identified and combined to form the basis of the scenarios. This enabled a systematic (as opposed to an intuitive) identification of plausible future scenarios and helped to ensure that the scenarios created using this approach can be easily updated in later years, increasing their 'usability' in processes that build upon them.

Following the development of the projections, a robustness and consistency analysis was undertaken using the artificial intelligence-powered software ScenLab. The aim was to identify the 'best' macro-scenarios from all the possible future development paths imaginable (which would be too large a group of scenarios to deliver helpful results). The analysis bundled future projections from the set of key factors into potential scenarios and evaluated them for their robustness, consistency and plausibility. A robust

scenario is both plausible ('it is rather well imaginable that this could occur in this way') and consistent ('it makes sense to group developments in this way'). The results of the analysis led to the selection of four highly robust, plausible and consistent raw scenarios[7]. A second round of expert interviews was then conducted to validate the draft scenarios and identify any additional insights or blind spots.

Once the selection of the raw scenarios had been confirmed, the identified scenario candidates were developed into four draft scenario narratives. These draft scenarios formed the first descriptions of the scenarios, developed from the underlying information (i.e. the key factor's projections featured in them). These draft scenarios were then presented to the EU-OSHA OSH Knowledge Advisory Group, and feedback was received and integrated into the development of the final scenario narratives.
The final scenario narratives include full storylines, describing the scenarios, how each development pathway came to be, the levers and turning points, and the implications for OSH. Each scenario was supplemented with visuals and an illustrative vignette to aid communication.
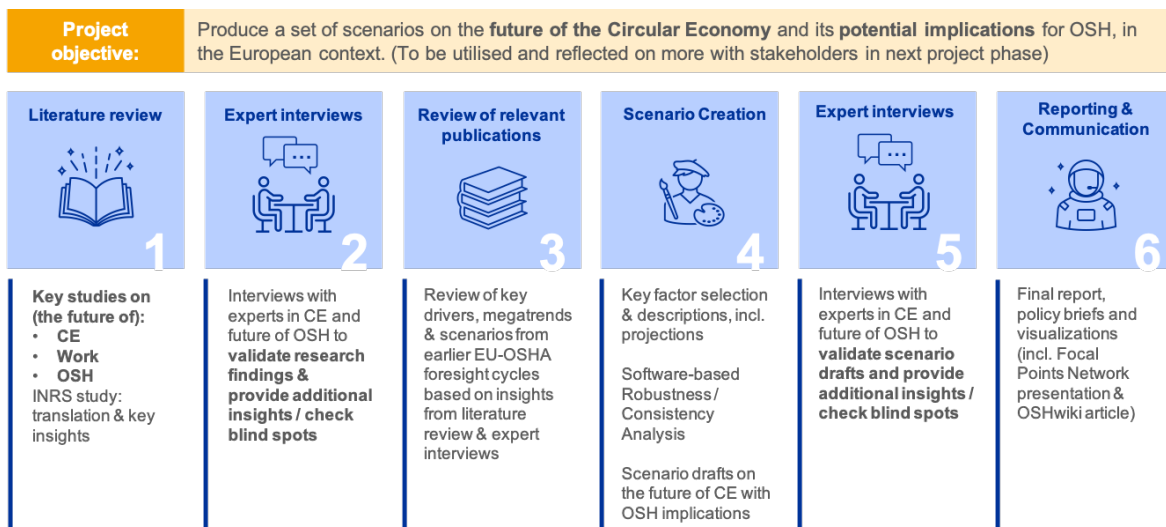
Overall project approach

2.2 Literature review

2.2.1 Approach to selecting literature for review

This section presents the approach to selecting literature for review (the lists of literature selected are presented in the following sections). An initial longlist of circa 100 studies on the topics of the CE, OSH and the future of work was compiled as the first step, based on the following selection criteria:

- Future-focused foresight literature (looking ahead 10-30+ years) centred primarily on the future of the CE and/or on the future of work (more specifically, identifying traditional and emerging OSH risks related to the CE), published since 2015, and ideally from all or most EU Member States, where such literature exists.
- Current and proposed initiatives in EU Member States pertaining to the CE and OSH.
- Data drawn from a range of organisations, with priority given to official reports from EU Member States and multinational agencies (e.g. UN, World Bank). Where necessary, research was supplemented from a wide (global) research base, e.g. to note relevant interesting developments in the CE and OSH occurring outside the EU.
- Numerical data sources, including extrapolated data and forecasts, where possible.
- Coverage of all STEEP fields (i.e. changes in the social, technological, economic, environmental and political spheres), with a special view to potential policy pathways.

From this initial longlist, a shortlist of circa 25 studies was selected for in-depth review (see section 2.2.2). The list was narrowed down using a ranking-based process taking into account the criteria above and by ensuring a balanced spread across the types and topics of resources available. The shortlisted studies were grouped according to the following categories: (1) drawing context from five key studies on the future of work; (2) visions of a CE (primarily from Europe); and (3) studies on future OSH risk factors.

An additional list of studies that provided a national or regional focus was also generated to provide region-specific insights that can be integrated into phase 2 of this study to supplement the research findings with short case studies (see section 2.2.3).

In parallel, a third and final literature list was created that incorporated past relevant publications from EU-OSHA in order to carry over learnings from previous foresight projects into this research. The existing foresight resources by EU-OSHA were reviewed with the objective of incorporating and building on existing findings (see section 2.2.4 for the list of EU-OSHA publications included for review). Thus, the key drivers of change, megatrends and scenarios developed in earlier foresight cycles by EU-OSHA were used as one strand of foresight insights and were then integrated with the findings from the studies included in the literature analysis on CE/OSH topics.

In the final step, key sections from the report 'Économie circulaire en 2040' (INRS, 2019a) were translated into English (from the original French) to form a synthesis report, and key insights relevant to this project were identified and incorporated into the findings of the literature review (see section 2.2.5).

Thus, the literature review was built upon three central strands: (1) a list of studies on the CE, the future of work and future OSH risk factors, (2) the incorporation of the insights from the translated synthesis report and (3) publications from earlier foresight cycles by EU-OSHA.

Literature review	Key insights from INRS study	Review of relevant EU-OSHA publications
1	**2**	**3**
Key studies on (the future of): • CE • Work • OSH	**INRS 2019 study 'A Circular Economy in 2040':** Translation of key sections and identification of key insights	Review of key drivers, megatrends & scenarios from earlier EU-OSHA foresight cycles based on insights from literature review & expert interviews

Literature review

The three central strands of the literature review

2.2.2 List of reviewed literature on the future of OSH, work and the circular economy

The list is structured by project category and is in alphabetical order within each category.

No.	Study organisation/author	Study name	Reference
Five key studies on the future of work			
1	European Commission	The changing nature of work and skills in the digital age	JRC, 2019
2	International Labour Organisation (ILO)	The future of work: a literature review	ILO, 2018a
3	International Labour Organisation (ILO)/Global Commission on the Future of Work	Work for a brighter future	ILO, 2019a
4	Jerome C. Glenn et al., The Millennium Project	Work/technology 2050. Scenarios and actions	Glenn, 2020
5	RSA (Royal Society for Arts, Manufactures and Commerce — Action and Research Centre)	The four futures of work: coping with uncertainty in an age of radical technologies	RSA, 2019
CE visions			
6	Club of Rome	The circular economy and benefits for society	Club of Rome, 2015
7	Ellen MacArthur Foundation	Achieving 'growth within'	Ellen MacArthur Foundation, 2017b
8	Ellen MacArthur Foundation	Growth within: a circular economy vision for a competitive Europe	Ellen MacArthur Foundation, 2015a
9	European Commission	Circular Economy Action Plan	European Commission, 2020a
10	European Committee of the Regions	The local and regional dimension in the New Circular Economy Action Plan	European Committee of the Regions, 2020
11	European Federation of Public Service Unions (EPSU)	Waste management in Europe. Good jobs in the circular economy?	EPSU, 2017
12	ESPON EGTC (European Grouping on Territorial Cooperation)	SHARING — Stocktaking and assessment of typologies of urban circular collaborative economy initiatives	EPSON EGTC, 2020
13	International Labour Organisation (ILO)	World Employment and Social Outlook 2018: Greening with jobs	ILO, 2018b
14	Material Economics	The circular economy and Covid-19 recovery	Material Economics, 2020
15	Organisation for Economic Co-operation and Development (OECD)	Business models for the circular economy: opportunities and challenges for policy	OECD, 2019a
16	Valenzuela, F. and Böhm, S.	Against wasted politics: a critique of the circular economy	Valenzuela and Böhm, 2017
17	World Economic Forum (WEF)	Global lighthouse network: four durable shifts for a great reset in manufacturing	WEF, 2020a
Future of OSH			
18	Christie, N. and Ward, H.	The health and safety risks for people who drive for work in the gig economy	Christie and Ward, 2019
19	European Commission	Impacts of circular economy policies on the labour market	European Commission, 2018
20	European Federation of Public Service Unions (EPSU)	Safe jobs in the circular economy	EPSU, 2020
21	European Trade Union Institute (ETUI)	Occupational safety and health in 2040: four scenarios. How will the next generation in Europe deal with occupational safety and health issues?	ETUI, 2017
22	International Labour Organisation (ILO)	Safety and health at the heart of the Future of Work: building on 100 years of experience	ILO, 2019b
23	Organisation for Economic Co-operation and Development (OECD) Environment Directorate	Labour market consequences of a transition to a circular economy: a review paper — Environment Working Paper N°162	OECD, 2020a

	Future of OSH		
24	Samant, Y.	Summary report workshop on digitalization. Future of work and occupational safety and health: from a Nordic approach towards a global coalition. Working on Safety meeting, Vienna	Samant et al., 2019
25	WHO Regional Office for Europe	Circular economy and health: opportunities and risks	WHO, 2018

2.2.3 List of reviewed region-specific literature on the circular economy

The list is presented in alphabetical order.

No.	Study organisation	Study name	Reference
CE regional/national literature			
1	Circle Economy	Circular jobs: understanding employment in the circular economy in the Netherlands	Circle Economy, 2020a
2	Circle Economy	The future of work: baseline employment analysis and skills pathways for the circular economy in Scotland	Circle Economy, 2020b
3	Circle Economy; FABRIC; TNO; Municipality of Amsterdam	Circular Amsterdam: a vision and action agenda for the city and metropolitan area	Circle Economy et al., 2015
4	Dutch Ministry of Infrastructure and Dutch Ministry of Economic Affairs	A circular economy in the Netherlands by 2050	Dutch Ministry of Infrastructure, 2016
5	Ellen MacArthur Foundation	Potential for Denmark as a circular economy. A case study from: delivering the circular economy — a toolkit for policy makers	Ellen MacArthur Foundation, 2015b
6	Finnish Innovation Fund Sitra	Leading the cycle — Finnish road map to a circular economy 2016-2025	SITRA, 2016
7	Green Alliance/WRAP	Opportunities to tackle Britain's labour market challenges through growth in the circular economy	Green Alliance and WRAP, 2015
8	Ministry of Environment and Spatial Planning, Republic of Slovenia and Circular Change Platform	Roadmap towards the circular economy in Slovenia	Ministry of Environment and Spatial Planning, 2018
9	National Academy of Science and Engineering (acatech)	Pathways towards a German circular economy. Lessons from European strategies preliminary study	National Academy of Science and Engineering, 2019
10	Scottish Government, Environment and Forestry Directorate	Making things last: a circular economy strategy for Scotland	Scottish Government, 2016
11	DAKOFA (Waste and Resource Network Denmark)	Circular economy — Denmark as a circular economy solution hub	DAKOFA, 2016

2.2.4 List of integrated EU-OSHA literature

The list is ordered by publication year.

No.	Study organisation	Study name	Reference
1	EU-OSHA	Impact of artificial intelligence on occupational health and safety	EU-OSHA, 2021
2	EU-OSHA	Review of the future of agriculture and occupational safety and health (OSH): foresight on new and emerging risks in OSH	EU-OSHA, 2020a
3	EU-OSHA	Occupational exoskeletons: wearable robotic devices and preventing work-related musculoskeletal disorders in the workplace of the future	EU-OSHA, 2020b
4	EU-OSHA	Smart personal protective equipment: intelligent protection for the future	EU-OSHA, 2020c
5	EU-OSHA	Supply chains and their present and future implications for occupational safety and health	EU-OSHA, 2020d
6	EU-OSHA	The impact of using exoskeletons on occupational safety and health	EU-OSHA, 2019a
7	EU-OSHA	The fourth industrial revolution and social innovation in the workplace	EU-OSHA, 2019b
8	EU-OSHA	OSH and the future of work: benefits and risks of artificial intelligence tools in workplaces	EU-OSHA, 2019c
9	EU-OSHA	The future role of big data and machine learning in health and safety inspection efficiency	EU-OSHA, 2019d
10	EU-OSHA	Exposure to biological agents and related health effects in the waste management and wastewater treatment sectors	EU-OSHA, 2019e
11	EU-OSHA	The future of the (e-)retail sector from an occupational safety and health point of view	EU-OSHA, 2018b
12	EU-OSHA	Foresight on new and emerging occupational safety and health risks associated with digitalisation by 2025	EU-OSHA, 2018a
13	EU-OSHA	Managing performance-enhancing drugs in the workplace: an OSH perspective	EU-OSHA, 2018c
14	EU-OSHA	Monitoring technology in the workplace	EU-OSHA, 2017a
15	EU-OSHA	Protecting workers in the online platform economy: an overview of regulatory and policy developments in the EU	EU-OSHA, 2017b
16	EU-OSHA	3D printing and additive manufacturing — the implications for OSH	EU-OSHA, 2017c
17	EU-OSHA	The ageing workforce: implications for occupational safety and health. A research review	EU-OSHA, 2016
18	EU-OSHA	A review on the future of work: online labour exchanges, or 'crowdsourcing' — implications for occupational safety and health	EU-OSHA, 2015a
19	EU-OSHA	A review on the future of work: robotics	EU-OSHA, 2015b
20	EU-OSHA	A review on the future of work: performance-enhancing drugs	EU-OSHA, 2015c
21	EU-OSHA	E-Fact 80: Hazard Identification Checklist. Occupational health and safety (OSH) risks in the wind energy sector	EU-OSHA, 2014a
22	EU-OSHA	E-Fact 79: Occupational safety and health in the wind energy sector	EU-OSHA, 2014b
23	EU-OSHA	Green jobs and occupational safety and health: foresight on new and emerging risks associated with new technologies by 2020	EU-OSHA, 2013a
24	EU-OSHA	Nanotechnology — early lessons from early warnings (*Late lessons II*, Chapter 22)	EU-OSHA, 2013b
25	EU-OSHA	Occupational safety and health in the wind energy sector	EU-OSHA, 2013b
26	EU-OSHA	Expert forecast on emerging biological risks related to occupational safety and health	EU-OSHA, 2007

2.2.5 Translation and extraction of insights from INRS report

As part of this project, key sections from the report 'Économie circulaire en 2040' (INRS, 2019a) were selected with the assistance of Cécile Désaunay of Futuribles[8] and translated into English (from the original French), and key insights relevant to this project were identified and summarised in order to integrate them into this project. While the full INRS report is yet to be translated into English, a series of summary reports and articles on the original report have been published in the English language (see INRS, 2019b; Malenfer et al., 2019; Héry and Malenfer, 2020[9]). To unite and extend upon this previous collection of reports and articles, the expertise of one of the original report contributors was sought, alongside the skills of a translator, and key sections were translated to form the synthesis report.

2.2.6 Identification of key factors

In order to methodically identify all themes (i.e. key issues, trends, drivers, megatrends and key factors, etc.) discussed within the body of reviewed studies, an analytical matrix and mapping approach was developed to systematically map the key issues as described in existing research. Within the matrix, the issues from each study were identified and categorised in a STEEP structure, with an added category for CE-specific themes[10]. In a follow-up step, a cross-check was conducted to determine whether issues identified in one study were also covered in the other studies (even if less prominently). This resulted in an overview of the common themes across the studies, with a total of 48 separate themes identified (see the meta-analysis matrix below).

This step of the meta-analysis revealed a broad range of issues relevant for the future of the CE and future working conditions/job quality; topics such as digitalisation and automation, climate change effects, developments towards economic greening, and trends towards waste prevention and increased recycling were covered by a large proportion of the studies. At the same time, while the analysis showed that a range of factors from across the STEEP sectors can be identified as relevant to the future of the CE and the effects on OSH, some issues with less relevance, or not specifically related, to the CE were also taken into account in the next steps. These included aspects such as migration flows and an increase in informal work; implications for mental health from increasing monitoring in OSH measures due to technological development; and possible paradigm shifts in education towards widespread lifelong learning in supported and distributed forms[11].

From these themes, a draft list of key factors with strong influence on the future of the CE and future working conditions/job quality was developed, incorporating the insights from the translated synthesis report[12]. These key factors were then refined through the first expert interview process and a range of projections for each key factor was developed, which were then used to construct a range of potential scenarios (for further details on how the key factors were applied to form the basis of the scenarios, refer to section 2.4; for the final list of key factors and projections, see section 4).

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[8] Cécile Désaunay from Futuribles was a member of the original project group for the INRS 'A circular economy in 2040' study and was thus a valuable contributor to this step.

[9] Note, both Michel Héry and Marc Malenfer of INRS were also interviewed for this project (see section 2.3).

[10] More specialised technologies or innovations, such as the development of individual technologies aimed at improving recycling or workplace processes, are not explored within the meta-analysis owing to their specificity, but will feature in later project stages (i.e. in the development of the scenario narratives).

[11] Technology-supported learning refers to learning environments where technology is integrated to support learners and teachers, and distributed learning refers to models that allow teachers and students to be in different, non-centralised locations. These can be regarded as a lever to enable rapid diffusion of (also OSH-related) knowledge and skills development when new technologies enter the workplace at a rapid pace.

[12] The process here was less one of selection, and more one of clustering and re-categorisation, with themes being attributed to the fields of the key factors or identified as areas to be covered in the scenario descriptions.

Study Title	Organisation / Author	Region (Global or Europe)	Theme	Time Horizon	Social								Technology											Environmental				Economy											Circular Economy					Politics								
					Mobility / Migration	Demographic Change	Lifelong Learning	Inequality	Work-Life Balance	Individualisation	Shift to Self-Actualisation	Urbanisation	Digitalisation / Digitisation	Automation	Artificial Intelligence (AI)	Big Data	Robotics	Internet of Things (IoT)	Nanotechnology	Human Enhancement	Biotechnology	3D-Printing	Blockchain	Climate Change	Pollution	Environmental Degradation	Resource Depletion	Up- & Re-skilling	New Forms of Work	Shift to Service-Centred Jobs	Job Polarisation	Economic Greening	Greenwashing	Globalisation	Job Insecurity / Job Churn	Re-Shoring	Consumer Empowerment	Closing Gender Gap	Waste Prevention	Lifecycle Tracking	Leasing & Sharing Society	Recycling	Net Job Gains	Regulation	Digital Participation	New Tax Regime	Focus on Education	Push for Gender Equality	Spending on Public Infrastructure	Ethical Government	Anti-Globalisation Movements	Establishment of UBI-Programmes
The Future of Work: A Literature Review	International Labour Organization (ILO)	Global	Future of Work	[not given]	1	1		1	1				1	1	1		1					1	1	1				1	1		1	1		1	1	1		1							1							1	1	1
The Changing Nature of Work and Skills in the Digital Age	European Commission	Global	Future of Work	[not given]	1	1	1	1					1	1	1	1											1	1	1	1															1		1				
Work for a Brighter Future	ILO / Global Commission on the Future of Work	Global	Future of Work	[not given]		1	1						1	1	1		1											1					1								1			1	1	1	
The Four Futures of Work: Coping with uncertainty in an age of radical technologies	RSA (The Royal Society for Arts, Manufactures and Commerce, Action and Research Centre)	Europe / UK	Future of Work	[not given]			1						1	1	1	1	1	1									1						1	1						1					1	
Work / Technology 2050. Scenarios and Actions	Jerome C. Glenn et al; The Millennium Project	Global	Future of Work	2050	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Circular Economy Action Plan	European Commission	Europe	CE Visions	2030 [2050]									1												1	1	1	1		1		1				1		1	1	1	1				1	
The Circular Economy and Covid-19 Recovery	Material Economics	Europe	CE Visions	2030 [2050]									1	1	1					1		1	1	1	1				1							1	1	1	1				1	
The Local and Regional Dimension in the New Circular Economy Action Plan	European Committee of the Regions	Europe	CE Visions	2030															1		1											1		1	1	1			1	
Waste Management in Europe. Good Jobs in the Circular Economy?	European Federation of Public Service Unions (EPSU)	Europe	CE Visions	[2030]							1			1									1							1			1	1	1	1	1			1
Growth Within: A Circular Economy Vision for a Competitive Europe	Ellen MacArthur Foundation	Europe	CE Visions	2030		1		1		1		1	1		1		1						1	1	1	1	1	1				1		1	1	1	1		1	
World Employment and Social Outlook 2018: Greening with jobs	International Labour Organization (ILO)	Global	CE Visions	2030	1	1		1													1	1	1	1				1		1		1	1	1			1	1	1		1
The Circular Economy and Benefits for Society	Club of Rome	Europe (Study)	CE Visions	2030									1	1		1		1	1	1	1	1	1	1			1	1		1	1	1			1	1
SHARING — Stocktaking and assessment of typologies of Urban Circular Collaborative Economy initiatives	ESPON EGTC	Europe	CE Visions	[2030]	1	1	1	1				1	1										1	1		1			1			1	1			1
Against wasted politics: A critique of the circular economy	Francisco Valenzuela and Steffen B.	Europe	CE Visions	[not given]		1		1													1	1	1	1			1	1				1	1	1
Achieving "Growth Within"	Ellen MacArthur Foundation	Europe	CE Visions	2030									1	1	1		1	1	1			1	1	1		1	1	1	1			1	1		1	1		1		1	1
Global Lighthouse Network: Four Durable Shifts for a Great Reset in Manufacturing	World Economic Forum	Global	CE Visions	[not given]									1	1	1	1	1	1							1	1	1					1
Business Models for the Circular Economy: Opportunities and Challenges for Policy	OECD	Global	CE Visions	[2030] [2060]									1	1	1	1	1								1	1	1	1			1	1		1	1
Safe Jobs in the Circular Economy	European Federation of Public Service Unions (EPSU)	Europe	Future of OSH	[not given]							1												1				1		1			1	1	1	1		1
Safety and Health at the heart of the Future of Work: Building on 100 years of experience	International Labour Organization (ILO)	Global	Future of OSH	[2030]	1	1							1	1	1	1	1	1	1			1		1	1	1	1		1		1		1			1	1
Circular Economy and Health: Opportunities and Risks	WHO Regional Office for Europe	Europe	Future of OSH	[2030]								1															1				1	1	1	1		1
Labour Market Consequences of a Transition to a Circular Economy: A Review Paper — Environment Working Paper No 162	OECD Environment Directorate	Global	Future of OSH	[2030]	1		1						1			1									1	1	1	1		1	1	1		1	1		1	1	1
Impacts of circular economy policies on the labour market	European Commission	Europe	Future of OSH	[2030]			1	1							1											1			1		1	1	1	1
Occupational safety and health in 2040: Four scenarios. How will the next generation in Europe deal with occupational safety and health issues?	European Trade Union Institute	Europe	Future of OSH	2040		1	1	1	1	1			1			1			1	1	1			1			1		1			1
Summary report Workshop on Digitalisation. Future of work and occupational safety and health: From a nordic approach towards a global coalition. Working on Safety meeting, Vienna	Vision Zero	Europe	Future of OSH	[not given]			1	1					1	1											1				1								1
The health and safety risks for people who drive for work in the gig economy	Christie, N. and Ward, H.	Europe / UK	Future of OSH	[present-day]																									1

Insights into the meta-analysis matrix, showing the 48 themes relevant to the future of the CE and the implications for OSH identified across the studies

2.3 Expert consultation

This section presents the list of experts selected for consultation. An initial longlist of circa 40 experts in the topics of the CE, OSH and the future of work was compiled. The list aimed to include participants based on the following criteria:

- a mix of professional backgrounds;
- a mix of organisational affiliations, including non-profits, start-ups and corporates, academia/research, policy/international institutions (while ensuring as much balance in sectoral backgrounds as possible, and respecting tripartism);
- an equal representation of men and women, to the extent feasible;
- at least 25 % 'younger' (i.e. under 40 years) participants with a high level of expertise;
- a mix of nationalities across the EU regions.

This initial longlist was reduced to a selection of 10 experts as potential interviewees. All experts on this shortlist were asked to provide their knowledge and insights on future aspects of a CE and its potential consequences for OSH (see section 2.3.1 for the list of interviewees, and section 8.3 for the interview questionnaires and summaries). A semi-structured approach to the interviewing process was adopted throughout the project. The first round of interviews sought to validate and extend the outcomes of the literature review, while the second round of interviews was focused on validating and identifying blind spots in the raw scenarios. Hence, different interview questionnaires were used as a basis for discussion in each round.

Interview questions targeted the experts' knowledge on:
- future trends or levers related to the CE that could fundamentally or radically change OSH in the future (thinking as far ahead as 2040);
- validation of the initial list of key factors provided, plus any additional trends or levers for change related to the CE;
- significant implications for OSH potentially resulting from the CE in Europe up to 2040;
- any blind spots (developments not on the mainstream radar) that may have a significant impact on OSH up to 2040[13];
- The experts were also asked to give eedback on scenario drafts, to feed into scenario selection and scenario descriptions.

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[13] The interview questionnaires can be found in section 8.3.

2.3.1 List of experts interviewed

The list is ordered alphabetically.

No.	Name	Organisation
1	Wouter Fransman	TNO (Netherlands Organisation for Applied Scientific Research), Risk Analysis for Products in Development
2	Michel Héry and Marc Malenfer	INRS
3	André Hoogendijk	Inspectorate SZW — Ministry of Social Affairs and Employment, Netherlands
4	Viktor Kempa	ETUI (also OSH Knowledge Advisory Group (OKAG) member)
5	Lothar Lieck	EU-OSHA
6	Johan van Middelaar	TNO, Safety and Environment
7	Nina H. Nielsen	ACSH WIG (Danish Trade Union Confederation)
8	Dietmar Reinert	Institute of Occupational Safety and Health of the German Social Accident Insurance (IFA)
9	Mieke de Schoenmakere	European Environment Agency (EEA)
10	Vera Weghmann	University of Greenwich

2.4 Scenario construction

As described in the overview of the project approach and methodology (see sections 1.2 and 2.1), the scenarios were constructed based on a key factor-based methodology. The 48 themes relevant to future of the CE and with implications for OSH that were identified across the studies (see section 2.2.6) were clustered and ranked by the frequency in which they were described in the literature and the magnitude of their potential implications on working conditions and the quality of jobs in 2040. The clustering resulted in a list of 15 key factors, which included three givens[14] (for further information, see section 4). The finalised selection of key factors were grouped under the STEEP categories and arranged in a morphological box. A morphological box is a grid technique for teasing out multiple projections from a key factor and combining them with those of other key factors to form raw scenarios.

Example of key factors (in blue) and their projections (in yellow) arranged in a morphological box. The raw scenarios are represented by the coloured lines.

Thus, for each key factor a range of alternative projections (i.e. alternative possible future development paths in the field up to 2040) was developed, based on the understanding of selected initial conditions and drivers (from the literature review and expert interviews), and mapped against a number of dimensions (e.g. rapid vs. slow adaptation, improving vs. deteriorating conditions). With the support of a scenario software tool, plausible combinations of different projections were then identified and combined to form scenarios, enabling a systematic (vs. an intuitive) identification of credible future scenarios.

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[14] If only one kind of future development is imaginable, only one projection can be covered, and the relevant factor is categorised as a 'given'.

Example of the range of projections that can emerge from one key factor.

The AI-powered software ScenLab was then used to conduct a robustness and consistency analysis to identify the 'best' macro-scenarios from all possible future development paths. The analysis bundled future projections from the set of key factors into potential scenarios and evaluated them for their robustness, consistency and plausibility. The results of the analysis led to the selection of four highly robust, plausible and consistent raw scenarios, which were then developed into four draft scenario narratives.

The draft scenarios were then presented to the EU-OSHA OSH Knowledge Advisory Group, and feedback was received and integrated into the development of the final scenario narratives, which can be found in section 5.

3 Key messages from the INRS report[15]

This section presents a summary of the key messages from the translated report 'Économie circulaire en 2040' (INRS, 2019a), as well as several other related texts (see INRS, 2019b; Malenfer et al., 2019; Héry and Malenfer, 2020). The translated synthesis report and the key messages below were produced for EU-OSHA for the purpose of incorporating the key findings of these valuable studies into this project. The summary was compiled by Futuribles (with the services of a translator) in coordination with INRS[16]. Sometimes additional sources were added, where these were at hand, to aid clarity.

3.1 Global key messages from the INRS report

Our planet's resources are finite, and yet humanity is depleting them at a more rapid pace each year. Most illustrative of this fact is Earth overshoot day — the day of the year on which humanity's resource consumption for the year exceeds Earth's capacity to generate those resources that year. In 1990, overshoot day fell on 11 October; in 2019, it came as early as 29 July (GFN, 2021): humanity's current economic mode is unsustainable.

Change towards a circular economy is inevitable but can be achieved only progressively (Héry and Malenfer, 2020). First, we need to create a system in which resource efficiency is increased at all stages of a product's life cycle. Second, overall consumption must be reduced. Finally, waste management needs to improve to the point where only a small quantity of non-renewable inputs is permanently lost, i.e. where the loop is closed. Currently, we see only a small reduction (decoupling[17]) of 1.3 % annually in materials intensity, and, for the coming decades, a doubling of global materials used is forecast — from 89 Gt in 2017 to 167 Gt in 2060 (OECD, 2018).

The circular economy offers enormous potential to reduce resource consumption and environmental externalities. Lowering inputs of raw materials is a must: François Grosse has shown that, if the global production of a raw material grows by more than 1 % per year, no circular economy policy will have a lasting impact on its management, even with a high recycling rate (Grosse, 2010). For example, if steel production continued throughout the 21st century at the same exponentially increasing pace as in the 20th (3.5 % per year), as much steel would be produced in a hundred years as we previously produced in a thousand. And, in 270 years' time, we would be extracting ten thousand times more ore each year than we do today. This projection would, of course, be impossible to realise, especially because of the limited resources of steel. But it demonstrates that even if 80 % of the steel used worldwide were recycled, this would barely reduce global demand and therefore the global amount of steel extracted.

In addition, the circular economy also has the potential to create jobs. Re-using and recycling are more labour intensive than disposal. According to a recent study commissioned by the European Commission, the development of circular economy policies in Europe could lead to the creation of an additional 700 000 jobs by 2030 (European Commission, 2018). Other publications estimate that 2 million (European Commission, 2020b) or between 1 and 3 million jobs could be created by 2030, most of them in Germany, the UK, Italy, France and Spain (European Parliament, 2017), with a 1 % boost to GDP (European Commission, 2020b). Over the past 15 years, growth in the environmental economy has consistently outpaced that of the overall economy, with regard to both employment and gross value added (Gaudillat, 2020). This demonstrates that efficiency and employment can be increased simultaneously.

However, to achieve these optimistic outcomes, parts of the economy would have to be reshored to the EU to create shorter loops that make better use of primary and secondary raw materials. Waste management, in particular, would have to be conducted in the EU. Currently, waste processing is often

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[15] This section was produced by Cécile Désaunay and the team at Futuribles; we want to thank them wholeheartedly for their expertise and support in this project.

[16] We would like to thank INRS for its support in realising this summary, specifically Michel Héry and Marc Malenfer, but also all other colleagues involved.

[17] The term 'decoupling' describes an improvement in resource efficiency, and thus refers to separating GDP growth from materials use . As stated by the OECD (2018): 'Historically, economic decoupling has been one of the dominant drivers of changes in materials intensity at the sectoral level' . Absolute decoupling of materials use and environmental degradation from GDP growth is the target of the UN's Sustainable Development Goal 8.4 (UN-GA, 2015).

handled by informal workers in developing countries. These jobs would return to the EU; hence, primary job creation would occur in the waste management sector.

In addition, many nations have banned the import of waste in recent years, in particular China (since 2017) (Wen et al., 2021). This has forced developed nations to re-nationalise waste processing, leading to positive outcomes, including annual savings 'of about 2.35 billion euros of eco-cost' (Wen et al., 2021). To date, EU countries have exported a significant part of their plastic and hazardous waste (Eurostat, 2020a). As of 1 January 2021, however, almost all export of plastic waste from the EU to non-OECD countries has been banned, and all future exports will be more strictly monitored (European Commission, 2020c). As a result, a much greater degree of recycling will have to be managed in the EU. However, the precise locations of these new waste processing facilities and the conditions under which they would operate remain unclear; choices would depend on the type of waste, recycling activities already in place in each EU Member State, etc.

At the moment, many EU countries 'still have a long way to go to make their waste management conform to EU targets' (EEA, 2020a, p. 7). In addition, waste stream management and processing remain in the early stages of digitalisation and automation. However, the pull towards a circular economy is a powerful driver for modernisation, with promising innovations ranging 'from digitally advanced maintenance to sorting enabled by artificial intelligence' (EEA, 2020a, p. 8), or the identification of materials through digitally readable markers (EEA, 2021). This would drastically reduce risks for workers, including a lowered exposure to hazardous materials due to remote work. Currently, approximately only one in two recycling plants in Europe has some automated processes in place; this proportion is expected to increase in the future (*Environment Journal*, 2018). Here, automation could lead to the cutting of many low-skilled jobs in the waste management sector, but it is more likely that automation would be used to achieve cleaner waste streams and support waste management workers.

Taking the above into account, the global key messages from the INRS report can be summarised as follows.

1) A range of possible applications of the concept of 'circular economy'
At the beginning of its implementation in Europe, the circular economy was primarily a theoretical concept. In 2017, the circularity rate (the share of material resources used in the region that came from recycled products and recovered material) for the EU was 11.2 % (EPSU, 2020); this had grown to 11.9 % in 2019 (Eurostat, 2020b). There are no fixed ways and means to boost this number. The implementation of the circular economy within companies can lead to a great diversity of business models and practices: ecological design, reduce, reuse, recycle (3R principle), product-service system, repairing, etc., or even 'urban mining' (Fraunhofer, 2020). In all cases, the development of the circular economy involves all actors: private enterprise, public authorities, local governments and consumers.

2) Circular economy could become a 'catch all' concept, used by a lot of public and private actors but without any shared definition or concrete actions
One consequence of the first message above is that the circular economy can lead to greenwashing practices, i.e. companies overstating their participation in the circular economy as part of their selling proposition. Consumers' eco-consciences would be eased, and they would be tempted to consume more, defeating one purpose of the circular economy. Hence, the 2020 Circular Economy Action Plan states that the European Commission 'will also propose that companies substantiate their environmental claims using Product and Organisation Environmental Footprint methods' (European Commission, 2020d). This ensures that consumers receive reliable and useful information, prevents greenwashing and obsolescence practices, and helps to develop EU-wide minimum criteria on transparency and reliability of labels — the current glut of labels only serves to confuse consumers[18].

3) Environmental goals could become more important than OSH issues
Implementing a circular economy could lead to prioritising environmental issues over OSH. Hence, one key challenge is to make sure that OSH requirements are considered equally important in the design of goods as marketing, manufacturing considerations and environmental concerns. Currently,

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[18] Currently, '[t]here are more than 200 environmental labels active in the EU, and more than 450 active worldwide; there are more than 80 widely used reporting initiatives and methods for carbon emissions only' (European Commission, 2020e).

however, OSH seems to be considered a secondary concern: the EU's March 2020 Circular Economy Action Plan mentions neither workers nor health and safety issues (EPSU, 2020)[19]. Yet the transition from a linear to circular economy offers a great opportunity to give OSH a much higher priority, if not the highest.

4) Need for traceability of materials and potential of technologies
Circular economy implies new uses of materials and the use of different kind of materials (secondary (recycled) raw materials, new recyclable materials, etc.). This may lead to new hazards emerging in the waste management industry, which makes it necessary to have precise knowledge of a product's composition and flow, and any health risks associated with its materials. Hence, an improved traceability of materials will be vital. Traceability will involve the creation of a solid reference system that ensures the relevance of the data — one example is the recent Recycled Plastics Traceability Certification Scheme (ECESP, 2020). This reference system can only be created with the aid of regulation (with Member States taking a key role in industrial policy) and standardisation (here, private initiatives would be at the forefront).

Other measures linked to and complementing traceability are': purification of secondary raw materials, reinforcement of preventive measures (totally closed processes, capture of polluting emissions, etc.), use of resources for other types of production that are less likely to expose workers (or consumers) to risks, energy recovery, etc.

3.2 Key messages regarding health and safety issues at work from the INRS report

1) Impacts on OSH could be very different depending on the type of companies or organisations involved

The development of the circular economy could lead to three different but complementary situations:

> 1) A network of small or medium-sized enterprises specialised in different niches and acting as sub-contractors, and organised at the initiative of designers and manufacturers (generally large companies that sub-contract these operations). In theory, these companies have the technical means to develop a far-reaching prevention policy, but may lack the economic means unless a high level of corporate social responsibility is promoted by the outsourcing company.

> 2) Independent micro- and small enterprises responding to various requests inside a local geographic area, including some forms of grey and black economy.

> 3) Investment in the social and solidarity economy (SSE) by companies that find opportunities in these repair activities to reintegrate excluded workers back into the workforce; they develop stable outreach activities in this niche with a workforce that is gradually acquiring skills.

Depending on the exact type of situation that occurs, impacts on OSH would be different. The first situation offers an environment in which standards of OSH training and awareness would be relatively high. In the second and third cases, we must consider that the workplaces in which diverse technical interventions will be carried out would possibly be designed and equipped on the basis of limited funds, resulting in a fragmented OSH oversight landscape. In the third situation, previously unemployed workers would have to be (re)skilled in workplace health and safety rules. Re-integration into the world of labour through the SSE is a matter of not only techniques, but also OSH.

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[19] The EU's Just Transition Mechanism (JTM), published on 14 January 2020, aims to provide support to regions facing considerable socioeconomic challenges related to the transition towards climate neutrality. While this initiative may help align environmental and social goals related to the CE and OSH in the future, it had not yet been published at the time of publication of the March 2019 INRS report.

2) Increased dependency of workers and small enterprises on large companies
Many activities within the circular economy can generate more remote and more dispersed dependency relationships (for example, as workers further along the value chain come to rely more heavily on the knowledge inherent to the earlier production stages). In particular, independent workers/freelancers and micro-enterprises could be forced to take on high-risk activities while lacking the equipment and knowledge to do so safely. These workers will therefore be more vulnerable to tough and unpleasant working conditions, low wages, and disregard of their health and safety. They, in particular, should be protected by OSH institutions.

3) Higher risks generated by recycling and recycled materials
In a circular economy, the materials used by companies and workers are more diverse and complex. Risks for workers are therefore higher, especially during dismantling and recycling activities. There is institutional awareness of some of these risks — compared with the average for all other sectors, the occupational accident risk in the waste management sector is already 2.5 times higher (EU-OSHA, 2020e). However, there is a severe lack of research on the health and safety of circular economy workers.

Hence, occupational risks for safety and health, which come as the result of handling new materials or performing new recycling activities, must be carefully studied in advance. In addition, mere awareness of risks is not enough. Measures have to be taken to control them, with regard to both equipment (e.g. personal protective equipment; PPE) and training. Currently, workers in the waste industry often lack both the skills and the means to do their jobs safely (EPSU, 2020). EU-OSHA research conducted between 2015 and 2017 showed that workers in the waste management and wastewater treatment sectors are at a high risk of exposure to biological agents (EU-OSHA, 2020f), while findings by the EWCS (European Working Conditions Survey) demonstrate that employees in waste management often feel that their health is not sufficiently protected: 36.9 % agreed with the statement 'my health and safety is at risk because of my work', and 33.9 % said that it was negatively affected — a higher percentage than in any other industry sector (EPSU, 2017). Exposure to physical factors — vibrations, noise, high and low temperatures, or smoke dust and fumes — is also much more frequent than in almost all other sectors (EPSU, 2017). Key risks listed in the relevant literature are heavy manual handling and exposure to bio-aerosols (airborne particles that contribute to indoor air pollution), heavy metals and organic pollutants (EPSU, 2020).

In the future, information provided by OSH institutions will obviously be essential. In addition to what has already been stated above, there is considerable need for increased research into the health and safety of workers in waste management in view of the increased introduction of new materials.

4) Need to reinforce communication between workers and OSH institutions
Implementation of a circular economy could lead to a scattering of actors, which would make it more difficult for OSH institutions to successfully pursue information and awareness activities. In a circular economy, the following services with different OSH implications coexist, and most will be delivered by a wide range of actors: rental and leasing activities, retailing activities of second-hand goods stores, wholesale of waste and scrap, recovery of sorted materials, repair of computers, personal equipment and other household goods, waste collection, treatment and disposal, and repair of machinery and equipment. Traditional industry players would operate alongside elements of the sharing economy, in which **responsibility for safe operation often remains a grey area between seller and buyer**, and we might also see a gig economy in which repair or waste management work is distributed across platforms, as well as across a wide range of informal workers.

Workers in each of these services would have **different OSH needs and a widely varying OSH knowledge base**. Here, suitable communication channels would have to be set up, research conducted and regulations adapted to make sure that OSH institutions have the means to correctly identify workers and their requirements, are able to provide them with actionable information, support upskilling and, where necessary, force employers to improve conditions — considerable challenges in a fragmented OSH landscape.

5) Increased need for professional training
For societies to adapt to the circular economy, there will be a considerable need for skills, training and

capacity building. Many green jobs will require 'some form of upskilling, rather than a complete re-skilling' (OECD, 2020a, p. 37) in preparation for a heterogeneous range of tasks. The OSH requirements for the different occupations are outlined below.

- For traditional occupations previously considered obsolete (e.g. repair), 'lost' or dormant knowledge will have to be retrieved — here, old OSH knowledge and practices will have to be carefully adapted and updated before dissemination to a wider audience.
- Existing occupations, for example conception and marketing, will need to evolve — OSH institutions would have to make sure that product safety (with regard to repair and recycling), for example, is a key consideration in design.
- For new occupations, for example in recycling and secondary raw materials refinement, OSH requirements must be researched and developed rapidly for new professions in the circular economy and become an integral part of all communicated best practices.
- For the transition of workers between occupations in the same or different sector of activity, OSH agencies would need to closely cooperate with providers of re- and upskilling services, for instance trade unions.

4 Key factors for the future of the circular economy with impacts on OSH

4.1 List and descriptions of key factors, with a view to its implications on OSH

As stated in the methodology section (section 2) of this report, key factors were used to capture key fields of development and change determining the future of the CE and its potential effects on OSH. This approach was selected principally as it is best suitable for integrating insights (e.g. information on trends and drivers as well as relevant megatrends, etc.) from a variety of sources, including the literature analysis and the expert interviews. After an initial list of 48 themes had been identified as relevant to the future of the CE and its implications for OSH, these were clustered and ranked by (1) the frequency in which they were described in the literature and, in particular, the expert interviews and (2) the magnitude of their potential implications for working conditions and the quality of jobs in 2040. The resulting list comprised 15 key factors (including three givens[20]) that were then described in terms of expected future developments and relevance to and potential implications for OSH. It is important to note that key factors are developments that have a very high likelihood of occurring and will hence influence the development of a CE, but they do not have a specific relationship with the CE. Thus, when selecting the key factors – which may vary in the degree of specificity in relation to the CE – for the scenario development, the focus is on their potential impact on the CE and potential implications for working conditions and the quality of jobs. In the next step, the possible future developments for each key factor were described systematically; these 'future projections' outline alternatives for the future development in the field. Below is the list and descriptions of the key factors (and givens) that formed the basis of the scenarios for this project.

No.	Name	Description	STEEP category
Givens			
G1	**Demographic change and migration**	In Europe, as in most mature economies with rising life expectancies and low fertility rates, populations age and shrink, leading to smaller and older labour forces and changing consumption patterns. Rising volatility in migration streams in recent years will also impact upon labour forces and consumption patterns of the coming decades.	Society
G2	**Climate change consequences**	Climate change is driven by human emissions of greenhouse gases that lead to temperature increases. This has numerous consequences, such as rising sea levels, more frequent extreme weather events (flooding, droughts, storms, etc.) and biodiversity loss, all of which impact negatively on humanity. Even if emissions of greenhouse gases are minimised going forward, the negative consequences will be felt for centuries. Additionally, measures addressing climate change and its effects will have numerous implications for all relevant sectors.	Environment
G3	**Environmental degradation**	As a consequence of the depletion of air, soil and water, ecosystems and habitats are destroyed, biodiversity is lost, and agricultural and fishery yields drop. The pace of resource depletion continues to accelerate, with resources being consumed faster than they can be replenished or, in the case of non-renewables, faster than the development of possible replacements is progressing. Meanwhile, air pollution is widely recognised as a serious threat to human health and to the health of the planet as a whole.	Environment

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[20] If only one kind of future development is imaginable, only one projection can be covered, and the relevant factor is categorised as a 'given'.

No.	Name	Description	STEEP category
Key factors			
1	**Behaviour and consumption**	Consumer attitudes towards waste and consumption are changing, as is stakeholder pressure on the industry. Individual and industry efforts towards waste prevention (i.e. non-consumption, re-using and improved allocation) can lead to increased levels of recycling. However, overall consumption (and hence global resource demand) continues to rise, and volumes of waste have so far also continued to increase.	Society
2	**Digitalisation and automation**	Across workplaces, non-digital processes are being replaced by digital processes, a transformation that changes commerce and trade, and results in the disappearance of old professions (printing) and the emergence of new ones (web design). At the same time, processes previously handled manually are becoming increasingly automated, i.e. taken over by machines. This may lead to changing job descriptions (parts of a job are automated, other tasks added) or workers being made redundant (jobs lost).	Technology
3	**Robotics and AI**	Robotics includes the development of intelligent machines capable of independent operation, from welding robots used in manufacturing to autonomous, unmanned vehicles, whereas AI refers to technically advanced machines that can analyse their environment and provide critical insights. If end users' needs are integrated into the design process, such technologies may well be able to encourage and support safe working practices.	Technology
4	**Emergence and diffusion of new materials**	The emergence and diffusion of new materials (such as nanomaterials) offers a vast range of applications, e.g. in medicine or electronics. Biotechnology is another field that is experiencing the rapid emergence of new applications across multiple sectors, such as industrial (use of enzymes to replace industrial processes etc.), medical (natural antibiotics etc.), agricultural (genetically modified crops) and environmental (cleaning up after industrial accidents). However, with all properties not yet known, these new materials and biotechnologies may prove to be hazardous for waste collection and processing.	Technology
5	**New forms of work**	Standard forms of employment are retreating and work in the digital platform economy (including so-called gig work and work in the sharing economy) is on the rise. Non-standard forms of employment such as project-based, temporary, part-time, zero-hours contract or freelance work is replacing more permanent jobs in some sectors and is often distributed through digital platforms. In addition, more and more workers are working remotely and seeing increased flexibility in their working times, while globalisation and specialisation have led to extended outsourcing and an increase in subcontracting (i.e. new supply chains and distribution). An increase in informal or harder-to-regulate work forms may have implications for working conditions and job quality.	Economy
6	**Economic greening**	Economic greening occurs when businesses begin to focus more on environmental and ethical values (i.e. more emphasis on corporate social responsibility, a shift to renewable energy, greater resource efficiency, fairer pay, etc.). This can come as a result of more vocal demands from stakeholders, or as price signals begin to be felt down the supply chain (owing to consumer willingness to pay more for ethical goods, government penalties for specific resources with a large footprint, etc.).	Economy

No.	Name	Description	STEEP category
7	**Changing forms of ownership**	Rather than owning a product, consumers can lease products and have the relevant function delivered as a service or share it with their peers. Producers are following suit and leasing products or parts of their production from other suppliers (e.g. car manufacturers leasing the painting of their vehicles).	Economy
8	**Energy transition**	As legislation directs economies to shift from carbon-heavy to renewable energy generation (e.g. solar and wind), impacts will be felt throughout society, including in waste and recycling streams, as well as at the level of accessing the raw materials necessary for the production of the energy generation elements, for example.	Economy
9	**Regulation**	Sustainability movements are emphasising the need for stronger, less laissez-faire regulation that focuses more on the environment and workers' rights. Increasingly, governments are realising that incremental change is not enough, and that strict new regulations and a more hands-on approach may be necessary (e.g. placing taxation on the extraction and exploitation of raw materials — as opposed to on labour).	Politics
10	**From globalisation to localisation**	While globalisation has shown fairly steady growth since the 1980s, some indicators suggest that this trend may be slowing or even reversing (owing to numerous factors such as rising protectionism, loss of confidence in international trade and offshoring vs. reshoring). Alongside these developments, owing to the combination of rising awareness of environmental impacts and waste exports no longer being accepted in the previous destination countries, a considerable, sustained increase in recycling quotas is expected — which might need to be managed and processed closer to home.	Politics
11	**Public funding uncertainty**	With competing pressures for public funding from government budgets that are already stretched as a result of financial crises and the COVID-19 response efforts, public infrastructure and programmes face insufficient (and dwindling) expenditure. Alongside competing funding pressures, rising political uncertainty impacts on public programmes, which may be here today but gone tomorrow.	Politics
12	**Uncertainty and frequency of global catastrophes**	In an increasingly interconnected world, catastrophes — either man-made (e.g. the global financial crisis) or natural (e.g. extreme weather events, COVID-19) — have far-reaching impacts that are extremely hard to plan for. Their consequences can be felt across supply chains and can strongly influence the health and safety of almost all global citizens — either directly or indirectly.	Environment

4.1.1 Demographic change and migration

Brief description and definition

In Europe, as in most mature economies with rising life expectancies and low fertility rates, populations age and shrink, leading to smaller and older labour forces and changing consumption patterns. Rising volatility in migration streams in recent years will also impact upon labour forces and consumption patterns of the coming decades.

Expected future developments

- Over the time horizon covered, the population of the EU-27 will overall first continue to grow, albeit much more slowly than in the past, and then continue to decrease. By 2030, an estimated 449.1 million people will live in the EU-27 countries (up from 447.7 million in 2020). By 2040, the population will be at 446.8 million, and then decrease to an estimated 432.5 million by 2060. This is based on the assumption of rather stable birth rates and net migration flows (Eurostat, 2020c)
- At the same time, the share of the working-age population (15-64 years) in the EU-27 is projected to decrease from 64 % in 2019 to 55 % in 2040, with the median age rising to almost 47 years (from 43.1 today) (Eurostat, 2020d).
- Globally, population growth is slowing down, with 10-year growth rates dropping to 7.3 % for 2030-2040 (from 10.7 % for 2010-2019), resulting in an estimated population of 9.2 billion in 2040 (up from 7.8 billion in 2020) (UN-PD, 2021).
- Volatility of international migration streams has increased in recent decades, with forced displacement doubling between 2000 and 2020 to 34 million people; the COVID-19 pandemic is meanwhile assumed to have reduced the number of international migrants by approximately 2 million globally (July 2019 to June 2020) (UN-PD, 2020).
- Future migration into the EU is expected to increase significantly by between 21 % and 44 % above the average annual inflow between 2008 and 2017, with migrants coming from Africa in particular (IOM, 2020).

Relevance and potential implications for OSH

- As labour forces age, the nature of health and safety risks in the workplace changes — older people have fewer accidents at work, but these are more likely to be serious or fatal (Eurostat, 2020e), and relative accident numbers may rise if more older people are forced to work in physically demanding occupations (ILO, 2018a, 2019a). Longer working lives also mean a greater likelihood of developing occupational diseases and chronic health problems as a result of the increase in cumulative exposure. Deteriorating vision and hearing ability also increase the risk of accidents, but this, as in the case of reduced strength-related abilities, can be counteracted by age-specific OSH measures (EU-OSHA, 2016; Eurostat, 2020e).
- Worldwide, migrant workers are subject to significantly greater occupational hazards than native-born workers, leading to poor health outcomes, more workplace injuries and occupational fatalities (Moyce and Schenker, 2018; EU-OSHA, 2020h).
- As workforces become more culturally diverse, negative effects for OSH ensue, as there are more misunderstandings, risk perception differs, and there is a lack of awareness of local habits and standards (EU-OSHA, 2020h).
- As populations in the EU's rural regions age and shrink significantly faster than in urban regions, the OSH landscape will become much more uneven (ESPON, 2020), making enforcement of OSH regulations more challenging.

Projection

As a result of increasing immigration flows (IOM, 2020), Europe's overall population will continue to grow until about 2030, but will begin to decline slightly afterwards, reaching 446.8 million in 2040 (Eurostat, 2020c). As is the case today, birth rates will remain below replacement rates during this period; however, migration will increase (nearly double compared with 2000-2010) (IOM, 2020). As a result, the population will continue to age, reaching a median age of almost 47 years (up from 43.1 years in 2020) (Eurostat, 2020d). Both migration and ageing will change the composition of the European labour force, leading to an older and more diverse working population (Eurostat, 2020d).

4.1.2 Climate change consequences

Brief description and definition

Climate change is driven by human emissions of greenhouse gases that lead to temperature increases. This has numerous consequences, such as rising sea levels, more frequent extreme weather events (flooding, droughts, storms, etc. — as short-term, sudden and unforeseeable events; these are covered in detail in section 4.1.15, 'Uncertainty and frequency of global catastrophes') and biodiversity loss, all of which impact negatively on humanity. Even if emissions of greenhouse gases are minimised going forward, the negative consequences will be felt for centuries. Additionally, measures addressing climate change and its effects will have numerous implications for all relevant sectors.

Expected future developments

- Global warming is expected to reach at least 1.5 °C above pre-industrial levels by 2040, and, unless immediate collective action is taken, the situation will worsen significantly into the future (IPCC, 2018). Furthermore, this threshold may be hit in the near term, as early as 2024 (BBC, 2020a). European land temperatures are increasing even faster; they have already reached 1.7-1.9 °C above pre-industrial levels and may exceed 3.5 °C by mid-century (EEA, 2020b).
- At 1.5 °C globally, we will see mass die-offs of coral reefs, food shortages and more frequent and extreme r floods, droughts, fires and hurricanes. At least 14 % of the Earth's population will be exposed to severe heatwaves at least once every five years (NASA, 2019).
- In Europe, a wide range of economic sectors and regions will be substantially affected, with heatwaves becoming nearly twice as likely in the Mediterranean and southern Europe, for example (Jacob et al., 2018).
- Reductions in labour productivity and agriculture productivity are expected, while sea level rise and increased flooding will affect many regions in Europe, including the transport network and other critical infrastructures (JRC, 2018a).
- The EU is committed to taking steps to address climate change, primarily by reducing greenhouse gas emissions, and is rated positively on its performance so far (an increase in the use of renewables, the lowering of greenhouse gas emissions) (CCPI, 2020). As a result of the COVID-19 pandemic, 2020 emissions are estimated to have declined by 4-7 % compared with 2019 levels, but transformational action will be required by 2030 to limit global warming to 1.5 °C, with a necessary reduction roughly equivalent to the combined emissions of the six largest emitter states (WMO, 2020).

Relevance and potential implications for OSH

- Temperature increases lead to negative health and safety effects, even if workers slow their pace or stop working to protect themselves from the heat stress. Workers will also be less likely to use PPE correctly if this increases heat build-up (ILO, 2019b). Exposure to increased temperature can also result in reduced vigilance and increased risk of injury or lapses in safety.
- In structures built in low-temperature environments, excessive heat may result in equipment malfunctions (cable breaks, hairline cracks). As the design life is unexpectedly shortened, this may affect the safety of workers relying on those structures (McKinsey, 2020a).
- Not only manual, but also cognitive, activities suffer under rising temperatures, leading to an increase in the likelihood of accidental injuries (ILO, 2018a). Changes in exposure to climate- or weather-related disasters can also cause or exacerbate stress (Crimmins et al., 2016).
- Higher temperatures also result in poorer air quality (ozone, particulate matter (also as a result of wildfires), higher pollen counts), and disease-carrying insects will affect wider geographical areas, threatening the health of outdoor workers (NDRC, 2020). Increased indoor humidity (also as a result of flooding) may result in greater exposure to mould and other biological factors (CDC, 2014).
- With the frequency and severity of droughts increasing, toxic substances may be released in the dust (NDRC, 2020).
  - In addition to the hazards listed above, agricultural or forestry workers are also at risk from pesticide exposure as a result of increased use of pesticides to combat insect growth (reduced pesticide use may lead to more musculoskeletal disorders through an increase in manual weeding). Forestry workers are also at a greater risk from forest fires and specific forestry risks (and extreme danger in clearing up trees damaged by weather and insects) (EU-OSHA, 2020h).

- Extreme weather events may also lead to mental health issues (post-traumatic stress disorder, anxiety, depression) (IEEP, 2020).
- Heat can affect cooling, heating and ventilation, while cold temperatures will affect un-winterised equipment. Workers may lack the necessary OSH-relevant knowledge to deal with these conditions safely, particularly in regions unaccustomed to very high or low temperature (ILO, 2019b; NDRC, 2020; WHO, 2017).

Projection

It remains unlikely that worldwide greenhouse gas emissions will be lowered substantially over the next two decades, but, even if they are, significant temperature increases are locked in and will occur in any case (WMO, 2020). As a result, a sea level rise of at least 30 cm is expected to mid-century, leading to more severe flooding during storms and submerging of coastal areas; storms will also increase in severity and frequency (NASA, 2019). Europe will see more heatwaves and droughts, negatively affecting agricultural production and human health, and leading to biodiversity loss (JRC, 2018a).

4.1.3 Environmental degradation

Brief description and definition

As a consequence of the depletion of air, soil and water, ecosystems and habitats are destroyed, biodiversity is lost, and agricultural and fishery yields drop. The pace of resource depletion continues to accelerate, with resources being consumed faster than they can be replenished or, in the case of non-renewables, faster than the development of possible replacements is progressing. Meanwhile, air pollution is widely recognised as a serious threat to human health and that of the planet as a whole.

Expected future developments

- In 2020, the total weight of human-made materials exceeded the Earth's biomass (Chatham House, 2020a), making this the Anthropocene: the age in which human activity is dominating and reshaping the planet.
- The loss of the global populations of mammals, birds, fish, amphibians and reptiles (which plunged by 68 % between 1970 and 2016) is expected to accelerate up to 2050, particularly because of increased land and marine habitat use (WWF, 2020).
- As a result, the vital contribution nature provides is deteriorating rapidly, noticeable in the loss of animal pollination, with transformative changes necessary to achieve sustainability. The danger posed to humanity is similar to that presented by climate change (IPBES, 2019).
- Without significant changes to current practices, the extent of suitable habitat, wildlife population density and local compositional intactness will all decrease substantially up to 2050, while global extinctions are likely to skyrocket (UN-CBD, 2020).
- Global resource use is expected to double over the next 40 years (from 89 Gt in 2017 to 167 Gt in 2060) (UN-IPR, 2019).

Relevance and potential implications for OSH

- As the pace of resource use increases, extraction of resources becomes riskier, as easy-to-reach deposits have been completely exploited (McKinsey, 2014).
- With some ecosystem services (benefits the natural environment provides to people, e.g. food, biological pest control, pollination) becoming more and more scarce, notably pollination, workers have to engage in unhealthy replacement procedures (if natural predators of pests have been killed, pesticide use increases) (ETUI, 2017).
- Prolonged exposure to pollutant particles (air pollution) results in serious health risks to workers (both indoor, e.g. industrial and office workers, and outdoor, e.g. in construction or farming) and reduces productivity, with regard to both working days lost and slower overall workflows (ScienceDaily, 2019; EEA, 2019; HBR, 2016).
- Environmental degradation, such as pollution stemming from waste dumps and landfills, contaminated sites and dirty industries, is much more likely to affect the physical and mental health of (socially deprived/low qualified) workers in poor work environments, e.g. informal workers in the car-scrapping industry and workers in obsolete metal working factories (IEEP, 2020; EEA, 2020c).

- Emergence of novel diseases and zoonotic pathogens (such as COVID-19) is linked to environmental degradation. Outdoor workers, such as farmers (both in general and with regard to handling livestock) and forestry workers, but also workers in abattoirs and small-scale biogas or waste treatment facilities, are at higher risk of encountering these hazards than the rest of the population (EEA, 2020c).

Projection

As of 2020, none of the 2010 Aichi targets to combat biodiversity loss has been more than partially achieved, and most have not been achieved at all (UN-CBD, 2020). Across all scenarios, negative trends in nature will continue over the coming decades, in some areas at a reduced pace, as the slowing of deforestation suggests (IPBES, 2019). Negative health effects from both water and air pollution are likely to increase up to 2050, leading to reduced quality of life for billions of people and the premature death of millions of others (UNEP, 2019). At the same time, land degradation will further reduce the productivity of agricultural spaces, while more than half of all marine fish stocks continue to be harvested at unsustainable levels (IPBES, 2019).

4.1.4 Behaviour and consumption

Brief description and definition

Consumer attitudes towards waste and consumption are changing, as is stakeholder pressure on the industry. Individual and industry efforts towards waste prevention (i.e. non-consumption, re-using and improved allocation) can lead to increased levels of recycling. However, overall consumption (and hence global resource demand) continues to rise, and volumes of waste have so far also continued to increase.

Expected/potential future developments

- The continued rise of the global middle class, which will almost treble, to 5.3 billion, between 2009 and 2030 (Brookings, 2018), will fuel the growth of consumerism. The potential attitude shift to consumption (towards digital consumption) triggered by the COVID-19 pandemic is difficult to quantify (TNR, 2020).
- Driven by urbanisation and growing populations, waste generation is expected to increase by 70 % up to 2050, particularly in high-income countries (World Bank, 2018). E-waste is expected to grow at an even greater rate (e-waste is the fastest growing waste in Europe, with less than 40 % recycled) (European Parliament, 2020), doubling over the same period (BBC, 2020b), with currently very low rates of recycling: the fate of 82.6 % of all e-waste created in 2019 remains unclear (UNU, 2020).
- While consumer concern for the environment is intensifying in Europe (Oney, 2020), uncertainty about recycling remains largely unchanged (Eurobarometer, 2019a) and is unlikely to shift dramatically in the future (Viridor, 2020). Furthermore, plastics recycling, although expected to increase significantly up to 2030, it is not growing fast enough to meet higher recycling targets (both qualitative and quantitative)(McKinsey, 2020b).

Relevance and potential implications for OSH

- As individualisation continues, people may be more prone to risk-taking and become more experimental in the workplace, which may impact negatively on OSH (ETUI, 2017).
- As concern for the environment continues to intensify, people will increasingly opt for longer lasting, functional and safe products that contain fewer or no hazardous chemicals. As 'substances of very high concern' are phased out, recycling will become gradually safer, even if it takes some time before these substances disappear completely form waste streams (European Commission, 2020d).
- Recycling workers do not currently receive sufficient training in OSH, an issue that 'is largely overlooked' (ILO, 2018b) and is problematic in combination with the increased risk-taking mentioned in the first point above (and may be an outcome of an overall low risk awareness in the relatively young recycling industry). This is of particular concern, as, globally, recycling is 'generally carried out by workers in the informal economy' who face 'major OSH hazards' (ILO, 2019b; similarly EPSU, 2017).
- Here, future upskilling initiatives would considerably increase job safety (European Commission, 2018).

- Consumer acceptance of longer product life cycles (reduced obsolescence) and increased willingness to recycle (boost to secondary raw materials) would cut the number of jobs in material-intensive sectors and raw materials extraction, which are also among the most accident-intensive sectors (OECD, 2020a).

Projection 1: Ethical consumption and employment
The Fairphone[21] was only the beginning. Consumers still enjoy consuming, but they want to do so ethically, and insist on cradle-to-grave eco-conscious design. Overall consumption levels continue to rise, but at a slowing pace, while products are designed to be safely repairable, upgradable and recyclable. While recycling rates have gone through the roof, working conditions and job quality remain in the spotlight as a result of increased public and political focus (and regulation).

Projection 2: Talk is cheap
For businesses, profits and only profits count, and as for the consumers — well, there is no such thing as buying too much, is there? And if your home is overflowing with stuff, just throw it out. Workers in the waste disposal industries and resource extraction pay the price, with many of them having to work in a high-risk environment where working conditions and job quality receive little consideration from employers. Consumption of single-use products is also on the rise owing to a new focus on hygiene and increasing health concerns.

Projection 3: Record recycling, but shopping soars, too
Eco-consciousness is on the rise, but people have not fallen out of love with shopping. As a result, recycling rates go up, but so do waste volumes. Each year, the recycling industry achieves new records, but at a price. Workers must tackle more waste than ever before, with myriads of inputs, and are forced to go to extreme lengths to meet the recycling targets set — all at a considerable risk to themselves.

4.1.5 Digitalisation and automation

Brief description and definition
Across workplaces, non-digital processes are being replaced by digital processes, a transformation that changes commerce and trade and results in the disappearance of old professions (printing) and the emergence of new ones (web design). At the same time, processes previously handled manually are becoming increasingly automated, i.e. taken over by machines. This may lead to changing job descriptions (parts of a job are automated, other tasks added) or workers being made redundant (jobs lost).

Expected/potential future developments
- Technology primarily replaces workers in routine tasks, forcing a growing number of workers to move from declining occupations to growing ones (OECD, 2019b).
- Job growth is expected to lag behind job creation up to 2025, leading to higher unemployment (WEF, 2020b).
- The concentration of low educated workers in sectors and occupations that are at high risk from automation/digitalisation has been increasing in recent years (particularly with the accelerating effect of the COVID-19 pandemic), exposing workers to a much higher likelihood of job loss (OECD, 2021).
- It is expected that, as the wave of automation grows over the next decade, many of the 21 million workers forced to change occupations in Europe up to 2030 will be unable to upskill, and eventually will become re-employable, while working those in occupations in which only specific tasks are automated will struggle to adapt to changing work descriptions (McKinsey, 2020c).
- Over the next two decades, automation and digitalisation will reach sectors that so far have not been affected or have remained largely unaffected, e.g. agriculture and bricks and mortar retail (McKinsey, 2019a; Future Farming, 2020).

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[21] The FairPhone is a smartphone focused on repairability and recyclability, and is manufactured using fairly-sourced materials and in good labour environments (Ecobahn, 2020). Some features of older models can be easily upgraded to newer standards, significantly reducing e-waste.

Relevance and potential implications for OSH

- As digitalisation greatly increases demand (by up to 390 %) for some raw materials extracted primarily in the informal economy (with very low OSH standards), risks for workers will increase, particularly outside the EU (PowerShift, 2017).
- Overall, however, jobs in risky professions (labourers in mining, construction, etc.) are more likely to be automated than those in other sectors, reducing overall OSH hazards (JRC, 2019).
- Digitalisation has increased stress at the workplace, which exacerbates mental health risks (ILO, 2019a).
- Some developments both decrease and increase OSH hazards: for example, while teleworking reduces risks associated with commuting, psychosocial risks grow (as a result of 'lone working') (ILO, 2019b), as do ergonomic risks (EU-OSHA, 2018a).
- Similarly, automation and digitalisation increase (perceived) job insecurity, which also impacts negatively on psychosocial health (ILO, 2019b). Increased monitoring of workers with regard to job performance may have a similar effect (EU-OSHA, 2017a).
- In some areas, automation may outpace risk assessment, e.g. with regard to road safety compliance of autonomous vehicles (RSA, 2019).

Projection 1: Underemployed and poorly supported

Digitalisation has brought the promised rationalisation gains — and the feared job losses. However, the job gains expected to offset the latter never materialised, primarily because of the skills mismatch in the EU labour force. Insufficient retraining has resulted in a vast pool of underqualified workers who lack the skills necessary for employment in the new digital world. Falling wages mean that many automatable processes continue to be done manually, as people are cheaper than machines. Hence, working conditions remain largely unchanged, and occasionally are even worse, as employee costs are often cut, given that they hurt the bottom line much more than previously.

Projection 2: Successful adaptation

The EU has successfully adapted to digitalisation and automation, through thorough planning and with adequate safety measures in place. As a result, no software or machine went live before it had been carefully checked for all potential short- and long-term safety risks. Gone are the hazardous occupations of yesteryear, and good uptake of the free retraining measures offered by national governments means that workers both are confronted with fewer risks and show better safety practices — working conditions and quality of jobs increase as a result.

Projection 3: Safety is the machine's job

Digital technologies are everywhere, and work is abundant. Retraining schemes are focused on getting people back into employment as rapidly as possible, regardless of any negative consequences. As a result, workers have become more diverse and dispersed. Responsibility for working conditions is often difficult to establish, and even more difficult to oversee.

4.1.6 Robotics and artificial intelligence

Brief description and definition

Robotics includes the development of intelligent machines capable of independent operation, from welding robots in manufacturing to autonomous, unmanned vehicles, whereas AI refers to technically advanced machines that can analyse their environment and provide critical insights. If end users' needs are integrated into the design process, such technologies may well be able to encourage and support safe working practices.

Expected/potential future developments

- The pace of robotics and AI adoption remains rapid and may accelerate in some areas, as there is a significant increase in the number of firms expecting to adopt non-humanoid robots and AI (WEF, 2020b).
- As a result of the introduction of AI and robotics into the workplace, up to 94 million workers in Europe will require significant retraining to keep their jobs, while 21 million EU workers will have to find new jobs in the decade up to 2030 (with job losses and gains roughly equal), meaning that workers will face unprecedented disruption (McKinsey, 2020c).
- AI brings significant job polarisation, especially for workers without university degrees (Bruegel, 2020).

- AI has the potential to play a key role in the reskilling of workers, assessing learning needs, personalising training and accelerating skills adoption (WEF, 2020c).

Relevance and potential implications for OSH
- Any large-scale displacement of workers across many industries will result in institutional knowledge loss. This will include OSH-related knowledge, in particular tacit knowledge.
- Integration of AI and robots makes robots less predictable for workers, potentially increasing OSH hazards (EU-OSHA, 2021), while overreliance may lead to deskilling (EU-OSHA, 2019a, 2021), cybersecurity issues (EU-OSHA, 2019a, 2021), less task variation and more sedentary tasks, as well as psychosocial effects (EU-OSHA, 2021).
- AI has the potential to aggravate OSH risks in digitalised workplaces (EU-OSHA, 2019c).
- Autonomous vehicles have the potential to offer significant safety benefits over manned driving (Ellen MacArthur Foundation, 2015a).
- Robots can handle dirty, dangerous and demeaning jobs with high levels of associated OSH hazards, but human-robot interaction may lead to increased risks in the workplace (e.g. through workers over- or underestimating robot capabilities and situational awareness) (ILO, 2019b).
- Exoskeletons help to reduce the amount of time spent in tiring or painful positions (EU-OSHA, 2019a), but their introduction may be hampered by workers' reluctance to accept them (EU-OSHA, 2020b).
- AI often shares its programmers' blind spots, which may increase OSH hazards (e.g. if the OSH needs of ethnic minority works are not considered to the same extent as those of white workers, because AI programmers are more likely to be white) (PwC, 2020).
- Tests have shown that human operators may override robots and AI in critical situations and ignore warnings (CIPD, 2021), or may have less experience in critical situations, resulting in an effective OSH deskilling.
- Monitoring by AI may improve safety, but also increases stress (EU-OSHA, 2017a, 2019a, 2021) and may lead to legal issues.
- Smart protective equipment has the potential to offer increased safety and health for workers (EU-OSHA, 2020c).

Projection 1: Rushing towards new dangers
It could not go fast enough: AI and robotics have been unleashed upon the European business landscape in the name of global competitiveness, leading to a rapid increase in human/machine interactions, in particular regarding collaborative robots/cobots. Working conditions are a consideration, but often only after the fact. With regard to operational health and safety, the overall result is mixed: on the one hand, workers no longer have to operate in many hazardous environments; on the other, the actions of both AI and robots are often unpredictable, or place task completion above human safety.

Projection 2: Slowly but surely
A highly systematic rollout of both AI and robotics means that all possible safety precautions in human/machine interaction are undertaken. Designers and regulators have really taken Asimov's first law of robotics ('A robot may not injure a human being or, through inaction, allow a human being to come to harm') to heart. With OSH integrated into AI and safety- and prevention-oriented robot design from the beginning, working conditions have greatly improved across all industries.

4.1.7 Emergence and diffusion of new materials

Brief description and definition
The emergence and diffusion of new materials (such as nanomaterials) offers a vast range of applications, e.g. in medicine or electronics. Biotechnology is another field that is experiencing the rapid emergence of new applications across multiple sectors, such as industrial (use of enzymes to replace industrial processes, etc.), medical (natural antibiotics etc.), agricultural (genetically modified crops) and environmental (cleaning up after industrial accidents). However, with all properties not yet known, these new materials and biotechnologies may prove to be hazardous for waste collection and processing.

Expected/potential future developments

- The increasing ability to understand and engineer biology offers transformative new capabilities, including more sustainable modes of production for many products (up to 60 % of all physical inputs to the global economy could be produced biologically, replacing many fossil-based materials) (McKinsey, 2020d).
- Developments in this area may accelerate considerably in the decade up to 2030 (McKinsey, 2020d), even though bio-innovation carries unique risks (see below) (McKinsey, 2020d).
- Nanomaterials offer considerable potential for the transformation towards an economy based on renewables, e.g. with regard to energy storage and use of lightweight materials (Prasanna and Deshmukh, 2020).
- Risk assessment of nanomaterials remains inherently difficult and is a subject of intense debate (Anon., 2020).
- Overall, consumers and workers remain critical of the use of nanomaterials and demand strict labelling (EUON, 2020).

Relevance and potential implications for OSH

- Nanomaterials present unique health challenges (ILO, 2019b), in particular with regard to ingestion and inhalation (EEA, 2013). Furthermore, particulate nanomaterials in powder form may explode.
- Nanopaints and coatings pose unique challenges during recycling activities (difficulties in identifying and safely processing) (G20 Insights, 2020). New risks are continually emerging in this area, including the risk of long-latency hazards (e.g. with carcinogens) and diseases that are difficult to trace back to jobs (EEA, 2013).
- Biological agents are known to cause health problems. Between 2005 and 2015, exposure to biological agents at the workplace increased by 50 % in Europe (Eurofound, 2017).
- Biology is interconnected, self-replicating and difficult to control (it does not respect jurisdictional boundaries); workers could be confronted with new biological agents where they least expect them. COVID-19 demonstrated the danger of the interspecies leap (McKinsey, 2020d).
- In biotechnology, low barriers to entry increase the potential for misuse by OSH-unaware actors, with possible severe consequences (such as creating and unleashing viruses) (McKinsey, 2020d).

Projection 1: Keeping pace with new developments

Given that new materials are a way to reduce resource inputs and lower fossil fuel use (e.g. lightweight vehicles), a conscious effort is made to ease adaptation across a wide range of industries. In the EU, climate change has entrenched the learning that negative consequences of industrial activities should be minimised before the fact. With worker health and safety playing a prominent role in the licensing of new materials, labour rights are entrenched in workplaces.

Projection 2: Threats from the outside world

In the EU, excessive caution concerning new materials has resulted in very few new materials being approved for use. Therefore, there has been no need to adapt labour legislation. However, use outside the EU has increased dramatically. Now, workers come across illegal or 'grey' imports of products involving (undeclared) new materials during recycling and repairing activities, but lack the necessary safety practices to handle them safely.

Projection 3: Safety last

You must have priorities, and, with regard to new materials, global competitiveness and the economic value of any new invention come first. The health hazards of new materials are seldom considered or measured prior to introduction into the EU.

4.1.8 New forms of work

Brief description and definition

Standard forms of employment are retreating, and work in the digital platform economy (including so-called gig work and the sharing economy) is on the rise. Non-standard forms of employment, such as project-based, temporary, part-time, zero-hours contract or freelance work, are replacing more permanent jobs in some sectors, often distributed through digital platforms. In addition, more and more

workers are working remotely and seeing increased flexibility in their working times, while globalisation and specialisation have led to extended outsourcing and an increase of sub-contracting (i.e. new supply chains and distribution). An increase in informal or harder-to-regulate work forms may have implications for working conditions and job quality.

Expected/potential future developments

- Between 2001 and 2017, the number of part-time and temporary workers in the EU grew by over 30 %, with technology a key driver of this development as work disaggregated into specific tasks (JRC, 2019).
- For workers, these forms of employment are associated with substantially less work security and poorer working conditions (ILO, 2018a).
- The proportion of work performed by workers in these forms of work is expected to rise significantly in the future (ILO, 2018a), with Europe's employment landscape set to become more and more diverse (Eurofound, 2020).
- Platform work, however, remains relatively rare in most EU-27 nations (Eurofound, 2020).
- Many European nations are taking action to ensure the protection of vulnerable workers but remain challenged by issues concerning classification of workers in new forms of work and their access to collective bargaining (OECD, 2019c).
- The current EU initiative on platform work (a legislative proposal scheduled for publication at the end of 2021) aims to improve the working conditions of platform workers. The influence of this initiative and of the proposed Digital Service Act (DSA) on workers and their collective bargaining potential remains to be seen (European Commission, 2021a).

Relevance and potential implications for OSH

- Platform work carries several risks to physical health and safety (EU-OSHA, 2017b; ILO, 2018a; JRC, 2019), particularly mental health risks (EU-OSHA, 2017b; RSA, 2019).
- In some regions, peer providers of services are exempt from some requirements concerning OSH. Furthermore, the lack of platform responsibility intensifies some issues (see below) (OECD, 2019a; ILO, 2019b; ESPON EGTC, 2020). As companies shrink their permanent staff pool and more people become self-employed, the OSH landscape becomes more fragmented, as OSH regulations and unions often do not protect freelance workers and contingent workers (ETUI, 2017; EU-OSHA, 2019b).
- Studies show that injury rates among non-standard workers are higher (EU-OSHA, 2017b) — a result of increased time pressure (pay per assignment), lack of OSH training, OSH awareness and safety equipment, and exhaustion caused by working long hours (EU-OSHA, 2015a; EU-OSHA, 2017b; Christie and Ward, 2019).
- For desk work, there is an increased risk of visual fatigue and musculoskeletal problems (due to equipment not meeting ergonomic requirements), psychosocial problems, and stress caused by continuous evaluation and blurring of work-life boundaries, as well as job insecurity (EU-OSHA, 2015a, 2017b).
- Cyber-security risks increase, as things and people are more interconnected, and platform workers may lack specific awareness (EU-OSHA, 2018a).
- In the sharing economy, environmental risks may increase, because, by selling services rather than products, the responsibility for the disposal of waste is transferred from the customer to the producer (EPSU, 2020).
- OSH agencies will be challenged to shift their focus from regulating and controlling organisations towards supporting individuals (advice on ergonomics, dealing with social exclusion, etc.) (EU-OSHA, 2019b).

Projection 1: Businesses compete for talent — but only in some areas

With regulation primarily focused on providing a level playing field, competition heats up between platforms, as well as between platforms and conventional employers. In the war for talent, and with all other factors equal, working conditions and job quality play an ever-growing role in securing the best hires. Hence, in some occupational areas working conditions are excellent and much improved, even in fields where OSH hazards are relatively low to begin with, whereas in the 'buyers' market' for low-skilled workers, working conditions are often given little (to zero) consideration.

Projection 2: Deeply fractured employment landscape

Across most EU industries, platform and gig work have increased tremendously and, in some sectors, resulted in a fractured and uneven employment landscape. The 'Russian doll effect' of sub-contracts within sub-contracts means that responsibility for workers ultimately rests with the workers themselves, leading to higher risks, but also to grass-roots whistleblowing efforts.

Projection 3: Strict regulatory environment

As existing concerns about the quality and stability of some jobs within the platform economy deepened, a comprehensive legislative effort in the EU results in a strict regulatory environment. With platforms now having to shoulder the same responsibilities as regular employers, the resulting drop in competitiveness has led them to withdraw from some (e.g. OSH-intensive) services.

4.1.9 Economic greening

Brief description and definition

Economic greening occurs when businesses begin to focus more on environmental and ethical values (i.e. more emphasis on corporate social responsibility (CSR), a shift to renewable energy, greater resource efficiency, fairer pay, etc.). This can come as a result of more vocal demands from stakeholders, or as price signals begin to be felt down the supply chain (owing to consumer willingness to pay more for ethical goods, government penalties for specific resources with a large footprint, etc.).

Expected/potential future developments
- Between 2012 and 2018, the number of jobs linked to the CE in the EU grew by 5 % (European Commission, 2020d).
- By lowering resource inputs (increasing resource efficiency in production) and extending product lives (redesigning, repairing, recycling), considerable employment gains of up to 7 % can be achieved (ILO, 2019b; OECD, 2020a).
- Investing more in the green economy can advance an inclusive future of work, as environmental degradation disproportionately affects vulnerable populations (ILO, 2019a).
- Future greening must include a stronger focus on waste prevention, which currently often lacks as a result of the profit margin waste offers (EPSU, 2017).
- 'Green recovery' efforts following the COVID-19 pandemic offer the opportunity to achieve significant progress up to 2030 simply by strategic allocation of funds (OECD, 2020b).
- Among consumers, the COVID-19 pandemic has accelerated the shift towards sustainability, increasing the pressure on companies to act (BCG, 2020).

Relevance and potential implications for OSH
- 'Green jobs' are not necessarily safe and decent jobs but may be affected by newly emerging risks (EU-OSHA, 2013a; ILO, 2019b). In addition, in emerging and developing countries in particular, recycling activities are generally carried out by workers in the informal economy (ILO, 2019b).
- Until recently, EU CE policies ignored the health and safety of workers, and are only slowly catching up (EPSU, 2017). Similarly, current CE company policies in the EU pay little attention to working conditions and OSH (EPSU, 2020).
- To better achieve a two-way communication about OSH issues with greening enterprises and organisations of all sizes, a people-centred social dialogue with a strong emphasis on skills development is necessary (ILO, 2016).
- As targets for recycling become more ambitious, waste streams become more concentrated and more hazardous to handle (EU-OSHA, 2013a).
- Use of new materials (such as heat storage chemicals and new insulation in construction) could result in workers being exposed to new substances during installation, refurbishment or recycling activities (EU-OSHA, 2013a).
- Workers encounter considerable risks during the servicing of wind turbines and solar farms, as well as during recycling activities (ILO, 2019b).

Projection 1: Greening presents new risks to workers

A rise in the environmental and ethical considerations of individuals in the EU results in flow-on effects in regulation and industry practices. However, this shift does not necessary lead to better working

conditions for affected workers, as new unaddressed risks emerge as a result (i.e. from the shift to renewable energy generation, increased recycling volumes, etc.).

Projection 2: Paying lip service only — cost-effectiveness rules
Across EU industries, environmental and ethical practices, including CSR, are paid lip service only. Business is ultimately conducted according to cost-effectiveness and profits above all else. The environment and workers' rights suffer as a result.

Projection 3: Businesses compete on greening and ethics
In the EU, businesses cannot gain ethical credentials without considering the working conditions of all workers across the entire value chain. Accreditation ratings are awarded to top-performing businesses in the categories of environment and ethics. Businesses know that their ratings affect profits and thus compete to showcase their fair treatment of workers and the environment.

4.1.10 Changing forms of ownership

Brief description and definition
Rather than owning a product, consumers can lease products and have the relevant function delivered as a service or share it with their peers. Producers are following suit and leasing products or parts of their production from other suppliers (e.g. car manufacturers leasing the painting of their vehicles).

Expected/potential future developments
- Driven by the proliferation of the Internet and changes in lifestyles and attitudes, the European sharing economy is considered a 'deep socio-economic trend' (European Commission, 2016) and a paradigm shift towards an economy focused on collaboration rather than growth and profit (IÖW, 2017). However, even prior to the COVID-19 pandemic, this potential was increasingly unfulfilled (Yao, 2019).
- Pre COVID-19 (in 2018), just under a quarter of the European population (younger people in particular) had used services offered via collaborative platforms, an increase of about one third compared with previous surveys (Eurostat, 2018).
- While the European sharing economy remains relatively small — in 2018 the size of the collaborative economy was estimated at €26.5 billion (0.17 % of EU GDP), with work provided for 394 000 people (0.15 % of EU employment) (EC-DG IM, 2018) — it is expected to grow rapidly, with a 20-fold increase in turnover between 2015 and 2025 (PwC, 2016). However, growth is expected to be uneven across countries and sectors (PwC, 2017). Should all underused assets be brought into use, annual gains of €483 billion would be possible (EPRS, 2016), but this would require major regulatory efforts (CEPS, 2020).
- The COVID-19 pandemic resulted in a temporary setback in the sharing economy (at minimum), but it also threw the sharing economy's short- to mid-term future into disarray. Overall losses remain difficult to quantify; most negatively affected were mobility and accommodation (including co-working) (CEPS, 2020; Hossain, 2021). Peer-to-peer sharing, however, grew significantly in some sectors, e.g. the German service Nebenan.de and the Dutch service Peerby.com (Handelsblatt, 2020; Metabolic, 2020).
- The B2B sharing economy is also based on sharing underused assets, e.g. free space on transport vehicles, free production capacity, or data (e.g. on the European B2B sharing platform FLOOW2.com (LEAD, 2020)). In the construction sector, comprehensive adoption of B2B sharing has the potential to reduce waste by up to 20 % (Cramo, 2018). Currently, B2B sharing remains in its infancy with the exception of niche sectors (e.g. sharing of medical equipment) (Cohealo, 2020).

Relevance and potential implications for OSH
- Safety is a key concern for users of sharing services and platforms: in one survey, 49 % of respondents mentioned the grey area of 'responsibility in the event of a problem' as their biggest worry (Eurostat, 2018); in another, almost 29 % reported problems because of 'poor quality', and close to 12 % experienced 'safety issues' (EC-DG JC, 2017). However, the only OSH-relevant information on user safety available is for rented e-scooters, which are associated with accident rates that are up to 10 times higher than for bicycles (FERSI, 2020).

- Users of peer-to-peer (P2P) sharing services show a below-average concern for safety compared with the average consumer (Barbour et al., 2020).
- Service providers in the sharing economy are exposed to the same OSH risks as workers in the online platform economy (see the above key factor, 'New forms of work') (see EU-OSHA, 2015a).
- Where equipment is shared by non-professionals, responsibility for maintenance remains unclear.
- The decentralised nature of the sharing economy makes training, supervision and rule enforcement considerably more difficult.

Projection 1: Sharing and leasing boom
With belts tightening owing to economic recessions, and sustainability movements gaining traction, increasing numbers of individuals are choosing to share or lease products (such as cars, bicycles and gym equipment) rather than owning them outright. After realising the associated cost savings, many industries are also exploring new ownership forms as they look to save costs by leasing out parts of their supply chain processes (such as assembly and construction, and painting). While this shift is resulting in positive outcomes for the CE, little to no consideration has been given to the working conditions of those who collect, distribute, repair and ultimately dispose of these products.

Projection 2: Safer design
With an increase in the sharing and leasing of products by both individuals and industry, an increasing level of care is being taken in the design of such products to ensure safety in the dismantling, repair and disposal stages.

Projection 3: Throw-away culture
Increased caution around the sharing of products, in part due to the COVID-19 pandemic, has led to a significant reduction in the sharing and leasing economy. Consequently, there has been a rise in waste and recycling volumes, leading to higher risks to workers as they grapple with increased waste volumes.

4.1.11 Energy transition

Brief description and definition
As legislation directs economies to shift from carbon-heavy to renewable energy generation (e.g. solar and wind), impacts will be felt throughout society, including in waste and recycling streams, as well as at the level of accessing the raw materials necessary for the production of the energy generation elements, for example.

Expected/potential future developments
- In the past two decades, EU Member States have vastly expanded renewable energy production, increasing within 15 years from 9.6 % (2004) to 19.7 % (2019, only 0.3 % short of the 2020 target) of the gross final energy consumption (European Commission, 2020f,g). In 2020, renewables accounted for 40 % of the overall electricity production, for the first time beating fossil fuels (34%, with coal dropping by 32 % in 2020 alone) (Ember, 2020).
- The EU has set ambitious targets ('European Green Deal') for the coming decades and hopes to become the world's first climate-neutral continent by 2050 (European Commission, 2019b).
- The COVID-19 pandemic will slow down new wind and solar installations by around 30%; however, overall, new installations will need to double or triple in the 2020s to be on target for a 55 % emissions reduction by 2030 (Ember, 2020).
- At 8.9 %, the current share of renewable energy used in transport remains low (and is primarily the use of biofuels), with a target of 14 % planned for 2030 (Eurostat, 2020f). While a complete decarbonisation of the transport sector by 2050 is possible, merely switching to electricity will not be sufficient; alternative fuels (e.g. hydrogen) will be necessary (Ricardo, 2020).
- To achieve the flexibility necessary in an energy generation system focused on renewables, energy storage (power-to-gas, batteries, etc.) will have to be vastly expanded, in particular regarding the 2050 horizon, requiring mass infrastructure instalments (EU-DGE, 2020). In this context, EU legislation on batteries will be modernised (to improve recyclability, efficiency and safety) (European Commission, 2020h).

- In the EU, some 1.5 million workers are employed in the renewables sector, primarily in biomass and wind, followed by biofuels and photovoltaics (PVs) (JRC, 2020). While some 160 000 jobs are expected to be lost in the coal regions, mainly in Poland, Germany and Czechia, up to 2030 (JRC, 2018b), up to 4.8 million new jobs could be created, albeit with a considerable skills mismatch (JRC, 2020).
- By 2030, some 120 000 e-car batteries will have to be recycled annually, rapidly increasing to 1.8 million by 2040 (Abdelbaky et al., 2020).

Relevance and potential implications for OSH
- As energy production changes, there will be new entrant workers to the industry. Workers will not always be sufficiently familiar with basic risks and new combinations thereof (EU-OSHA, 2013a).
- If more small and medium-sized enterprises (SMEs) use their land (e.g. rooftop PV panels) or organic waste (e.g. biomass in breweries) to produce electricity as a sideline and rely on their own workers or sub-contractors for installation and maintenance, necessary OSH-relevant skills may not be available. Similarly, unsophisticated, perhaps DIY, domestic installations are also potentially hazardous (EU-OSHA, 2013a).
- Wind turbines are associated with specific hazards, in particular offshore sites, during production (hazardous chemicals), installation, maintenance and dismantling (EEA, 2013; EU-OSHA, 2013b, 2014a,b).
- The shift to renewables will change recycling and waste streams. For wind power, recycling of glass-fibre-composite turbine blades represents a (solvable) challenge (Wind Europe, 2020; Windpower Monthly, 2020).
- Recycling of PV panels — which in Europe will reach their end of life on a large scale in 2035 — remains insufficiently explored (in particular the safety-relevant leaching from broken panels of, for example, cadmium telluride, a known carcinogen), and considerable differences exist in the necessary treatment of small-scale and larger units. Here, the necessary practices still need to be developed (Franz and Piringer, 2020).
- Recycling of lithium-ion batteries is also difficult because of the lack of standardisation (Thompson et al., 2020). New storage technologies currently under development will also present challenges (Battery 2030, 2020).
- Energy storage in batteries creates OSH challenges in maintenance and recycling, with a broad range of risks (fire, chemical leakage, etc.) (INRS, 2019a).
- Biogas (methanisation) involves pathogens and the risk of ingestion/inhalation (INRS, 2019a).
- Production of advanced biofuels ('second-generation', made from non-food biomass), which is to increase from 0.5 to 3.6 % of gross energy consumption in transport in the EU by 2030 (European Commission, 2019b), may involve the use of nanomaterials with unexplored specific risks (Khoo et al., 2020).
- The decommissioning of old power plants is also associated with OSH-relevant physical and chemical risks (release of asbestos, etc.) (Geigle Safety Group, 2020). In the case of nuclear power plants, there are also radiological risks (Kim et al., 2020).
- The procedure for the decommissioning of oil wells and fields in the North Sea in the coming decades is still a subject of debate. If dismantling is chosen over scuttling, the relevant work would be hazardous. In addition, any downturn prior to decommissioning would mean the loss of valuable skilled and knowledgeable workers (Offshore, 2020).
- High-voltage batteries in electric vehicles present new risks for car mechanics, breakdown recovery staff and rescue personnel, but little research on the subject exists as regards best practices and actual frequency of incidents (Linja-aho, 2020).
- Should e-vehicles enter the market in great numbers over a short timespan, major reskilling efforts would be necessary (Linja-aho, 2020).

Projection 1: Renewable energy at all costs
The worsening environmental crisis pushes EU nations to quicken their transition to renewable energy generation. Old, carbon-heavy, energy generators are dismantled as renewable energy infrastructure is hastily erected. Throughout these hazardous processes, little consideration is given to workers' rights.

Projection 2: Little progress on any front
The transition to renewable energy generation faces many setbacks along the way, including opposition from workers' rights advocates. Seemingly stuck in a deadlock, neither energy transition nor workers' rights progress at more than a snail's pace.

Projection 3: EU leads the way towards renewables
With the transition to renewable energy progressing either in line or ahead of targets in the EU, the EU is seen as the global environmental leader. As such, EU nations carry out closer scrutiny and take extra care to ensure that workers' rights are being upheld — lest any scandal detract from their leading reputation.

4.1.12   Regulation

Brief description and definition
Sustainability movements are emphasising the need for stronger, less laissez-faire regulation that focuses more on the environment and workers' rights. Increasingly, governments are realising that incremental change is not enough, and that strict new regulations and a more hands-on approach may be necessary (i.e. placing taxation on the extraction and exploitation of raw materials — as opposed to on labour).

Expected/potential future developments
- Through political pressure, European sustainability movements have during the past half-century achieved several significant legislative successes (banning of leaded petrol and nuclear testing, much reduced pollution of waterways, combating ozone hole formation and acid rain, etc.) (*Guardian*, 2020).
- In recent years, the reach of sustainability movements (e.g. Fridays for Future) has increased, while Green parties have enjoyed considerable gains in both national and European elections, boosting their programmatic influence going forward (*Guardian*, 2019). Environmental issues have broad support in the EU population: 94 % say the environment is important to them, with 53 % considering climate change the most important issue (46 % air pollution, 46 % waste), 33 % willing to change the way we consume (31 % the way we produce and trade) and 83 % agreeing that EU legislation is necessary to protect the environment in their country (Eurobarometer, 2019a).
- Over the past decades, the EU has, through directives and regulations, enforced a set of social and economic policies that are binding for its Member States (European Commission, 2012).
- By taking action against Member States that fail to ensure that EU standards are achieved, the EU has transformed national policies in some areas, most notably the environment and labour rights (European Commission, 2020f). The EU's role as a driver of progressive policies is underlined by the fact that Brexit is generally expected to lead to a lowering of environmental and worker protection standards in the United Kingdom (FES, 2017; UCE, 2020).
- Today, EU environmental policy is characterised by regulatory flexibility and meta-regulation, pluralistic regulation and collaborative governance (involvement of stakeholder groups). The original approach of prohibiting or restricting harmful activities, and imposing penalties if targets were not met, was replaced in the 1990s by fiscal (environmental taxes, charges and subsidies) and quantity instruments (tradeable permit schemes), which were employed, among other sectors, in waste management (Cairn, 2012).
- The EU has an ability to globalise the rules for the common market ('The Brussels Effect'), in particular regarding environmental standards and the regulation of technology (more than 100 countries have adopted privacy rules modelled on the GDPR (General Data Protection Regulation), and REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) and car standards have been similarly adopted) (MSB, 2020).
- The EU's aim of becoming a 'climate-neutral continent' by 2050 requires drastic legal measures to be taken (European Commission, 2020g).
- With a view to the expanding online platform economy, more sufficient protection for the self-employed has become necessary (RSA, 2019). Hence, demands that 'safety and health at work [should] be recognised as a fundamental principle and right at work' are becoming more vocal (ILO, 2019a, p. 13). Workers' rights are also closely connected to environmental protection: 'OSH standards provide a significant body of rules aimed at the protection of the environment' (ILO, 2018b, p. 75).

- However, the 'one in-one out' principle (where one old law or piece of regulation is removed for each new one introduced) of the new European Commission (aimed at a 'lean' bureaucracy) has been considered 'incompatible' with effective environmental legislation, as the principle would force law-makers to scrap one measure before they could introduce a new one, placing an undue burden on environmental legislation (Green 10, 2019).
- The COVID-19 pandemic has, on the one hand, given lobbyists the opportunity to call for a rollback of environmental standards to boost near-to-mid economic recovery (DW, 2020; EEB, 2020; OD, 2020); on the other hand, it has given rise to calls for making the European Green Deal central to recovery efforts (CHN, 2020).

Relevance and potential implications for OSH
- Strict legislative standards would offer an opportunity to build databases for all materials, reducing hazards in recycling (Ellen MacArthur Foundation, 2017b).
- A push for increased standardisation to reduce e-waste (cf. current efforts to standardise chargers for mobile phones, etc.) would also significantly reduce current recycling hazards, e.g. in the case of e-vehicle batteries (Thompson et al., 2020).
- Similarly, planned amendments to and tightening of REACH (and other provisions intended to improve information on the chemical content of products) would also positively impact OSH both upstream — in that products are to be safe and sustainable by design — and downstream — increased safety of and trust in recycled materials and products (European Commission, 2020i).
- Better integration of OSH considerations into the drafting of environmental legislation is a key concern going forward (ILO, 2018b, 2019a), as current legislation does not sufficiently focus on the occupational health and safety of workers (EPSU, 2020).

Projection 1: Environment above all else
With increased public focus on climate change and the environment, the EU introduces ambitious targets and strict new regulations aimed at hastening the transition to carbon neutrality (and a CE). In the haste to improve environmental outcomes, little consideration is given to workers' rights and the quality of jobs in affected industries.

Projection 2: Safer environments, safer workplaces
The push to create more sustainable economies goes hand in hand with workers' rights in the EU. Tightened regulation in both spheres leads to better environmental and workers' outcomes across EU nations.

Projection 3: Degrading environments and workplaces
Industry pushback and weak political will thwart attempts at strengthening regulation across the board. The environment and workers' rights suffer as a consequence.

Projection 4: Workers' rights prioritised
With other issues, such as pandemics and economic crises, stealing public and political attention, the transition towards sustainable societies goes on the back-burner. The ability of workers to safely keep the economy running is prioritised, however, and workers' rights increase as a result.

4.1.13   From globalisation to localisation

Brief description and definition
While globalisation has shown fairly steady growth since the 1980s, some indicators show that this trend may be slowing or even reversing (due to numerous factors, such as rising protectionism, loss of confidence in international trade, offshoring vs. reshoring and the COVID-19 pandemic). Alongside these developments, owing to the combination of rising awareness of environmental impacts and waste exports no longer being accepted in the previous destination countries, a considerable, sustained increase in recycling quotas is expected — which might need to be managed and processed closer to home.

Expected/potential future developments

- In the past two decades, public criticism of globalisation has increased in Europe (see, in particular, the 2016 protests against the Transatlantic Trade and Investment Partnership (TTIP) (IW, 2016)), primarily on the grounds that a higher economic integration reduces national autonomy (e.g. Brexit was considered by its proponents as a vote for national sovereignty) (IFO, 2020). However, even though negative attitudes have increased (by 5 %) it remains a minority view, with a majority of Europeans (6 in 10) continuing to believe that they benefit from international trade (Eurobarometer, 2019b).
- Technological progress, primarily in automation and 3D printing, makes production closer to the final consumer cheaper. Similarly, calls for greener supply chains have resulted in companies shortening supply chains and reducing their exposure to cross-border supply chain disruptions (Chatham House, 2020b).
- The COVID-19 pandemic exposed the fragility of global supply chains and resulted in the 'largest and fastest decline in international flows in modern history' (HBR, 2020, para. 2), with a drop of up to a third in international trade (ibid.). Calls for greater European self-reliance have increased, in particular in vulnerable sectors such as medical supplies (SB, 2020). On the other hand, the pre-COVID slowdown in international information flows was replaced by rapid growth, signifying that people, companies and countries remain prepared to do business with each other (DHL, 2021).
- The nature of globalisation is changing. Over the past 15 years, manufacturing globalisation declined, while information globalisation ('e-globalisation') increased. This development is expected to continue (ECIPE, 2020).
- The decade to 2030 is likely to prove one of transformation for globalised trade. Reshoring, regionalisation, diversification (as opposed to specialisation) and replication will bring shorter and less fragmented value chains (from global to regional value chains) and a shift to smaller scale, distributed manufacturing (e.g. based on 3D printing) (Unctad, 2020).
- Recycling streams are also expected to be regionalised by 2030, in particular as a result of the EU ban on plastic waste exports (European Commission, 2020k). Stakeholder calls for a similar ban on e-waste (waste from electrical and electronic equipment; WEEE) exports are growing, but currently e-waste continues to be exported (BAN, 2020). Recycling will have to increase significantly up to 2030; however, it is not yet growing sufficiently as an industry (McKinsey, 2020b).

Relevance and potential implications for OSH

- More regionalised supply chains offer the opportunity to improve cradle-to-grave documentation and enforce more stringent safety standards, as well as increased supervision, which, regarding recycling in particular, would be positive for OSH.
- Current plastics recycling capacities in Europe are insufficient to handle the much higher regionalised plastics streams expected for the next decade. This may lead to waste being handled by inexperienced companies with mismatched skills, increasing OSH hazards (McKinsey, 2020b; EPSU, 2017).
- Similarly, WEEE recycling capacities in the EU will have to be expanded rapidly, potentially leading to similar OSH issues (EPSU, 2017; Cesaro et al., 2018).
- If the reshoring of manufacturing should lead to an expansion in 3D printing, in particular with regard to small-scale localised production, considerable new health hazards would emerge (exposure to chemicals and metal powders, harmful emissions, operation in casual working locations, unschooled personnel lacking safety consciousness, heat) (EU-OSHA, 2017d; ETS, 2020; NTRC, 2020a, b), while some hazards connected to mechanical manufacturing (operation of lathes and saws) would be reduced (ETS, 2020).
- Extreme relocalisation and a breakdown of globalisation may result in materials shortages. Ersatz inputs could be of insufficient quality and lead to OSH hazards during manufacturing and operation.

Projection 1: Globalisation drives outsourcing

The strength of existing global value chains and multilateral partnerships drives the stable trend of increasing globalisation. In tandem, there is the increasing practice of outsourcing waste management and processing to other world regions. This has little impact on working conditions in the EU.

Projection 2: Protectionism drives localisation
Globalisation is slowly retreating owing to a combination of factors, including the continued rise in trade-restrictive measures and trade disruptions caused by the COVID-19 pandemic. As international supply chains (and relations) break down, EU countries are forced to process waste within the European bloc. With a workforce inexperienced in managing (and ill-equipped to manage) such levels of waste, working conditions worsen in the waste industry of poorer EU states.

Projection 3: EU as waste recipient
The increasing significance of multilateral trade decisions (reached jointly by multiple political players) drives globalisation and has the potential to bring about a new global balance of power. The shift in the location of economic power and consumer markets towards Asia transforms markets and economies on the continent — leading to increased levels of consumerism and waste. The EU's efficient waste processing plants (including waste-to-energy plants) are increasingly accepting waste from Asia. However, high value is put on workers' rights in these areas.

Projection 4: Disparity between EU nations
Fears of a trade war between the United States and China remain high. Some countries, including the United States, the United Kingdom, China, Russia and India, continue to enact more protectionist measures. Within the EU, policies continue to be driven by free trade and market forces, leading to the outsourcing of waste processing to poorer regions.

4.1.14 Public funding uncertainty

Brief description and definition
With competing pressures for public funding from government budgets that are already stretched as a result of financial crises and the COVID-19 response efforts, public infrastructure and programmes face insufficient (and dwindling) expenditure. Alongside competing funding pressures, rising political uncertainty impacts on public programmes, which may be here today but gone tomorrow.

Expected/potential future developments
- The impact of the COVID-19 pandemic has resulted in record budget deficits in almost all European nations, with a contraction in EU GDP of at least 7.5 %, significantly higher than during the financial crisis of 2007-08 (EU-DGEFA, 2020).
- In the aftermath of the financial crisis of 2009, many European nations opted for austerity programmes that reduced spending on, and the scope of, public programmes (public transport, education, social security, etc.) and resulted in privatisation (e.g. public housing) (Cabral et al., 2013).
- Over the near to mid-term future, the guarantees and loans undertaken by European governments as part of emergency measures during the COVID-19 crisis will have a sustained negative impact on public finance (ECB, 2021).
- The post-COVID-19 period is considered to provide a 'once-in-a-lifetime opportunity for the EU' to transition towards a circular and climate neutral economy (EU-DGIP, 2020). Under its 'Next Generation' recovery plan (in addition to its Recovery and Resilience Facility), the EU will provide loans and grants to Member States for projects that promise a green dividend (e.g. CO_2-focused building renovation programmes or subsidies for PV installations), while reskilling measures will be supported by the JTM (ibid.).
- With European public expenditures expanding over the near term while tax revenue remains flat or below pre-COVID-19 levels, fiscal deficits will surge (during the 2007-08 crisis, debt ratios in the eurozone 'rose from 65.9 % of GDP in 2007 to around 93 % five years later' (ING, 2020)). This vastly increases debt sustainability risks (EU-DGEFA, 2021), which may force most European nations to return to austerity measures, or at the very least severely limit the scope of their discretionary spending, in the run-up to 2030. Internationally, the International Monetary Fund has already tied its COVID-19 loans to poor countries to subsequent austerity measures (Oxfam, 2020).
- The COVID-19 pandemic may also have an 'economic hangover'; with employment, wage growth and consumption sustainably suppressed (ECB, 2020), this results in a smaller tax base and reduced tax incomes, which further diminish room for discretionary spending.
- While populism lost some of its lustre in Europe during the COVID-19 crisis, the underlying root drivers of (primarily right-wing) populism have not been negatively affected (Vieten, 2020), while some may even be exacerbated: unemployment, inequality and (as a consequence)

political dissatisfaction (Burni, 2021). This would make populist takeovers more likely (Kelly, 2020).

- Populist actors in Europe are overwhelmingly opposed to the EU's climate policy; they also, as a rule, do not enact national climate policies when in power and demand an end to such policies when in opposition (Adelphi, 2019). It is hence unlikely that major programmes to mitigate climate change would survive a populist takeover.

Relevance and potential implications for OSH
- Populist parties and policies have been shown to be detrimental to working standards and workers' rights, including OSH (Cumming et al., 2020).
- Austerity measures would likely reduce the number of OSH inspections: during the United Kingdom's period of austerity following the last financial crisis, budgets for health and safety inspections in the infrastructure industry were cut by 35 %, resulting in a doubling of industrial incidents in building sites and the loss of relevant skills (Papertrail, 2016).
- Persistent unemployment after a crisis also leads to a loss of skills (including OSH-relevant skills) among the unemployed (Ramsden, 2021), and potentially greater willingness to engage in risky behaviour at the workplace to secure employment.
- Underfunding of public projects is likely to lead to increased safety and health hazards for workers tasked with maintaining public infrastructure.
- Should the JTM be cancelled or face significant budget cuts, workers leaving the fossil fuel value chain may not be able to participate in reskilling measures, resulting in inadequate OSH training.

Projection 1: Insufficient investment
With competing pressures for public spending, particularly from the health and social services sector, funding for green transition initiatives is deprioritised. Waste processing plants are increasingly in a state of disrepair, while the frequency of waste collection services is reduced. However, political unity remains high as citizens place their trust in science and democracy to help weather the growing economic crisis.

Projection 2: Strong support for green transition
With strong and stable government throughout almost all EU nations, consensus is found on a growing number of targets and initiatives. The green transition continues to be a flagship EU initiative, receiving ample funding to support the shift to a CE. However, little consideration is given to the working conditions of affected workers in the process.

Projection 3: Spending their way out of the economic crisis
After the COVID-19 crisis and following economic recession, many EU governments have taken the route of increased spending on public infrastructure and services in the hope of creating jobs and investing in people. Political uncertainty remains stable across the EU. However, it is clear that the governments that are boosting spending are enjoying longer parliamentary terms. Other, more austerity focused, governments have taken note and are likely to begin to follow suit.

4.1.15 Uncertainty and frequency of global catastrophes

Brief description and definition
In an increasingly interconnected world, catastrophes — either man-made (e.g. the global financial crisis) or natural (e.g. extreme weather events, COVID-19) — have far-reaching impacts that are extremely hard to plan for. Their consequences can be felt across supply chains and can strongly influence the health and safety of almost all global citizens — either directly or indirectly.

Expected/potential future developments
- As a result of climate change, the last 20 years brought a sharp increase in the number and severity of extreme weather events both worldwide and in Europe (EASAC, 2018; Germanwatch, 2021). While the impacts of severe weather events are not as devastating to European societies as to those in other regions, their effects are still considerable (with 72 200+ European casualties, the 2003 heatwave is the sixth worst natural disaster of the past two decades) (UNDRR, 2020) and mitigation requires costly countermeasures (Kron et al., 2019).
- Extreme weather events are expected to increase in severity and frequency in Europe. During the period 1981-2010, 5 % of the European population was affected by weather-related events

annually; this will gradually increase to two thirds by 2100. By 2050, the average number of additional deaths caused by heatwaves will soar to 90 000 per year in Europe (Kron et al., 2019).

- The weakening of the AMOC (Atlantic Meridional Overturning Circulation, i.e. Gulf Stream system) over the next two or three decades could also bring a further increase in extreme weather events beyond those already forecast, e.g. even higher frequency and severity of heatwaves and winter storms, and a further decrease in summer rainfall (PIK, 2021).
- Human destruction of biodiversity and human encroachment on natural habitats create the conditions for new viruses and diseases such as COVID-19. Unless land use changes, new pandemics with wide-ranging impacts are expected to occur more frequently in the future (Vidal, 2020).
- Since 2000, the global interconnectedness of national financial systems has continued to increase. But 'even though this trend has lessened somewhat since the global financial crisis', advanced economies in Europe are increasingly vulnerable to external shocks (DB, 2020). This makes global market crashes more likely in the future.
- Both the COVID-19 pandemic and the global financial crisis have demonstrated the vulnerability of a tightly intertwined and interdependent international system. This interconnectedness also increases the severity of cybersecurity risks. In the short term, the COVID-19-related increase in remote working considerably increases the likelihood of successful cyber-attacks. Malware and ransomware incidents in Europe have already grown by more than a third in 2020 (AGCS, 2020).

Relevance and potential implications for OSH
- During financial crises, 'safety [in the workplace] becomes a secondary issue', for both workers trying to find employment (often precarious work) when unemployment rates are high, and companies, especially smaller organisations under competitive pressure. Furthermore, there is a greater likelihood of labour law flexibilisation, which also impacts negatively on OSH (Boustras and Guldenmund, 2018).
- Widespread (blanket) cyber-attacks have the power to take down entire industries and cause regional outages (in particular if utilities are affected), which may make previously safe working environments hazardous and create OSH risks, the severity of which increase with automation (EU-OSHA, 2019a, 2021).
- The COVID-19 pandemic has demonstrated a lack of preparedness for the OSH issues that arise from pandemics. This concerns a lack of PPE (and other safety equipment in areas of critical concern for OSH in times of pandemics) and PPE safe usage practices; a lack of adequate collective technical and organisational prevention measures in workplaces; and, more generally, a lack of health and safety protocols for business, sectors and society as a whole, in particular with regard to collective decision-making (NFOWG, 2020; OECD, 2020c).
- Flooding may lead to the release of chemicals (WHO, 2018; CCPS, 2019).
- Heat can affect cooling, heating and ventilation, while cold temperatures will affect un-winterised equipment. Workers may lack the necessary OSH-relevant knowledge to deal with these conditions safely, in particular in regions unaccustomed to very high or low temperatures (WHO, 2017; ILO, 2019b; NDRC, 2020).

Projection 1: Austerity measures
Increased uncertainty surrounding the next global catastrophe leads EU governments to enact austerity measures in order to have sufficient funds set aside to manage potential future fallouts. This leads to reduced funding for implementing practices aimed at transitioning to a CE, and for ensuring the rights of workers.

Projection 2: Burgeoning informal economy
The toll is still being felt from the last global catastrophe, with unemployment at an all-time high in the EU. As a result, while workers' rights in most industries have remained unchanged, the growing informal economy is rife with poor working conditions and practices.

Projection 3: Health and safety the number 1 priority
The COVID-19 pandemic re-enforced the importance of having a strong and healthy EU workforce. As such, increased funding has been channelled into improving working conditions, including health and safety practices. Whatever crisis comes next, the health and safety of the people will be the highest priority.

5 The scenarios: European circular economies in 2040, with a first look at potential implications for OSH

With any scenario study it is important to highlight the desired role that the scenarios are created to fulfil, which is to encourage discussion around what these alternative pathways may imply for the future, and what that means for present-day options for action. They are meant to encourage dialogue and reflection with stakeholders around future possibilities, with the aim of informing today's policy- and decision-makers in an anticipatory manner. Thus, it needs to be stressed that these scenarios are not to be interpreted as any type of prediction on what the future might or might not be. It is also important to note that these scenarios are not to be taken as the final result of the project, but rather the first step towards the next phase of stakeholder engagement, reflecting in more depth on what the results imply for OSH research, initiatives and policy-making today.

The sections below outline the four scenarios on the CE in 2040 developed for this project, as well as providing a first look at potential implications for OSH. An illustrative vignette is provided for each scenario to help the reader insert themselves into daily life in 2040, while visuals depicting aspects of the scenario worlds are scattered throughout the text.
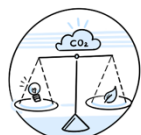
The roaring 40's – fully circular and inclusive	Carbon neutrality – of a hazardous kind	Staying afloat – amid economic and environmental crises	Regional Circularities – with European Divides
In 2040, the products that sell best are those that are cradle-to-cradle and "net-positive" in terms of social and environmental sustainability.	The year 2040 marks the achievement of carbon neutrality in Europe. But: With environmental outcomes having been prioritized above all else, this has often come at the expense of job quality and working conditions.	In 2040, the biggest concern for many is just having a job - not what the job entails. Most people are focused on keeping things afloat, so that there's little consideration for much else - neither the environment, social rights nor job quality.	In 2040, everyone knows: Contracted employees are well looked after, but those in non-standard employment are not. Neither is the environment, with circularity being mostly regional.

Illustration showing an overview of the four scenarios

5.1 Scenario 1: The Roaring 40s — fully circular and inclusive

In 2040, the products that sell best are those that are cradle to cradle and 'net positive' in terms of social and environmental sustainability.

The scenario in a nutshell
In the mid-2020s, EU policy-makers (and industry) reconsidered their spending to fundamentally focus on sustainability. This is 'serious sustainability' following the paradigm of a 'just transition', covering social as well as environmental aspects. As a consequence, working conditions have greatly improved alongside the strong and rapid rise of the CE, with the principle of reduce, reuse and repair — before recycling. Reuse rates have risen dramatically, driven by the embedment of circular design into product development, along with a shift towards digitally supported safety measures for work in these fields.

The circular economy and working conditions in Europe up to 2040:

This is the best of worlds — and in more ways than one. For too long, environmental, social and economic issues were engaged in a three-way tug of war: one side's gain was the others' loss. In Europe's CE of 2040, however, everyone wins. **Working conditions across all sectors are significantly better** than they were two decades ago; pollution has been reduced massively; businesses find that **keeping a small footprint is good for the balance sheet**; and public trust in policy-makers and national and European leaders is greater than ever. This cannot be said for the rest of the world — bar a few exemplary nations. However, even in Europe, the long and often difficult transition towards serious sustainability is by no means complete. Realising the principles of 'reduce, reuse, recycle' across all sectors takes a lot of collaborative fine-tuning, as does keeping workers safe and secure in the multifaceted labour environment with a myriad of platforms and forms of employment. But problems are there to be overcome, not to be a source of despair. One key difference compared with the situation in 2020 is a **palpable sense of optimism in the EU**: with so many challenges successfully met, the future cannot be anything other than bright.

When you are aiming for zero waste, the very first thing you should not let go to waste is a good crisis. As terrible as the COVID-19 pandemic at the beginning of the 2020s was, it gave EU Member State governments a chance to rethink the economy. The EU Green Deal brought the beginning of the end to scattergun approaches and untargeted subsidies. When national governments increased public spending to avoid a post-pandemic recession, they **focused on local and larger-scale sustainability initiatives, improving public infrastructure** — e.g. building a serious network of recharging stations for e-vehicles — **and boosting funding for the transition to renewables**. Businesses shortened and greened their supply chains, and workers who lost their jobs to new technologies were retrained under the **Just Transition Mechanism** (JTM) **JTM**. Additionally, **continent-wide enactment of social inclusion legislation** and the other EU Pillars of Social Rights made sure that no one was left behind.
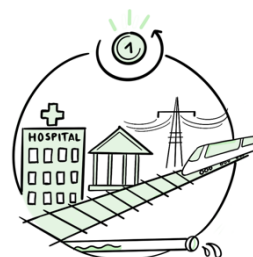
The European society of 2040, however, remains a consumer society — albeit one centred on ethical consumerism with high traceability of product origins and ecological impact, including that on the workers throughout the production chain. Thus, **consumers are finally 'walking the talk' when it comes to sustainability**; the information campaigns of the previous decades are paying off. People are now much more aware of the consequences of purchasing decisions, and **overwhelmingly opt for ethical products, even if they come with a price premium** (which, as a result of targeted policy interventions, happens less and less often). Similarly, **recycling rates are at an all-time high**. Now that all packaging has been reduced to a minimum and is clearly labelled, the great European recycling confusion is a thing of the past. Businesses are no longer content with greenwashing; **brands now primarily position themselves based on their ethical and environmental credentials**. They relish the challenges of **cutting-edge product design: creating a product that is durable, easy to repair and recycle, preferably made locally from renewable inputs, in safe environments with low-energy processes** is as close to squaring the circle as it sounds. However, the EU's 'closing the loop' has had repercussions in other world regions, namely those that exported raw materials to the EU or relied on Europe's waste exports as a source of income.

In the 2020s, **automation and digitalisation triggered a wave of retraining schemes for workers** made redundant as a result of efficiency gains. With businesses able to fill new positions with highly qualified applicants — including the best talent from abroad — the European economy moved steadily along and there was at least one new job for each job lost to rationalisation. Jobs became safer, too. **Hazardous tasks were automated and digital safety measures — including AI 'guardian angels' — now protect workers during all aspects of their jobs.** Environmental legislation, which had for so long been considered an obstacle to economic growth, proved to be a boon (at least in the
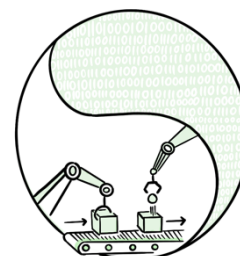
EU), as **low-resource inputs and use of secondary raw materials made Europe much less dependent on imports and less vulnerable to volatile resource prices**. By the 2030s, waste had become the largest import. **Europe's extremely efficient waste processing plants are global leaders in handling waste.** The industry is now highly regarded, not least for the safe, well-paid jobs it offers. The EU has even paid out reparations to other world regions that have struggled with the loss of income in their waste processing sectors.
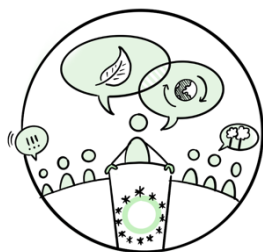
As far as Europe has come, there will always be room for improvement. Some of the old energy installations have still to be dismantled — a hazardous and costly process, in particular regarding the abandoned oil wells in the North Sea. And no matter how much we may have reduced construction waste, fully recyclable buildings are still some time away. But we are continuing to move forward: **new materials emerge all the time, and, no matter how positive their qualities may be, health hazards and recyclability must be tested prior to market introduction.** However, even though the transition to renewable energy was managed in step with virtually all the ambitious schedules and Europe is now almost carbon neutral, the impact of climate change is still felt across the continent, during the summer heatwaves in particular. Yet, as recklessly as people may have behaved in the past, now **everyone is aware of how closely their own well-being is connected to that of the environment**.

A glimpse into daily life in 2040:
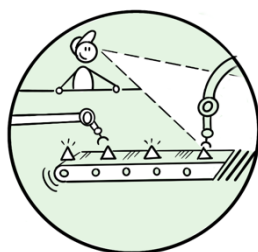
Aurélio Pereira, urban miner, Lisbon
'I can honestly say that I like what I do. Urban mining is never not interesting. There are so many positive facets of the job, and with your AI companion to manage risks and procedures (not to mention your schedule), it's a guaranteed safe workplace where you do not have to worry too much! Urban mining is both a hands-on and desk job. I used to be a surveyor before that work became automated — like so many other professions. I retrained under the Just Transition Mechanism. To be a successful miner you need experience, you have to know how buildings used to be constructed, and you always have to be able to find workarounds. Oh, and you need to be able to read old plans. When was something made? Can it be safely recycled and used? Can you get it out safely, separate it cleanly? Once you have established that, had your samples tested, you move on to the desk part of the work: it's time to find a recycler, a buyer or a leaser, hire a platform crew, while getting everything done with the builder breathing down your neck because they want to get going NOW with retrofitting and rebuilding. There are other enjoyable parts of the job as well: over the next three months, I'm going to be doing a material flow analysis for a small town near Salamanca to determine its urban metabolism. As I said, it's never boring.'

General implications for OSH from the scenario narrative:

- **Green energy transition**
  - During the rapid energy transition, energy production by SMEs (PV roof panels, organic production wastes for biomass) may be handled by staff **lacking OSH-relevant skills**, while new entrants to the industry will possibly not always follow best practices (EU-OSHA, 2013a).
  - Wind turbines (esp. offshore) are associated with **specific hazards** during production (chemicals), installation, maintenance and dismantling (EEA, 2013; EU-OSHA, 2013b, 2014a,b).
  - Biogas (methanisation) involves pathogens that carry a significant health risk if ingested/inhaled (INRS, 2019a), while advanced ('second generation') biofuels may involve the use of nanomaterials with **unexplored risks, particularly** during the first stages of implementation (Khoo et al., 2020).
  - Decommissioning old power plants carries **physical and chemical risks** (Geigle Safety Group, 2020). Decommissioning of old oil wells and fields in the North Sea is also hazardous, and would become more so if a prior downturn meant that valuable skilled/knowledgeable workers were lost (Offshore, 2020).

- **Challenges to recycling**
  - Changed recycling and waste streams: for wind power, **recycling challenges** include the glass-fibre-composite turbine blades (Wind Europe, 2020; Windpower Monthly, 2020), while recycling of PV panels (end of life to be reached on a large scale from 2035 onwards) remains **insufficiently explored** (leaching from broken panels in particular) (Franz and Piringer, 2020).
  - Maintenance (in automobile repair workshops), recycling and handling during emergencies (fire risk for first responders) of lithium-ion batteries is difficult; the **lack of standardisation** contributes to this (Thompson et al., 2020). New storage technologies currently under development will also **present challenges** (INRS, 2019a; Battery 2030, 2020; Linja-aho, 2020).
  - Repeated recycling cycles may lead to the breakdown of chemicals (**hazard for waste workers**) and impurities in secondary raw materials.
  - Importing waste from other regions carries the **risk of impure/falsely declared waste items**.
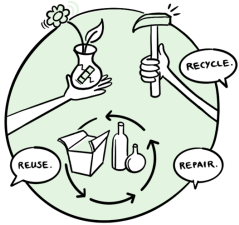
- **Digitalisation, automation, AI and robotics**
  - With information considered 'fuel for a sustainable economy' (EPC, 2020), worker safety in many areas will depend on **precise and timely provision of data** travelling with products downstream (to determine waste stream contents, safety of products with extended life cycles, etc.).
  - To enable a shift to a CE, a high level of digitalisation is required. As digital technologies permeate workplaces, **physical hazards are likely to decrease** (particularly in the waste sector, e.g. in waste-sorting tasks, and in the construction sector, e.g. in inspection tasks). Indirect risks will likely also decrease because of fewer commutes, for example. However, these could be partially offset by the **higher psychosocial risks** that can emerge in highly digitalised work environments (e.g. 'lone-working', perceived job insecurity and increased stress at the workplace (ILO, 2019a,b)).
  - Automation promises to **reduce hazard exposure** (in waste processing, etc.) (JRC, 2019), but may outpace risk assessment, e.g. with regard to road safety compliance of autonomous vehicles in domestic waste management (RSA, 2019). **Human-robot interaction may lead to increased risks in the workplace** (e.g. through workers over- or underestimating robot capabilities and situational awareness) (ILO, 2019b), in particular if the integration of AI and robots makes robots less predictable (EU-OSHA, 2021). Similarly, **overreliance may lead to deskilling** (EU-OSHA, 2019a, 2021) and **increased cybersecurity issues** (EU-OSHA, 2019a, 202).
  - With AI playing a key role in the transition to a CE (design of circular products, management of circular business models and infrastructure) (McKinsey, 2019b), its proliferation may increase material and immaterial safety risks unless a strict regulatory framework is in place (see European Commission, 2020j). Other **AI-related OSH hazards** come from AI often sharing its programmers' blind spots, which could result in discrimination embedded into algorithmic systems (PwC, 2020). In addition, tests have shown that human operators may override robots and AI in critical situations and ignore warnings (CIPD, 2021), or may have less experience in critical situations. Monitoring by AI **potentially improves safety, but also increases surveillance stress** (EU-OSHA, 2017a, 2019a, 2021), which, in a CE, will probably have the largest impacts on workers in the transport and waste collection sector.
  - Exoskeletons help to reduce the amount of time spent in tiring or painful positions (EU-OSHA, 2019a), and smart protective equipment has the potential to offer **increased safety for workers** (EU-OSHA, 2020c).

- **Regulation**
  - Strict legislative standards would offer an **opportunity to build databases for all materials**, reducing hazards in recycling (Ellen MacArthur Foundation, 2017a).
  - A push for **increased standardisation to reduce e-waste** (cf. current efforts to standardise chargers for mobile phones, etc.) would also significantly reduce current recycling hazards, e.g. in the case of e-vehicle batteries (Thompson et al., 2020).
  - Similarly, planned amendments to and tightening of REACH (and other provisions intended to improve information on the chemical content of products) would also positively impact OSH both upstream — in that products are to be safe and sustainable

by design — and downstream, **with increased safety of and trust in recycled materials and products** (European Commission, 2020k).

o A better integration of OSH considerations into the drafting of environmental legislation is a key concern going forward (ILO, 2018b, 2019a), as current legislation does not sufficiently focus on the occupational health and safety of workers (EPSU, 2020).

Circular economy-specific OSH implications from the scenario across example sectors[22]

The Roaring 40s — fully circular and inclusive	**What the CE means in the scenario:**
	• Strong and far-reaching EU CE realisation and diffusion, with new actors emerging and a massively reorganised value chain
	• Increased spending on public infrastructure and services to create jobs
	• EU becomes global environmental leader
	• Push for digitisation and automation
	• Strong increase in reuse, repair and recycling
	• New system design integrates safety and prevention principles
Energy sector	• Specific hazards and risks can arise from renewable energy generation (i.e. wind, solar, tidal), including in production, installation, maintenance and dismantling
	• Next-generation biogas and biofuels carry risk of pathogens and other unexplored risks (e.g. nanomaterials in biofuel)
	• Expansion of energy storage (batteries, hydrogen, advanced technologies) results in new operating and recycling risks
Transport sector	• Integration of autonomous vehicles reduces risks to drivers in particularly hazardous environments
	• Load level optimisation reduces risks of accidents for both drivers and loaders
	• Digital platforms to reduce transport without load and service interruption can lead to longer times between breaks for drivers
Manufacturing sector	• Distributed/localised manufacturing can lead to cluttered OSH landscape, fragmented work environments and work relations, as well as diffusion of responsibility
	• New technologies (3D printing, etc.) and new materials may have unexplored risks
	• Automation (a key enabler of the CE) promises to reduce hazard exposure but may outpace risk assessment, e.g. in road safety compliance of autonomous vehicles in domestic waste management.

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[22] While broader OSH implications of the scenarios, including implications of the major aspects of the scenario world, i.e. climate change, increased digitalisation, etc., are listed under each scenario narrative, in these sections we outline CE-specific aspects of each scenario across individual sectors. The sectors covered follow those outlined in EU-OSHA (2013a): energy; transport; manufacturing; construction; agriculture, forestry and food; and waste, recycling and environmental remediation. In cases where implications are conceivable across more than one sector, they are provided under the sector where the implication is most relevant or where it is likely to have the highest impact.

Construction sector	• Promotion of sustainable buildings (low energy consumption and high efficiency) favours innovation in the construction sector, with new materials carrying potential new risks • Renewable materials (e.g. wood, fungi for insulation, etc.) result in new risks during construction and use • As different economic sectors are likely to be affected by resource efficiency policies in different ways, the structure of the economy is likely to change. Increased recycling may lead to a reduction in the number of jobs in material-intensive sectors, e.g. construction, an accident-intensive sector (see, for example, OECD, 2020a), thus reducing overall incidence rates
Agriculture, forestry and food sectors	• As the use of pesticides and insecticides reduces, workers face fewer concomitant OSH hazards. Similarly, as livestock husbandry transitions to lower density, there are fewer risks from, for example, zoonoses, injuries (bites, kicking, etc.) and exposure to harmful substances/products • Smart farming/digitalisation improves process control, thus reducing risks. However, with fewer workers and more machinery/technology, mental stresses are likely to increase • Expansion of biogas facilities to reduce and better manage agricultural solid wastes may result in farmers being confronted with new OSH risks (e.g. the ingestion/inhalation of pathogens)
Waste, recycling and environmental remediation sectors	• Repeated recycling cycles may lead to the breakdown of chemicals (hazard for waste workers) and impurities in secondary raw materials • Importing waste from other regions carries the risk of impure/falsely declared waste items, thus increasing risk to workers • Highly automated waste processes, in particular with regard to the most hazardous steps, can greatly reduce physical risks to personnel (however, psychosocial risks could rise)

Insight into an example occupation in 2040[23]

Example occupation: renewable energy maintenance worker within the energy sector

Phone call between the union representative of solar maintenance workers and a maintenance worker (names withheld for privacy reasons), 1.6.2040:

Maintenance worker: 'Kind of you to ask, but no, I'm not worried about anything. I like it up here — you're never as free as when you're on a rooftop somewhere, the city at your feet, looking down on the pocket parks and urban farms — and I do feel safe. Sometimes, when you hear about the accidents people had two decades ago when the first serious urban PV installations started; it feels ridiculous, or horrifying. People working with helmets and hi-vis vests only, no airbag, nothing. Plus, it sounds like no one was ultimately responsible for them. I have Eugene watching over me …'

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[23] This section highlights OSH-relevant changes for an example occupation via a mini scenario vignette within each of the scenarios. For each scenario, the sector where change resulting from the CE is likely to be comparatively significant under the conditions of the scenario was chosen as an example. Example occupations were identified by mapping the sectors and drawing information from across the publications reviewed, as well as the expert interviews. However, the statements made here are to be regarded as assumptions-based, i.e. not predictive but drawing from a systematic set of assumptions developed for each of the scenarios and providing information on selected occupations where change is probably most dominant (under the given assumptions).

Union representative: 'Eugene?'

Maintenance worker: 'My safety AI! I call her Eugene. She's a worrier. Constantly checking my surroundings and my work — if a load is too heavy, she makes me get out the exoskeleton and checks my vitals to see whether I'm pushing myself too hard. She even gives positive feedback at the end of the day! And if someone somewhere in Europe develops a new best practice, she knows almost immediately. Then, the moment I have a similar task, there's the new step-by-step guidelines popping up in my smart-visor. I always notice how much I rely on her when I log out at the end of the day, and bang! The next thing I do is walk almost straight into traffic because there's no one telling me not to …'

5.2 Scenario 2: Carbon neutrality — of a hazardous kind

The year 2040 marks the achievement of carbon neutrality in Europe: but, with environmental outcomes having been prioritised above all else, this has often come at the expense of job quality and working conditions.

The scenario in a nutshell
The 2020s marked the beginning of a shift in consciousness among individuals and policy-makers alike. The warming climate, extreme weather events and habitat loss took centre stage in the early 2020s, leading to a new age of eco-consciousness. This new age has led to a surge in environmental regulation and environmentally friendly industry practices, but failed to combine adequate social aspects along the way. With the bulk of funding directed towards erecting renewable energy infrastructure and promoting CE initiatives, little was left for workers at the bottom of the barrel. As a result of the subsequent reductions in funding for social infrastructure and services, social rights, inclusion and job quality have declined for many.

The circular economy and working conditions in Europe up to 2040:

When the EU agreed on tougher climate goals late in 2020, one criticism levelled at the new climate laws was that the net-zero emissions target intended for 2050 would come too late to limit global warming to a bearable 1.5 °C. But that was before the **catastrophic heatwaves that scorched the continent** in the years that followed, devastating harvests and causing record deaths due to the extreme heat — even in northern Member States. **Carbon neutrality had to come sooner; in fact, it could not come fast enough**. The EU rapidly set new targets, pushing the net-zero emissions goal forward by 15 years to 2035. All other priorities were swept aside, and the race was on. The **measures rapidly adapted in the mid-2020s focused on renewable energies and, to a lesser degree, the transition to a circular economy — at any cost.**

Looking back from 2040, it seems remarkable how much was achieved in such a short time regarding the green energy transition: in little more than a decade, **Europe reached 100 % renewables**. Policy-makers felt emboldened to enact **environmental legislation that brought an end to carbon-heavy energy generation** and paved the way for the mainstreaming of e-vehicles, with a dense network of recharging stations set up all over Europe. Fossil fuel cars had to be rapidly phased out, often at a loss to their owners and major brand car-makers. **SMEs were encouraged to produce their own energy using PVs or biogas,** but, with micro-installations popping up everywhere, fly-by-night operators were commonplace. Large PV and wind energy power plants were put up in record time. Today, however, **these are ageing rapidly, putting workers at risk during inspections and maintenance.** One unplanned effect was the sense of purpose the successful green transition instilled among Member States — the EU's new position as a global environmental leader became a source of pride. It is not that the rest of the globe did not try to be hot on the EU's heels, as the effects of climate change were felt in every world region; it was just that no other nation or pact was able to match the EU's pace. In fact, there were few delays in making national Member State legislation conform with the new EU standards; the influence of grass-roots communities on policy-making had never been greater.
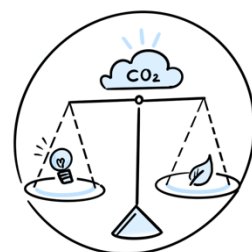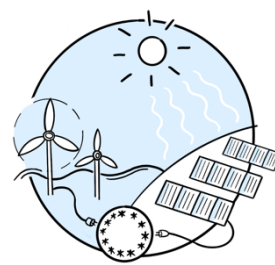
CE initiatives, too, were promoted heavily. Cities began to set up local networks, often creating their own standards and systems. Recycling increased, but, as processing capacities failed to keep pace with growing volumes, **large amounts of waste continued to be exported to and processed in other world regions**, occasionally triggering quality complaints about the secondary raw materials reimported into the EU. Per-capita consumption also grew, albeit much more slowly, and **people were much more willing to base their purchasing decisions on environmental factors**. Grass-roots movements pressured manufacturers and service providers to green their processes more thoroughly, often **leading to new regulations and industry practices that further shrank ecological footprints**. Both **for-profit and peer-to-peer sharing boomed**, and by 2030 'ownership shame' had become the new 'flight shame'.

Today, the **EU's economy is also much more localised and decentralised** than it used to be. In the 2020s, **digital technologies and automation were used to reduce the length of supply chains**, putting an end to the long rows of lorries cluttering the right-hand lanes of motorways all over Europe. **Work is located everywhere, and workers are widely dispersed, even if they work for the same company.** 'Lone working' is a frequent source of complaints, and, with in-person supervision impossible, **employers rely on AI and other monitoring software to manage workers and workplaces**. But as good as the employment situation is, workers have little say when it comes to aspects of inclusion, job quality and social rights.
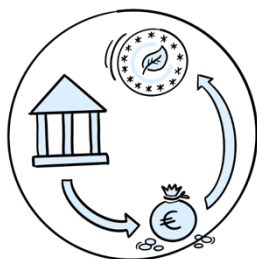
With the bulk of both public and private funding directed towards environmental initiatives, worker well-being continues to decline year on year. The cuts to mental health and social services funding were one lasting effect of the austerity measures enacted during the 2020s and 2030s. And with the few remaining social infrastructures and services in the community hollowed out and overloaded — there's talk of a mental health pandemic, particularly among those under 40, who have arguably been under a lot of pressure in their short working lives, especially with the COVID-19 pandemic and climate disasters. In the end, however, **it all boils down to a matter of priorities, and in Europe it's the environment that takes the top spot.**

A glimpse into daily life in 2040:

24 May 2040, Pforzheimer Zeitung
On Friday, an accident at a 3D fabricators in the village of Neuhausen, Baden-Württemberg, led to the release of large quantities of chemical powder into the local environment and resulted in the issuing of a 'stay indoors' directive to all residents in the district of Enz for a 72-hour period. All staff from the printing factory for surgical devices are receiving medical care at the Helios Klinikum Pforzheim, with reports that two employees remain in the critical care unit at the hospital. After two days of investigation at the printing factory, local environmental officials have now determined that the cause of the explosion was a power surge that occurred as the result of a faulty PV micro-installation. Relevant regulations for the maintenance of the city's sole energy generation station (built in 2028) had not been followed, and automatic monitoring had failed to detect the malfunction. The fabricator will remain out of operation for the next four days; all urgent print jobs will be automatically rerouted to a local 3D printing installation in the neighbouring village of Friolzheim. A federal environmental clean-up crew has been dispatched to contain the spillage. As yet, no statement has been issued regarding the extent of the damage, or a potentially irreversible impact on the surrounding region's air and soil quality, or waterways.
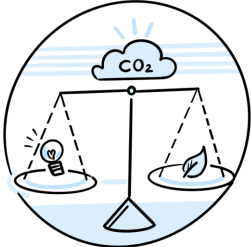
General implications for OSH from the scenario narrative:

- **Extreme weather and rising temperatures**
  - Both lead to negative health and safety effects, with **heat stress** being a major issue — particularly for those working outdoors. As temperatures rise, workers are also less likely to use PPE correctly (ILO, 2019b).
  - Cognitive activities also suffer under rising temperatures, leading to an increase in the likelihood of **accidental injuries** (ILO, 2018a).
  - Extreme weather events may also lead to (an increase in) **mental health issues** (post-traumatic stress disorder, anxiety, depression) (IEEP, 2020).
  - Flooding may lead to the **release of chemicals** (WHO, 2017; CCPS, 2019). Heat can affect cooling, heating and ventilation, while cold temperatures will affect un-winterised equipment. Workers may lack the necessary OSH-relevant knowledge to deal with these conditions safely, in particular in regions unaccustomed to very high or low temperatures (WHO, 2017; ILO, 2019b; NDRC, 2020).

- **Rapid energy transition**
  - Energy production by SMEs (PV roof panels, organic production of wastes for biomass) is likely to be handled by the company's own workers, who may not be fully familiar with OSH-relevant skills, while new entrants to the industry **will not always be familiar with basic risks and risk combinations** (EU-OSHA, 2013a).
  - Wind turbines, in particular offshore sites, are associated with **specific hazards** during production (hazardous chemicals), installation, maintenance and dismantling (EEA, 2013; EU-OSHA, 2013b, 2014a,b).
  - Biogas (methanisation) involves pathogens that carry a health risk if ingested/inhaled (INRS, 2019a), while advanced biofuels ('second generation', made from non-food biomass) may involve the use of **nanomaterials with unexplored specific risks** (Khoo et al., 2020).
  - Decommissioning of old power plants carries **physical and chemical risks** (Geigle Safety Group, 2020). Decommissioning of old oil wells and fields in the North Sea is

also hazardous, and would be more so if the downturn prior to decommissioning meant that valuable skilled/knowledgeable workers were lost (Offshore, 2020).

- o Use of new, unexplored materials (such as heat storage chemicals and new insulation in construction) could result in workers being **exposed to new substances** during installation, refurbishment or recycling activities (EU-OSHA, 2013a).

- **Challenges to recycling**
  - o Changed recycling and waste streams: for wind power, **recycling challenges** include the glass-fibre-composite turbine blades (Wind Europe, 2020; Windpower Monthly, 2020), while recycling of PV panels (end of life to be reached on a large scale from 2035 onwards) remains **insufficiently explored** (in particular the safety-relevant leaching from broken panels of, for example, cadmium telluride, a known carcinogen) (Franz and Piringer, 2020).
  - o Maintenance (in automobile repair workshops), recycling and handling during emergencies (fire risk for first responders) of lithium-ion batteries is difficult; the **lack of standardisation** contributes to this (Thompson et al., 2020). New storage technologies currently under development will also present challenges (INRS, 2019a; Battery 2030, 2020; Linja-aho, 2020).
  - o Austerity measures would likely **reduce the number of OSH inspections**: during the United Kingdom's period of austerity following the last financial crisis, budgets for health and safety inspections in the infrastructure industry were cut by 35 %, resulting in a doubling of industrial incidents in building sites and the loss of relevant skills (Papertrail, 2016).

- **Localised and decentralised economy**
  - o Sharing economy: users of P2P sharing services show a below-average concern for safety (Barbour et al., 2020). In addition, OSH training, supervision and rule **enforcement become considerably more difficult**.
  - o By selling services rather than products (in the sharing economy), the responsibility for the disposal of waste is transferred from the customer to the producer, which may **increase environmental risks** (EPSU, 2020).
  - o An expansion of 3D printing, in particular regarding small-scale localised production, would lead to the emergence of **new health hazards** (exposure to chemicals and metal powders, harmful emissions, operation in casual working locations, unschooled personnel lacking safety consciousness, heat) (EU-OSHA, 2017c; ETS, 2020; NTRC, 2020a,b).
  - o More regionalised supply chains offer the opportunity to improve cradle-to-grave documentation and **enforce more stringent safety standards**, as well as greater ease of OSH supervision.

Circular economy-specific OSH implications from the scenario across example sectors

Carbon neutrality — of a hazardous kind	**What the CE means in the scenario:** • EU-wide shift towards a CE, with ample government funding and support; digitalisation and new technologies help drive the transition • Ambitious targets for climate change adaptation and mitigation • Consumption levels rise much more slowly, with focus on ethical purchasing • Austerity measures in EU • Digital tech is everywhere, and work is abundant • Automation is relied on to improve workplace safety and health • New materials and recycling tech solutions are increasingly used
Energy sector	• Decommissioning of obsolete power plants carries physical and chemical risks • Use of new, unexplored materials (e.g. heat storage chemicals, new insulation in construction) could result in workers being exposed to new substances during installation, refurbishment or recycling activities • Nanomaterials from biofuels and other energy storage technologies present unique health challenges, in particular regarding ingestion and inhalation; furthermore, particulate nanomaterials in powder form may explode
Transport sector	• Peer-to-peer sharing of transport vehicles makes OSH training, supervision and rule enforcement considerably more difficult • Integration of hydrogen-powered heavy goods vehicles (HGVs) and hydrogen refuelling station networks increases risks of electrical shock and fuel flammability • Increased use of low-impact, natural and recyclable materials available in the local area minimises hazards in both the transport and recycling sectors, but may increase risks in other areas (i.e. changing product characteristics)
Manufacturing sector	• Expansion of 3D printing (and other new technologies) may lead to the emergence of new health hazards (exposure to chemicals and metal powders, harmful emissions, etc.) • New materials used in manufacturing inputs and processes may outpace risk assessment, resulting in workers confronting new and unexplored risks • More regionalised supply chains offer the opportunity to improve cradle-to-cradle documentation and enforce more stringent safety standards, as well as increased supervision
Construction sector	• In the transition stage to a CE, waste from construction and demolition that contains hazardous substances will need to be identified and removed from the building materials to allow for possible recycling purposes, thus increasing hazards faced by workers in the construction sector, but improving OSH outcomes down the value chain (i.e. waste sector) • Rapid introduction of new construction materials leads to workers being exposed to unforeseen risks during construction and maintenance • New technologies (e.g. brick-laying robots) often lack necessary safety features, thus presenting risks to operators

Agriculture, forestry and food sectors	• Reduction of external inputs in the production of agricultural commodities lessens risks associated with, for example, pesticide and fertiliser use • Reduction of negative discharges, such as waste and emissions in the environment, improves soil, water and air quality — reducing workers' exposure to pollutants • Processes and procedures aimed at reusing waste and increasing its value (e.g. heat, energy and nutrient recovery from mixed agricultural wastes) can result in new and unforeseen risks
Waste, recycling and environmental remediation sectors	• Changed recycling and waste streams as a result of the energy transition present new challenges, e.g. glass-fibre-composite turbine blades, safety-relevant leaching from broken PV panels • Lithium-ion batteries and other new battery storage technologies re likely to present challenges in handling, maintenance and recycling • New materials used in construction often focus solely on efficiency and can be difficult to recycle, while presenting new risks to waste processing workers

Insight into an example occupation in 2040

Example occupation: construction worker

Graffiti on the wall of a construction site on the outskirts of Rome, found in September 2040 by Lucio Zini, construction worker

'To all future colleagues, whatever you do, do not work here! The portable scanners do not detect a fraction of the stuff that's in these walls. This is not safe, and I think it's illegal. For your health and the health of your children, stay away! A friend'

5.3 Scenario 3: Staying afloat — amid economic and environmental crises

In 2040, the biggest concern for many is just having a job — and not what the job entails. Most people are focused on keeping things afloat, so there's little consideration for much else — not the environment, not social rights and not job quality.

The scenario in a nutshell

The 2040s are a decade when what many feared becomes a reality for most. An ongoing series of economic recessions, reduced public spending, environmental crises and rising unemployment are everyday headlines. Against this backdrop, business is ultimately conducted according to cost-effectiveness and profits. And while digitalisation has brought the promised rationalisation gains and some tech-based circularity measures, it has also brought along a vast pool of underqualified workers who lack the skills necessary for employment in the new digital world. The CE is mainly paid lip service. For workers with a competitive streak and good qualifications, the boom of platforms in some sectors has been a stroke of luck; however, most others find themselves caught in the 'Russian doll effect' of sub-contracts within sub-contracts and ever lower pay, especially in the recycling sector. With any available spending going towards much needed welfare initiatives, the so-called green (did somebody say 'just'?) transition is a distant memory.
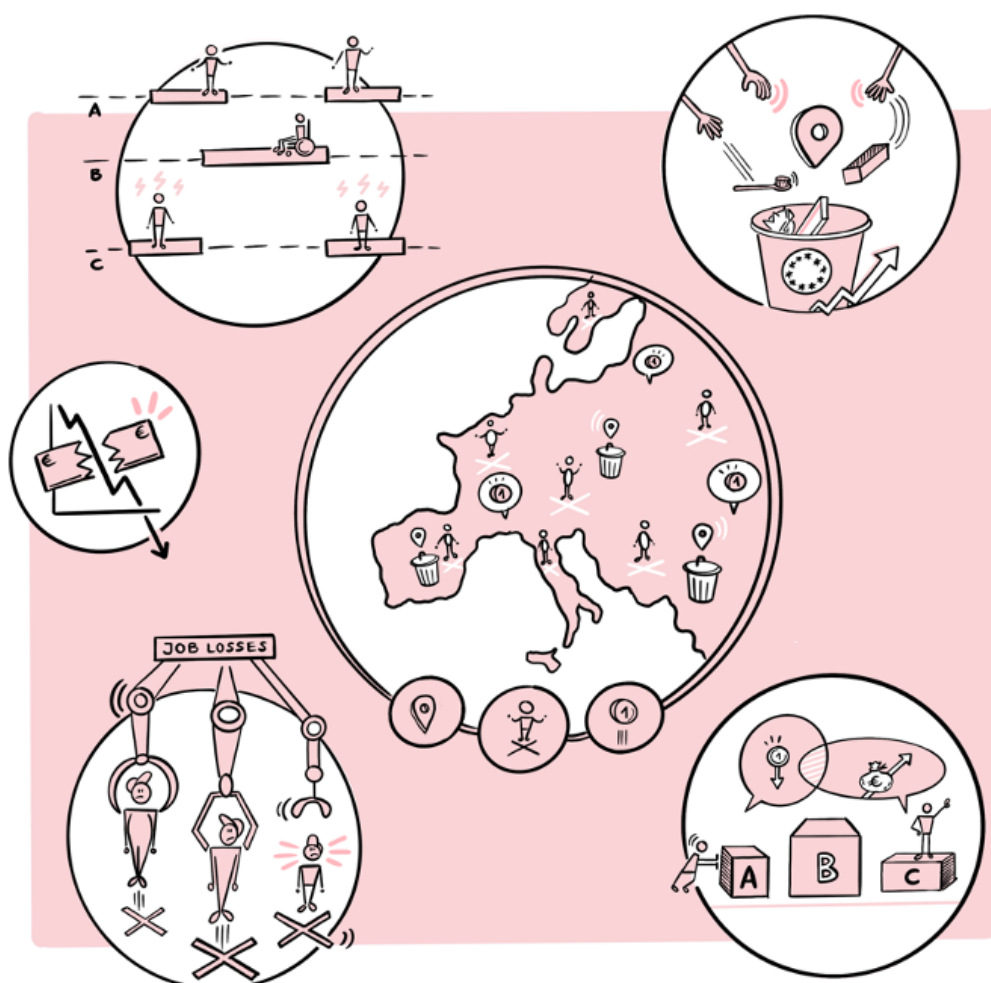
The circular economy and working conditions in Europe up to 2040:

A lot happened in the two decades following the 2021 United Nations Climate Change Conference — and most of it has been grim news for the environment, the economy and workers. After hygiene and health fears were heightened by the last pandemic, the **throw-away culture spread quickly throughout the EU (and beyond)**, which led to a **vast increase in the volumes of waste and recycling**. Economic crises persisted and, with **increased geopolitical volatility** and strained international relations, there were **repeated supply chain breakdowns**. Consequently, **EU countries resorted to processing waste within the European bloc**, but many Member States struggled to cope.

The recent economic crises have also meant that limited public funding has been directed towards the waste industry, and, with an inexperienced workforce ill-equipped to manage excessive levels of waste, working conditions have worsened in the sector, especially in poorer EU Member States.

The year 2040 marked more than 15 years since the EU last published any targets related to the transition to a CE. The vast majority agree that the EU conclusively failed in its ambitions — indeed, **there has been little progress on promoting reusability or recyclability, and even less change in adapting product design to aid repair.** With many industries — and the EU economy as a whole — managing to only barely hold on, **environmental and ethical practices (not to mention social inclusion) are mostly paid lip service**. And with funding for the green transition deprioritised and very little progress in the transition to renewable energy throughout the EU, **summers have brought heatwaves and power outages of increasing frequency and severity,** which have led to even more difficult and unsafe working conditions for many. Even though calls for greater environmental and social accountability from some non-profit organisations and trade unions have persisted and have recently become louder, industry push-back and weak political will have until now almost always thwarted attempts at strengthening regulation aimed at improving sustainability or working conditions. However, many argue that, with conditions **much worse in other world regions,** we should continue on this course because at least we are not the worst off.

In the late 2020s, some felt that the economic situation would improve as **digitalisation and automation delivered the promised rationalisation gains**. But it soon became clear that **job losses would be considerable**, as some had always feared. And **with reduced public and private sector spending, little funding was available for retraining efforts**. Today's mature workers are often overqualified and underemployed, while a growing proportion are stuck in unemployment. With few jobs available, the under-30s try their best to stay in education for as long as possible, with most directing their focus and talent towards the information technology sector — the sector with the most consistent growth. However, **for those lucky enough to have the right skills, platform and gig work have increased tremendously over the past two decades. But in some sectors, this has resulted in a fractured and uneven employment landscape**, with the 'Russian doll effect' of sub-contracts within sub-contracts**, particularly in the waste collection and sorting sectors.
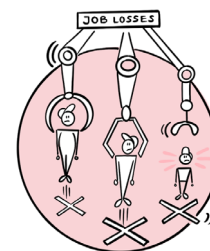
With economic considerations the primary (and often sole) focus of every industry, it is fair to say that, with any invention, global competitiveness and the economic value come first. As a result, the **health hazards of new materials are seldom considered or properly assessed prior to introduction in the EU**, and workers often lack guidance on, and knowledge of, what they should be aware of, particularly those working with end-of-life products. But when it comes to the choice between individual safety and putting food on the table, few can opt for the former.

A glimpse into daily life in 2040:

Zlín, Czechia, March 2040
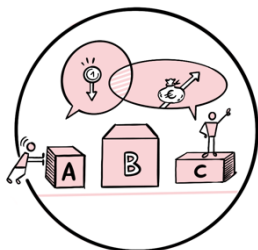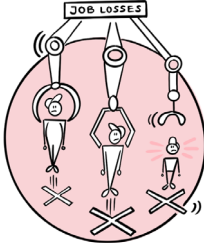
Agáta Novotná wakes up, as she does every day, at 04:50 sharp. This gives her just enough time to roll out of bed and log on to jobseek.eu, where job vacancies are published throughout the EU daily. After all, the early bird catches the job, at least on days when there is one to be caught. With a professional background in real estate (which has not offered the employment opportunities she had hoped for; after all, who would buy in this market?), Agáta has increasingly been forced to take on platform jobs in the waste collection industry just to make ends meet. Like the Uber drivers of yesteryear, cash'4'collect drivers provide on-demand waste collection services to households in the Moravia region. All that is required of potential workers is their own vehicle and a prompt collection and drop-off service. It's not that easy, however, if people take their time answering the door, or if there's a long wait at the local landfill — precious cents are sliced off workers' meagre earnings on each job. Today looks like a quiet one, though, with hardly any collection tickets on offer. Agáta slips back into bed for another few hours' sleep. She decides to put off worrying about how she's going to pay rent this month until after she next wakes up.

General implications for OSH from the scenario narrative:

- **Extreme weather and rising temperatures**
    - Both lead to negative health and safety effects, with **heat stress** being a major issue — particularly for those working outdoors. As temperatures rise, workers are also less likely to use PPE correctly (ILO, 2019b).
    - Cognitive activities also suffer under rising temperatures, leading to an increase in the likelihood of **accidental injuries** (ILO, 2018a).
    - Extreme weather events may also lead to (an increase in) **mental health issues** (post-traumatic stress disorder, anxiety, depression) (IEEP, 2020).

- **Rising waste and recycling volumes**
    - Sufficient **training in OSH is often overlooked** in the waste and recycling sector, particularly in tight economic circumstances.
    - If plastics recycling capacities in Europe are not upgraded to handle the much higher regionalised plastics streams expected in the coming decades, **OSH hazards are likely to increase** — particularly if inexperienced companies with mismatched skills are in charge of handling waste (EPSU, 2017; McKinsey, 2020b).
    - Conversely, increased recycling can **reduce the number of jobs in material-intensive sectors**, in particular construction, the most accident-intensive sector (OECD, 2020a).
    - More regionalised supply chains offer the opportunity to **improve cradle-to-grave documentation and enforce more stringent safety standards**, as well as **increased supervision**, which, with regard to recycling in particular, would be positive for OSH.

- **Highly platformed economy:**
    - As companies shrink their permanent staff pool and more people become self-employed, the OSH landscape becomes more fragmented, making it difficult to ensure the health and safety **of freelance and contingent workers** (ETUI, 2017; EU-OSHA, 2019b).
    - Platform work carries several **risks to physical health and safety** (ILO, 2018a; JRC, 2019), in particular **mental health risks** (RSA, 2019). Furthermore, unless a new legal framework is successfully introduced, lack of a clear employment structure means that **responsibility for OSH ultimately rests with the workers**.
    - If peer providers of services are exempt from some requirements concerning OSH, this, coupled with the **lack of platform responsibility**, would intensify many issues (ILO, 2019b; OECD, 2019a; ESPON EGTC, 2020).

- **Economic crises:**
    - During financial crises **workplace health and safety becomes a secondary issue**, both for workers trying to find employment and for companies (especially smaller organisations). Furthermore, there is a greater likelihood of **labour law flexibilisation**, which also impacts negatively on OSH (Boustras and Guldenmund, 2018).
    - Austerity measures are likely mean a reduction in the number of OSH inspections, which can result in an **increased number of industrial incidents and the loss of relevant skills** (Papertrail, 2016).
    - **Low infrastructure investment** will heighten the risk faced by workers, particularly in the building and construction sectors.
    - Persistent unemployment leads to a **loss of skills** (including OSH-relevant skills) among the unemployed (Ramsden, 2021) and potentially **greater willingness to engage in risky behaviour** at the workplace to secure employment.

Circular economy-specific OSH implications from the scenario across example sectors

Staying afloat — amid economic and environmental crises	What the CE means in the scenario: - The linear economy dominates; funding and support for the CE and other environmental initiatives regress - Globalisation is in retreat; all EU waste is processed onshore - Consumption of single-use products increases owing to hygiene concerns - Cost-effectiveness and profits are put above all else — environmental and ethical concerns are paid lip service only - Digitalisation leads to job losses, with insufficient focus on retraining by governments - Platform work booms
Energy sector	- Without the shift to renewable energy generation, workers face continued risks from fossil fuel energy generation practices, including injury, long-term illness and disability as a result of work-related hazards. They also face continued exposure to pollutants from fossil fuels, including nitrogen dioxide, ozone and fine particulate matter
Transport sector	- Without a significant shift towards a CE, transport practices — including risks and hazards — remain largely unchanged from today, e.g. musculoskeletal disorders, injury from carrying heavy loads, noise exposure
Manufacturing sector	- Without a significant shift towards more circular inputs and manufacturing processes, hazards and risks within the manufacturing industry remain largely unchanged from today, e.g. risk of accident and injury, musculoskeletal disorders, pulmonary disorders, psychosocial disorders
Construction sector	- Without major changes to construction practices regarding the integration of CE principles, hazards and risks remain largely unchanged from today, e.g. risk of accident and injury, exposure to airborne hazards, vibration and noise, work at height
Agriculture, forestry and food sectors	- Without major changes to food production and forestry practices regarding the integration of CE principles, risks remain largely unchanged from today, e.g. pesticide-related risks, musculoskeletal disorders, zoonotic diseases, psychosocial disorders

Waste, recycling and environmental remediation sectors	• Without major changes to waste and recycling practices regarding the integration of CE principles, risks not only remain unchanged but are heightened as a result of increased and more complex waste volumes.

Insight into an example occupation in 2040

Example occupation: logistics worker in the transport sector

Voice message from Nina Weiss to Clair Ferrier, 22.3.2042:
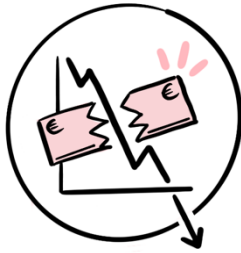
'I'll be late. Again. I know, and I'm sorry.

It's the waste pallets again. I'm so sick of how they crash and fall when I stack them — and then I get all the dust and sludge all over me. The guy who handed me the last pallet looked so pleased with himself, I could see the ₿[24] in his eyes. He said he found it all cleaning out the attic of a well-to-do immigrant family who had to return home in a hurry. It's not only us who are struggling. If only I would get a share of what that stuff brings in when they take apart the components, instead of just being paid per measly trip!

Anyway, I need to change into new overalls before I head back to the loading dock. The new boss is constantly reminding me that he has a list the length of his arm of people who would happily do my job — and for less pay, I'm guessing. And of course, if I look too shabby while wearing the company logo, AAARGGGH...

So, same old, same old. Will be home an hour late, I guess. Will hurry. Remind me to sign up to study again. And I know I say it all the time, but I am sorry for always being late. Love you, do not stay up.'

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[24] ₿ as the symbol for Bitcoin, referencing the use of cryptocurrency which symbolises reduced regulatory influence.

5.4 Scenario 4: Regional circularities — with European divides

In 2040, everyone knows: contracted employees are well looked after, but those in non-standard employment are not. Neither is the environment, with circularity being mostly regional.

The scenario in a nutshell
Economic growth and worker safety first: this was the guiding principle of policy and economic development in recent years. On the flipside, social inclusion and the environment continue to receive little attention from regulators; thus, inequality and pollution are growing — but not in everybody's neighbourhood. Within the EU, policies are driven by free trade and market forces, leading to the outsourcing of waste processing to other world regions and poorer EU nations, while richer EU nations enjoy the benefits. Circularity is thus mostly regional, with problems all too often outsourced and offshored. Underemployed and often unemployed, more and more workers in the EU feel forced to take on work in the informal economy to improve their circumstances — often unregulated, underpaid and increasingly precarious.
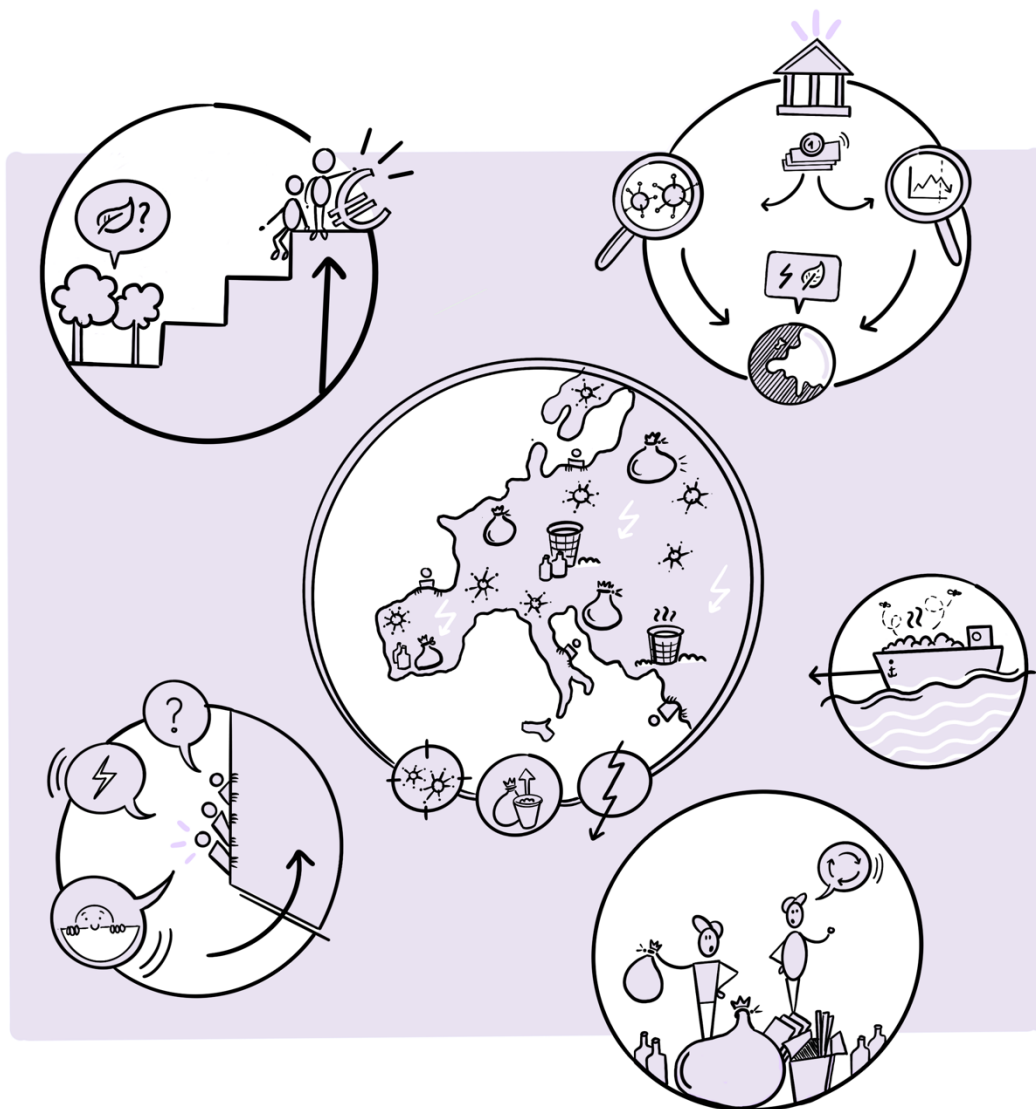
The circular economy and working conditions in Europe up to 2040:

The two most recent global pandemics made one fact abundantly clear to almost everyone: **it is the workers who are critical for our economy and on whom society hinges** — not just in Europe, but all over the world. 'Behind every good machine is an even better worker' became a set phrase in the late 2020s. Neither machines nor processes keep the economy running, but people do. And when **a functioning economy is your number one priority**, you safeguard your workers' well-being so that they show up for work each morning. But even though **working conditions have improved in Europe** and elsewhere (more or less) — with personal sanitation stations, plenty of paid sick leave, regular check-ups with medical staff and physiotherapists, and so on — demands for inclusion and diversity have been mostly silenced and replaced with an unspoken fear of job losses or, more precisely, employment losses. It is blindingly clear that **those in permanent employment have better all-round treatment, pay and security.** Workers who are not part of this privileged group are at a significant overall disadvantage, and a 'fall from grace' often leads people either to the social welfare offices or to enter the informal economy. Work intensification, job insecurity and atypical work become common practices. Come to the waste processing plants after dark and you'll see long queues stretching along the access roads: people who only want to do a little better for themselves and their families. It is tough at the bottom, particularly in the aftermath of the global automation wave of the late 20s.
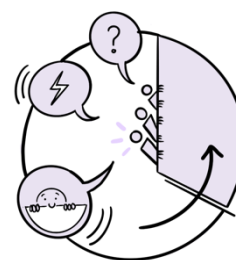
While the digitalisation and automation drive led to large-scale worker displacement and job losses, it also produced a significant boost for some industries. Take the waste industry for example: with the rising waste volumes and myriad of inputs, workers were grossly overstretched trying to meet profit targets (as good money could be made selling secondary raw materials at a high price on the black market), and this was putting excess strain on the workers. But then the market push for automation and digitalisation came along. Those left with a job found working conditions in the waste industry significantly improved, in part owing to the large numbers of robots doing the heavy lifting and handling hazardous sorting processes. Another improvement came as a result of the significantly tougher regulation of hazardous materials. The **regulators' focus on workers' health** resulted in very few such materials being granted approval for use in the EU. However, globalisation continues its steady march, and with the use of new materials outside of Europe increasing dramatically over the past decade workers constantly encounter illegal or 'grey' imports of products containing (undeclared) hazardous materials in the waste stream during recycling and processing activities. No wonder people dream of being on a standard employment contract with health benefits, sick pay and all the other bells and whistles. **It is tough out there for those at the edges**.
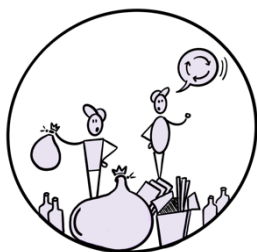
Despite the bleak outlook in some areas, **other regions have clearly achieved some kind of ecological and societal success.** These pockets are found in the richer EU states and tend to act almost autonomously from the EU as a whole; they have their own municipal reuse stations; run repair workshops and peer-to-peer lending libraries; and have strict household limits on waste and recycling — exceed your quota and you will be met with a hefty surcharge (although it is heavily rumoured that a lot of these 'circular cities' outsource their waste to other world regions). But throughout the rest of Europe, and in fact most of the globe, there has been **a steady societal shift away from the CE** since the early 2020s — perhaps in part due to hygiene concerns that arose from the pandemics. No longer do rideshares line the pavements of most European inner-city streets. Instead, people — especially students — have invested in personal e-scooters, particularly as these come with competitive pricing and lifetime replacement guarantees.
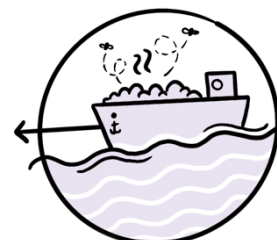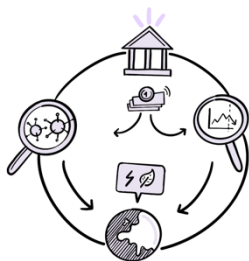
In fact, replacement has become the name of the game for a lot of industries in 'more brown than green' metropolitan areas: all people need to do is bring their broken electronics, appliances, furniture, or what have you to a local megastore warehouse and a replacement will be offered with (nearly) no questions asked. Where do these broken or defective goods end up? Just the two options really — waste or recycling. Venture to the outskirts of some of the poorer European cities and you will be struck by the mountains of accumulated waste. In theory, these waste piles are merely waiting to be recycled, but there have recently been reports from Europe's leading newspaper that some city officials in the east are considering converting these man-made waste mountains into artificial ski slopes for winter holiday-makers. Things being what they are, this idea to draw tourists will probably receive more EU funding than efforts towards low-carbon energy generation or greater resource efficiency. It is increasingly clear on this side of the tracks — we are in a world where **the money follows the market, and the market follows the money.**

A glimpse into daily life in 2040:

Connecting your values with your environment — ECO-RAD
Looking to nestle in your own private sanctuary in harmony with the surrounding environment? ECO-RAD has over 100 000 eco-housing units of all property types across Flanders. All units are built following the latest in net-zero-carbon building practices, with A+++ resource-efficient technology, next-generation smart-home devices and offering fair living wages to all employees. ECO-RAD eco-towns offer guilt-free living with a positive environmental impact. Wild forest laboratories circle the townships, with organic farmland for growing your own vegetables and rainwater reservoirs for taking a dip in summer. Townships even offer their own waste collection, washing and sorting plants*, with composters in every backyard. Do not delay, join thousands of others just like you who value sustainable living in an ECO-RAD eco-town today.
ECO-RAD designs not just the four walls of your home, but the environment beyond.
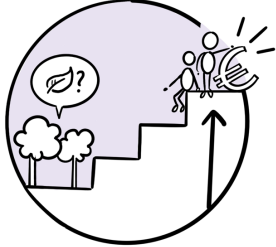
*All non-compostable waste conveniently outsourced beyond the township.

General implications for OSH from the scenario narrative:

- **Digitalisation and automation**
  - Regional CEs will find it difficult to establish the unbroken information streams necessary for safe circularity (to determine waste stream contents, safety of products with extended life cycles, etc.), as products and materials will enter/exit the loop unscheduled (e.g. invalidating blockchain ledgers), impacting waste sector workers in particular.
  - With AI playing a key role in CEs (design of circular products, management of circular business models and infrastructure) (McKinsey, 2019b), AI technology will proliferate. Regional CEs may lack the **strict regulatory framework necessary to safeguard consumer and worker safety** (European Commission, 2020j). Integration of AI and robots makes robots less predictable for workers, potentially increasing OSH hazards (EU-OSHA, 2021) in the construction and waste collection sectors, among others. Human-robot interaction may lead to **increased risks in the workplace** (e.g. through workers over- or underestimating robot capabilities and situational awareness) (ILO, 2019b). **Overreliance may lead to deskilling** (EU-OSHA, 2019a, 2021), **cybersecurity issues** (EU-OSHA, 2019a, 2021), **less task variation and more sedentary task**s (EU-OSHA, 2021).
  - Digitalisation can increase stress in the workplace (e.g. surveillance stress, performance pressure), exacerbating **mental health risks** (ILO, 2019a), which, in a (regional) CE, is likely to have the largest impacts on workers in the transport and waste collection sector. Similarly, automation and digitalisation increase perceived job insecurity, which also **impacts negatively on psychosocial health** (ILO, 2019b). Increased monitoring may have a similar effect (EU-OSHA, 2017a) and could particularly affect those in the transport and waste sectors.

- o In both the CE and non-CE business environments, automation **reduces hazard exposure** (in waste processing etc.) (JRC, 2019). In some areas, automation may outpace risk assessment, e.g. with regard to road safety compliance of autonomous vehicles (RSA, 2019) in domestic waste management. However, autonomous vehicles have the potential to **offer significant safety benefits** over manned driving (Ellen MacArthur Foundation, 2015a).
- o Any large-scale displacement of workers across many industries (e.g. resulting from a shift in the structure of the economy away from material-intensive sectors to a more labour-intensive and service-based CE economy) will result in **institutional knowledge loss**. This will include OSH-related knowledge, in particular tacit knowledge.

- **Outsourcing of waste processing**
  - o The outsourcing of waste processing to other regions **reduces risks in the region of origin** but can greatly **increase hazards in the receiving region**, particularly if the waste is stored for long periods of time, experiences high temperatures, etc.
  - o Outsourced waste is usually processed by non-standard employment workers or workers in the informal economy. Studies show that **injury rates among non-standard workers are higher** (EU-OSHA, 2017c), a result of increased time pressure (pay per assignment), lack of OSH training, awareness and safety equipment, and **exhaustion as a result of working long hours** (EU-OSHA, 2015a; EU-OSHA, 2017c; Christie and Ward, 2019). Furthermore, when the price of processing recycled materials rises, these workers are often required to process larger volumes that are **more concentrated and more hazardous** to handle.

- **Informal economy**
  - o **Noise and air pollution** at the workplace are a serious hazard to workers' health and safety, in particular in the informal economy and for low-qualified workers (EEA, 2020c).
  - o Currently, recycling workers receive **insufficient training in OSH**, an issue that is largely overlooked (ILO, 2018b). This is of particular concern in the informal economy, which accounts for most recycling work worldwide, and where workers face **major OSH hazards** (ILO, 2019b; similarly EPSU, 2017).
  - o Increased resource use and digitalisation greatly increase demand for some raw materials (by up to 390 %) that are extracted primarily in the informal economy — with very **low OSH standards and extremely high risks** for workers (PowerShift, 2017).

- **New hazardous materials**
  - o In regional and not strictly compartmentalised CEs, there is an increased **risk of undocumented new materials entering the material loop**, which may result in new hazards, in particular regarding waste streams and recycling.
  - o Biology is interconnected, self-replicating and difficult to control (it does not respect jurisdictional boundaries); workers could be confronted with **new biological agents** where they least expect them. COVID-19 demonstrated the danger of the interspecies leap (McKinsey, 2020d).
  - o In biotechnology, low barriers to entry increase the **potential for misuse** by OSH-unaware actors, with possible severe consequences (such as creating and unleashing viruses) (McKinsey, 2020d).
  - o Nanopaints and coatings pose unique challenges during recycling activities (difficulties in identifying and safely processing) (G20 Insights, 2020). **New risks are continually emerging** in this area, including the risk of long-latency hazards (e.g. with carcinogens) and diseases that are difficult to trace back to jobs (EU-OSHA, 2013b).
  - o Nanomaterials present **unique health challenges** (ILO, 2019b), in particular regarding ingestion and inhalation (EU-OSHA, 2013b); furthermore, particulate nanomaterials in powder form may explode.

Circular economy-specific OSH implications from the scenario across example sectors

Regional circularities — with European divides	**What the CE means in the scenario:** • CE efforts and progress are local and small in scale at most • EU transition towards sustainability is slow to non-existent • The health of the economy and of the workforce is prioritised • The sharing and leasing economy declines as a result of increased hygiene concerns • There is an overall rise in waste and recycling volumes, including in the number of different inputs and materials • The informal economy increases • The inequality gap between EU nations widens
Energy sector	• Expansion of energy storage (batteries, hydrogen, advanced technologies) results in new operating and recycling risks • The use of new, unexplored materials (e.g. heat storage chemicals, new insulation in construction) could result in workers being exposed to new substances during installation, refurbishment or recycling activities
Transport sector	• New (automation) technologies and concepts in transport — e.g. platooning in goods transport, delivery drones — may be introduced without necessary safety protocols in place • In some areas, automation (a key enabler of the CE) may outpace risk assessment, e.g. with regard to road safety compliance of autonomous vehicles • Without comprehensive reskilling, new power technologies used in transport increase OSH hazards in maintenance/repairs
Manufacturing sector	• In both CE and non-CE business environments, automation reduces hazard exposure in manufacturing processes and procedures • Automation and digitalisation (both key enablers of the CE) increase perceived job insecurity, which can impact negatively on psychosocial health. Furthermore, increased monitoring may have a similar effect • More regionalised supply chains offer the opportunity to improve cradle-to-grave documentation and enforce more stringent safety standards, as well as increased supervision
Construction sector	• Regionally uneven CEs make the exchange of product components, materials and OSH-relevant information difficult • Rapid introduction of new materials leads to workers being exposed to unforeseen risks during construction and maintenance, e.g. nanopaints and coatings pose unique challenges, with new risks continually emerging, including the risk of long-latency hazards (e.g. with carcinogens) and diseases that are difficult to trace back to jobs • New technologies (e.g. brick-laying robots) often lack necessary safety features, thus presenting risks to operators
Agriculture, forestry and food sectors	• In localised CEs, urban biowaste can be used as a fertiliser and biopesticide on farms near cities, reducing potential exposure to chemical pesticides and fertilisers • Smart farming/digitalisation improves process control, thus reducing risks. However, with fewer workers and more machinery/technology, mental stresses are likely to increase

Waste, recycling and environmental remediation sectors	• Outsourcing of waste processing to other regions reduces risks in the region of origin but can greatly increase hazards in the receiving region, particularly if the waste is stored for long periods of time, experiences high temperatures, etc. • Outsourced waste is usually processed by non-standard employment workers (or workers in the informal economy), which results in higher injury rates • In regional and not strictly compartmentalised CEs, there is an increased risk of undocumented new materials entering the material loop, which may result in new hazards

Insight into an example occupation in 2040

Example occupation: environmental services consultant in the waste, recycling and environmental remediation sector

From the onboarding note supplied to Kiva Shemesh, January 2040:

'As a recycling advisor, you will be travelling across Europe, visiting, assessing and providing advice for and at our customers' sites. It is critical to understand that each site visit is a risk, and that you must ensure our national regulation concerning your onsite tasks is adhered to UNDER ALL CIRCUMSTANCES. To assure this, you must:

1. Ensure that the form is signed by the customer BEFORE you enter their premises.
2. Do not enter a customer's site unless you are wearing the protective equipment supplied.
3. Run a virtual safety check on each room before entering or attending to any other tasks.
4. …'

6 Spotlights on digitalisation and the waste sector

Throughout this project, two issues emerged at the forefront of the discussions and the research analysed on potential future perspectives of the CE and its implications for OSH: the role that digitalisation might play for a future CE and the critical role of the waste sector in the CE. Thus, key insights around future perspectives concerning both issues are presented below, summarising the roles that digitalisation and the waste sector could play in the future of the CE, and the implications of each for possible future OSH risks (and opportunities or challenges). Both spotlight sections focus primarily on cross-cutting insights and implications — for details on possible future developments in each field and the related OSH implications under the conditions of each of the scenarios, please see the detailed descriptions of the scenarios in section 5.

6.1 Spotlight 1: Digitalisation in the circular economy

The political path towards the circular economy

In the 2015 United Nations Agenda 2030, the move towards more sustainable patterns of production and consumption was globally agreed: 12 of the 17 Sustainable Development Goals (SDGs) (UN, 2020a) adopted by all UN Member States depend directly on increasing resource efficiency to make resource use more sustainable (UNEP, 2017). Most directly connected to the concept of a CE are Targets 12.4 and 12.5 (UN, 2020b), which aim to 'achieve the environmentally sound management of chemicals and all wastes throughout their lifecycle' and to 'substantially reduce waste generation through prevention, reduction, recycling and reuse'.

At the same time, the EU adopted the Circular Economy Package (European Commission, 2015), its first plan to implement a CE. This was updated in 2020 (European Commission, 2020f), after a second major transformation had been added the year before: achieving climate neutrality by 2050 (European Commission, 2019b). These sustainability visions are supported by a digitalisation policy programme specifically intended to '[s]upport the circular economy' by, among other things, launching a 'circular electronics initiative' and improving communication on the origin, composition (including hazardous and rare materials), end-of-life handling and recycling of products (European Commission, 2020l). The New Industrial Strategy for Europe, released in March 2020, stressed the role that European industry must play in this process (European Commission, 2020j). Currently, however, only a small number of companies are actively realising smart circular strategies and linking their long-term digital and circular plans, and they lack guidance on how to best leverage digital technologies to maximise resource efficiency (Kristoffersen et al., 2020).

The role of digitalisation in creating a circular economy

To achieve a CE, the functionality of materials, processes and products must be optimised and maintained for as long as possible to minimise waste and residues. Here, digitalisation plays a crucial role as a key enabler and accelerator of the CE: by providing accurate information on the availability, location and condition of products and materials; by making processes in and between businesses more efficient; and by minimising waste and transaction costs and promoting longer product lives (Antikainen et al., 2018). Closing the material loop — i.e. implementing a CE — 'is primarily a problem of information' (WI, 2017): tracking resources and resource use over a product's entire life cycle, focusing on products-as-a-service business models, improving design, production and recycling, and providing consumers with better, actionable information on the environmental costs of consumption choices are all impossible without the free flow of huge amounts of data made possible by digitalisation.

Today, online platforms, smart devices, AI, the Internet of things (IoT) and blockchain are already used to 'improve design, production, consumption, reuse, repair, remanufacturing and waste management, including recycling' (EPC, 2020). But digitalisation does not automatically increase sustainability; unwanted rebound effects are possible. For example, e-commerce can be used to lower resource use (sharing economy) but may also be an enabler of increased consumption with a high material and energy footprint (online purchases). Furthermore, the energy and raw materials required for

digitalisation are problematic: if unchecked, the ICT footprint could increase to 14 % of global emissions by 2040 (European Commission, 2020l).

Digitalisation in the circular economy: effects on OSH[25]

Improved data provision and transfer make it possible to trace products and materials across their entire life cycles, allowing for **safer sharing and recycling of products** and **safer processing of waste streams**. **Better informing and empowering of consumers and workers** offer the chance for **timely safety feedback** through digital channels (e.g. on products failing while in use, or suggestions for better OSH practices), while digital tools will **improve consumer handling of end-of-life products** (no more batteries in household waste etc.). Digitally enabled **increased flexibility of working arrangements** (regarding working hours and workplaces) to lower resource use (i.e. reduced need for offices, which stand empty during weekends, better transport use, greater worker autonomy to reduce overheads, etc.) would probably remove some OSH risks (fewer commutes etc.), but greater worker autonomy could also **increase psychosocial stress and lead to unclear OSH responsibilities**. In a CE, digital platforms are used to better allocate resources (e.g. to distribute tools, or in Platform as a Service (PaaS) business models) (EPC, 2020). Allocating workers to jobs or tasks using digital platforms can lead to workers taking on jobs despite being **unaware of OSH risks, best practices and guidelines**, or place workers under increased pressure to ignore OSH regulations, and could result in a highly fragmented OSH landscape, **complicating inspections**. On the other hand, **easier reskilling using online platforms** offers the **chance to improve overall OSH awareness**, in particular regarding a more diverse working population.

6.2 Spotlight 2: Waste management in the circular economy

The political path towards the circular economy

The European Commission is committed to moving Europe towards a sustainable future. This green vision has two cornerstones, achieving climate neutrality (by 2050) (European Commission, 2019b) and creating a CE (European Commission, 2020d). A future 'closed loop' society will ideally be wasteless or will at least have greatly minimised all potential waste streams. In this closed-loop CE, the thinking around waste promises to shift towards waste being viewed as a resource as opposed to a burden, with potential for the 'refuse, reduce, reuse, recycle' principle to replace a logic of 'take, make, waste'. If the EU is successful in implementing a closed loop CE, this transformation will have considerable impacts on the waste sector in general and specifically on OSH in the waste sector.

A wasteless future in the circular economy

With the right use of new technologies ('exponential technologies'), we have the opportunity to resolve the problems related to waste management and recycling (Mavropoulos, 2016). The fourth industrial revolution is already a reality in the waste industry, with digital technologies used in monitoring and processing, and new applications currently being tested (e.g. 3D printers in plastic recycling, autonomous collection vehicles, etc.) (ISWA, 2019). Going forward, digital technologies are likely to deliver more and more effective waste management regimes. This will make it possible for Europe to improve recycling, it will make it easier for manufacturers to use recyclates ('secondary raw materials'), and it will give citizens the opportunity to improve purchasing and sorting decisions (EEA, 2021). With spatial and temporal patterns of waste generation better understood, green behaviour can be incentivised ('pay-as-you-throw' systems), reducing the risk of unforeseen materials in the waste

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[25] Note: this section looks only at the general, non-scenario-specific effects digitalisation in the CE could have on OSH. For an in-depth, detailed and more task-focused discussion of OSH outcomes, please see an earlier report by EU-OSHA on digitalisation (EU-OSHA, 2018a) as well as section 4.1.5 on the key factor of digitalisation and the implications for OSH provided for each scenario.

stream, while the hazardous parts of waste processing (sorting in particular) could be further automated and even remotely managed.

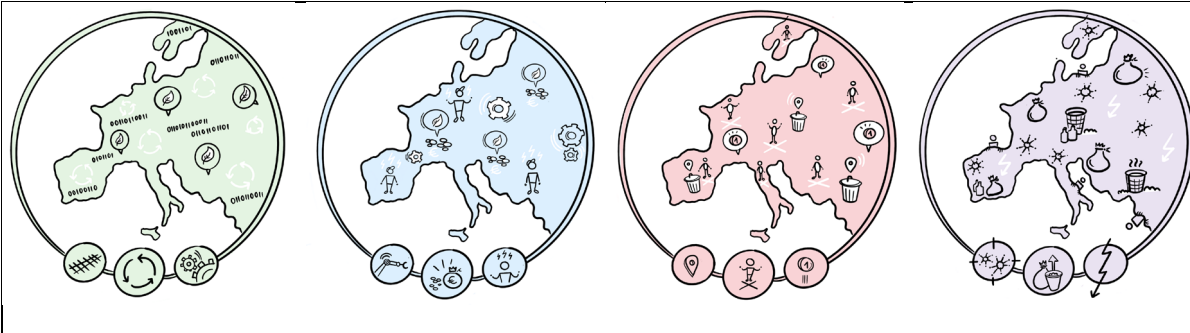**Waste management in the circular economy: effects on OSH**[26]

(Domestic) waste collection and transport by autonomous vehicles could minimise risks for workers, while a **greater sensor density** could increase awareness of waste stream contents, reducing hazards to workers during handling and sorting. The latter could be increasingly done by learning robots, which are becoming **more adept at identifying recyclable components** in complex waste streams (PwC, 2018). Human-robot interaction, on the other hand, is likely to become more complex, as workers **potentially misestimate robot capabilities and situational awareness**. Overreliance on automation may also **lead to deskilling**, in particular regarding emergency situations. If workers manage automated processes without contact with other human beings, psychosocial risks may increase. Unless there is regulatory pressure to fully explore recyclability prior to introduction, new materials entering the waste stream may lead to **new risks in waste processing**. **Standardisation of electronics and other complex products** could dramatically increase safety in dismantling, however. **Continuous reskilling in the waste sector** could help workers to better navigate the increased complexity of a more automated environment, reducing the likelihood of OSH events.

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[26] Note: this section looks only at the general non-scenario-specific or cross-cutting effects the CE could have on OSH in the waste sector. For an in-depth, detailed and more task-focused discussion of OSH outcomes and perspectives in the waste sector, please see earlier reports by EU-OSHA on the waste sector (e.g. EU-OSHA, 2007; EU-OSHA, 2019e,f; EU-OSHA, 2020e,f,i) as well as the implications for OSH given for each scenario.

7 Conclusions and outlook

7.1 Concluding reflections and key messages

The scenarios show that the potential pathways for CE in Europe and their effects on working conditions could vary widely, with a similarly wide-ranging set of first implications for OSH and possible future policy areas. While details on the specific OSH implications from each scenario are provided in section 5, below we outline effects for OSH that are valid across all four scenarios, albeit to different degrees. Thus, while the four European CE scenarios differ with regard to the opportunities and challenges they present for the future of OSH, some more generalised inferences can be made.

Regionalised supply chains. Whether supply chains shorten because of the search for smaller environmental footprints, or as an outcome of economic fragmentation, increased regionalisation regarding sourcing and production offers the chance to improve cradle-to-grave documentation and enforce more stringent safety standards.
Integration of OSH into (economic and environmental) legislation. So far, OSH considerations have not played a serious role in EU legislation on the CE or the environment. Initiatives to improve OSH integration are valuable across all four scenarios.
New technologies. During maintenance, and in particular during recycling, new technologies (from biotechnology to nanomaterials) can present new risks. Carefully exploring and minimising these risks is a clear challenge for OSH authorities, with the difficulty of this task varying according to the scenario.
Platform work. Unless responsibility for OSH is handled in the sense of the EU's new platform initiative (see European Commission, 2021b), any form of 'gig' economy will carry a number of risks to physical health and safety. However, psychosocial risks due to 'lone working' (see also below), supervision by AI, and the pressure of independent work are likely to remain.
Automation, digitalisation, AI and robotics. Technological and organisational advances remain a double-edged sword. While the risks associated with working in hazardous or physically challenging environments are likely to be to reduced, this will be offset by new emerging hazards (e.g. increased human-robot interaction will result in higher stress because of increased monitoring and performance pressure) and the spread of existing hazards as AI/robotics become more prevalent in an increasing number of sectors.
Remote work. In all scenarios, CE-related work becomes more mobile and flexible, which can make OSH supervision and knowledge transfer more difficult and can increase psychosocial issues.
Reskilling.: Large-scale reskilling and lifelong learning will be increasingly necessary to provide workers with the OSH knowledge and awareness necessary to work safely.

> **Sharing economy**: Similarly to platform work, safety in peer-to-peer sharing will have to be the subject of new regulation to clarify responsibilities. However, OSH supervision and knowledge transfer will likely become more difficult owing to diffusion of responsibility.

Before summarising and highlighting the key insights from these results, it is useful to refer to the **purpose of the scenarios** and how work with them will continue.

As always, it is critical to point out that **scenarios should not be mistaken for predictions**. Their purpose is not to describe what 'the future will be'. Rather, as the growing body of experience of foresight approaches in research and for supporting policy-making has made increasingly clear, they offer tangible insights into **what the future *could* bring**, and what these alternative pathways would imply for future and especially present-day options for action. They make **discussion and reflection on future possibilities possible, with the aim of informing today's decision-making and making policy more future oriented** (following the principle of anticipatory governance). Hence, the scenarios should be **seen less as a final result of the research or an end in itself, and more as a tool for making cooperative sense-making with stakeholders more future oriented.** In this project, this role of scenarios as a tool for cooperative sense-making around implications is very clear, as **EU-OSHA will continue to work with the scenarios, in a systematic process involving stakeholders in dialogue based on the scenarios**, reflecting in more depth on what the results imply for OSH research, initiatives and policy-making today. At this point in the process, the results have to be considered as providing an **impulse and basis for further discussion**. The results of this discussion will in turn enrich and deepen the scenarios and all downstream results.

At the same time, it is clear that the scenarios — as they are now — already include the first step of a cooperative sense-making process, bringing together a variety of insights and experts' perspectives. Drawing from the specific insights gained from the reviewed literature, alongside the experts' perspectives collected in the interviews, feedback from EU-OSHA's project team, and a session with EU-OSHA's advisory group OKAG, these findings are condensed into narratives of four possible, imaginable, distinct and alternative future developments up to 2040. From the scenarios and the underlying research, **several key themes in terms of imaginable pathways for the CE and its implications for OSH** have emerged. We highlight and summarise these below in the form of key messages that can be drawn when taking a bird's eye view perspective across the portfolio of scenarios.

1. There is as yet no 'agreed upon', i.e. widely **shared or common, definition and understanding of what a CE is. This contributes to a certain 'fuzziness' in the existing assumptions** about and expectations of potential future developments regarding the CE, and **opens the door to using the term and its concepts for the purpose of greenwashing**, e.g. using the term as a marketing label without clarifying bottom-line impacts. Increased clarity on bottom-line ambitions, and on what a CE is and is not, would be necessary to stop this practice.

2. Considering the rising exports of waste from Europe in recent years, **any reflection on CE perspectives in Europe will need to take into account global repercussions as well as value and production chain effects**. Even if rapid progress in the CE were made over the coming decades, the risk remains that exports of particularly problematic waste would continue, thereby also exporting problematic and often unsafe working conditions, and with it environmental impacts. A clear paradigm shift towards CE principles could, at least in the long run, be implemented sensibly and ethically, but only if this approach integrated global production chains and elements over the whole life cycle of any product and material.

3. Furthermore, the **European waste sector will need to play a pivotal role in the development of any future CE**, as Europe will not be able to meet its ambitious objectives without significant endeavours and transformations within the sector. The integration of (often costly) new technologies while meeting new challenges will be a complex undertaking, but the reskilling offensive necessary offers **opportunities to considerably improve OSH practices and outcomes for workers, if OSH considerations are made an inherent part of this process from the beginning.**

4. Digital technologies will play a key role in Europe's transition to a more circular economy, as **digitalisation is a key enabler and accelerator of the CE**. A high standard of OSH in a CE will

be achieved only if digitalisation processes, such as building a universal information ecosystem (a safe data space that minimises manipulation risks) or creating a monitoring system to prevent illegal imports of products that may be hazardous during recycling, are well managed. Accordingly, **OSH measures will need to keep pace with rapid change** and recognise potential shortfalls early to **meet the challenges of both increasing digitalisation and the transition to a CE.**

5. A **fundamental paradigm shift towards a CE seems possible only if driven by robust regulatory efforts and respective policy mechanisms**. Given that the bottom line of offshoring waste and its processing (and, with it, its environmental impacts and related problematic working conditions) is particularly enticing, a robust approach to legislation and enforcement will be necessary to change current practices. Circularity can be achieved only if life-cycle responsibility rests with the manufacturer and measures are taken to internalise external costs of any material and product life cycle.

6. Any fundamental paradigm shift towards a CE would probably have to imply the **far-reaching reorganisation of the value chain and the emergence of new actors**, e.g. in urban mining. This would probably lead to second- and third-order effects on infrastructure, such as new types of waste collection stations or a rise in pre-treatment solutions prior to collection.

7. Large-scale implementation of a CE — based on the principle of a 'just transition' — would not only come with a significant opportunity to advance OSH conditions, but could also lead to the emergence **of new risks and undesired side effects** (see the bullet points below each scenario for details). These concern primarily the **increase in health and safety risks when products or product elements are recycled repeatedly**, but also include other issues such as the **rising energy demand in the recycling sector** (due to, for example, the high energy intensity of recycling of critical raw metals) and delayed **regulation and OSH measures, which are outpaced by a potentially rapid increase in recycling efforts**. The latter may also lead to at least temporary spikes in informal work in the sector, where working conditions are particularly problematic.

8. From another perspective, these **emerging risks also have the potential to be used as growth opportunities**, if there are cost incentives and suitable markets. This would also include job growth in the respective sectors, such as waste management and its sub-sectors (see also EU-OSHA, 2013a), implying a strong need for education and upskilling.

9. The **range of progress in the CE and the integration of OSH measures could differ widely between regions, EU Member States and sectors**, and the risks as well as opportunities for OSH could similarly vary. A major lever for ensuring OSH is advanced alongside any kind of progress towards a CE will therefore lie in making sure there is **sufficient support for regions, sectors and countries where investments will be more difficult to come by, and where resources, e.g. for training and upskilling, are scarce**. Smart measures regarding financial support, investment incentives, and also sharing and rolling out of best practices are considered possible solutions to ensure that CE progress in Europe will not be beneficial for only some regions, sectors or countries, and hard to achieve for others.

10. A **window of opportunity** seems to currently present itself for **advancing the CE with a view to OSH improvements being realised in synergy**. There are several reasons for this, among them a recently increased focus on the interconnectedness of the social and environmental pillars of sustainability, as well as a growing awareness that an integrated view of efforts in those areas will clearly, over the long term, benefit the third pillar of sustainability — the economic sphere. The concepts of a **'just transition'**, the 'twin transition' and 'social-ecological transformation' combine both perspectives and are gaining traction. Ensuring that OSH perspectives and solutions are included or even pushed within the context of these transformation efforts could be a lever to bring about fundamental progress along the lines of both the CE and OSH goals.

Finally, when interpreting the above implications, it is important to note that, across all four scenarios, governance plays a key role for OSH outcomes. Legislative intervention can be used to unlock benefits and limit problems that may emerge from new technologies and modes of economic organisation. Additionally, stakeholder pressure may be necessary to ensure that new principles, rules and policies

needed to minimise or eliminate downsides are introduced. Should legislators lack the willingness to provide protection to workers, the effect would be more severe than that of technological development alone. These considerations show the scope available for shaping the future of OSH in any future European CE.

7.2 Outlook towards the next steps

Finally, we would like to highlight the next steps concerning this project. In addition to this report, a **set of accompanying materials** will be developed to support the dissemination of results. These will include an OSH Wiki article and as a set of policy briefs.. As outlined above, **a second project phase will focus on discussing the results so far with a variety of stakeholders and subsequently enriching the scenarios**. This will include deepening and reflecting further on the scenarios, especially on emerging OSH risks and opportunities in the context of a possible transition towards a CE.

For this next phase, as well as for further foresight work by EU-OSHA or other actors in the field of OSH, we see **several options that it might be worthwhile to pursue**. First, regarding the upcoming stakeholder engagement phase, we suggest that this includes experts in the fields of both OSH and CE, and that stakeholders from both arenas are involved in the workshops. In the workshops themselves, several aspects are particularly worthy of reflection, among them **regional and sectoral specifics of the scenarios**, or the role, **challenges and opportunities for different groups of actors** under the conditions of the four scenarios. Reflection could also focus on which aspects would be desirable and beneficial to which groups of workers, and which actors could play crucial roles in shaping pathways in a more desired direction. In terms of approaches, among a mix of more expert-based, in-depth and research-oriented reflections, a more open and widely participatory approach could also be envisaged, as well as using the scenarios for a serious gaming approach. And as always with scenarios, **specific attention should be given to the question of what they imply in terms of potential action today**, to avoid problematic developments and make desired developments more likely to happen.

Concerning the overall foresight work by EU-OSHA and other stakeholders in the field, we regard the **material brought together here as a portfolio of foresight elements that would lend itself to further use**. For example, the **systematics of key factors and projections underlying the scenarios can be used for other projects**, where it will be possible to draw from them and adapt them to other issues as and when needed. They provide a starting point that also brings together insights from previous foresight work by EU-OSHA, integrating them into a transparent, manageable and updateable structure. Thinking beyond single projects, a **systematic monitoring system for signals of change** that might influence key factors or other fields of change relevant to EU-OSHA is also an option that could be realised, which would provide a highly useful tool for continuously monitoring and communicating current change relevant for OSH.

8 Annex

8.1 Table of key concepts and terms

Key concept or term	Definition
Circular economy	'A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems.' (Ellen MacArthur Foundation, 2017b)
Driver/driver of change	'A current or emerging trend that is likely to shape (have an impact on) development of the policy or strategy area.' (UK Government Office for Science, 2017)
Given	A factor (see 'Key factor' below) for which only one kind of future development is imaginable and, therefore, for which there is only one possible projection
Key factor	See definition of 'Driver/driver of change' above.
Morphological box	A grid technique for teasing out multiple projections from a key factor and combining them with projections of other key factors to form projections or raw scenarios.
Projections	'A projection is an expected value of one or more indicators at particular points in the future, based on the understanding of selected initial conditions and drivers.' (Forward Thinking Platform and The Global Forum on Agricultural Research, 2014)
Robustness analysis	An analysis that evaluates potential scenarios, composed of bundles of future projections from the set of key factors, for their consistency and plausibility. It is undertaken to identify the 'best' macro-scenarios from all the future development paths that are imaginable (which would be too large a group of scenarios to deliver helpful results). In this project the analysis waserformed using the AI-powered software ScenLab.
Scenarios	'Multiple stories or images of how the future could look, [developed] in order to explore and learn from them in terms of implications for the present.' (OECD, 2019d)
STEEP	A generic tool or concept for structuring issues and insights in monitoring and scanning; the acronym stands for societal, technological, economic, environmental and political drivers (although there are several common variants that describe the same or slightly adapted analytical structures — PESTLE, PEST, STEP, STEEPLV, etc.). (UK Government Office for Science, 2017)
Trend	'A visible — or emerging — pattern of events that suggest change. In futures thinking, a "trend" becomes a "driver" when it acts on the policy or strategy area of interest.' (UK Government Office for Science, 2017)

8.2 Details on the overall approach for scenario construction: the key-factor-based methodology

In this project, a key-factor-based approach[27] for scenario construction was used. While the various approaches of scenario methodology all have their own strengths and weaknesses[28], we argue that the 'modular' or morphological way of constructing scenarios was best suited to the needs of this specific project. Future Impacts has worked with, and further developed, the methodology over recent years, focusing, for example, on improving the transparency of the scenario construction itself (as a 'black box' effect of this step can be problematic when working with the scenarios and stakeholders at a later stage, and can also cause problems when new insights or information needs to be incorporated).

The main benefits of the approach in the case of this project are as follows:

- **The insights captured for the scenario construction are structured very clearly and can cover a transparent sub-structure** (e.g. transparently mapping where insights refer to a specific national or regional context; the sub-structure can also be expanded later if new information emerges).
    - o Information and insights from a variety of studies, research and initiatives can thus be systematically and efficiently analysed, and the underlying assumptions from the sources covered (which will probably often be contradictory) can be analysed in a systematic fashion.
- **Scenario selection is transparent and systematic,** in contrast to more intuitive and 'black box' approaches, ensuring smoother communication and engagement with the scenarios when communicating with larger stakeholder groups later, in phase 2.
- **'Updatability' of the scenarios and its underlying research:**
    - o New information or insights on specific issues can be easily integrated into the key factor(s), projection(s) or scenario(s) without having to 're-do' the whole process (because of the modular character of the information structuring and scenario construction).
- **Adaptability of the scenarios and background research for communication/for engaging stakeholders with the scenarios:**
    - o **Specific topics can be put in the foreground when engaging with stakeholders on the scenarios, again owing to the modular nature of the approach, while remaining in the overall framework of the scenarios and remaining consistent with the overall project outcomes**. This modular approach enables the 'plug and play' use of information from all project steps, which will be helpful in phase 2 of this project in particular.
        - For example, in each workshop, details that might be of interest to the specific stakeholder group attending the workshop (e.g., more background to some of the key factor descriptions) can be 'plugged in' while leaving the overall scenario logic and consistency intact. This approach would not jeopardise the output consistency and quality, but rather increase it.
        - The structure of outputs would also lend itself to realising a card-based scenario game (a kind of tool that has been proven to be particularly beneficial for enabling deep engagement with scenario contents).
    - o **In addition, results from phase 2 can be 'plugged in' via the modular approach smoothly,** and at various levels of detail and depth, again leaving the overall consistency and structure intact.

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[27] The methodology was originally developed by a team at EU-JRC, and variants of the methodology exist. For more details on the approach, see, for example, Kosow and Gaßner (2008).

[28] For information on these and other potential scenario methodologies, see, for example, Curry and Schultz (2009).

8.3 Expert interview questionnaires and interview summaries

Round 1 Expert interviews: interview questionnaires
Expert interview questions

The European Agency for Safety and Health at Work, together with Future Impacts, is undertaking a scenario study to understand possible developments in the circular economy and their impacts on occupational health and safety (OSH) in the European Union.

We are focusing on understanding potential developments in the circular economy that could have fundamental — or even radical — implications for OSH. These developments may include **trends, radical innovations or even disruptions** that have the potential to transform the future of work and workplace health and safety in Europe up to 2040.

In your view, what are the three most significant trends or levers related to the circular economy that could fundamentally or radically change occupation health and safety in the future? (Thinking as far out as 2040.)
    1) ...
    2) …
    3) ...

Below are some of the potential developments — 'key factors' — that we are currently working on:
1. Behaviour: waste prevention (i.e. focus on reuse) leading to increased levels of recycled waste (both consumer and industrial).
2. New forms of work: including the platform, gig and sharing economies, among others.
3. Digitalisation and automation of workplace tasks (including robotics).
4. Increasing inequality: including wage inequality and job polarisation.
5. Localisation of waste management and recycling processes (i.e. reshoring/deglobalisation).

Apart from what we have discussed so far, and **on top of the five key factors mentioned, are there any additional trends or levers for change related to the circular economy that you see**?
    • ...
    • …
    • ...

What are the **three most significant implications that you see for occupational health and safety** potentially resulting from the circular economy in Europe up to 2040?
    1) ...
    2) …
    3) ...

And finally, when thinking about the circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040?**
    • ...
    • …
    • ...

Interview write-up: expert on OSH

In your view, what are the three most significant trends or levers related to the circular economy that could fundamentally or radically change occupation health and safety in the future? (Thinking as far out as 2040.)
1) The CE will lead to more separation of material, more repair, more maintenance — this brings about specific risks such as health risks associated with handling of dangerous materials (e.g. asbestos), and then also typical risks that emerge from maintenance and repair activities will increase. Around 35 % of all fatal accidents at work are in maintenance jobs. Thus, the rate of traditional risks will increase, and more risks related to dangerous materials may occur.
2) More biological risks, for example as a result of longer term storage of waste (such as fungi, bacteria, etc.). These biological risks are usually combated with chemicals (i.e. disinfectants), which carry their own set of risks to health and safety. All the criteria surrounding contamination risk still need to be developed.
3) More leasing-type arrangements (i.e. change in ownership structures), e.g. car companies already lease out the painting of the cars. These changing structures will require more coordination around recycling = one obligation more. More coordination for the company, and more for OSH in general.
4) Question on whether the CE is closed around Europe, or if you include the OSH risks from around the world as a result of outsourcing Europe's waste.

Below are some of the potential developments — 'key factors' — that we are currently working on:
1. Behaviour: waste prevention (i.e. focus on reuse) leading to increased levels of recycled waste (both consumer and industrial).
2. New forms of work: including the platform, gig and sharing economies, among others.
3. Digitalisation and automation of workplace tasks (including robotics).
4. Increasing inequality: including wage inequality and job polarisation.
5. Localisation of waste management and recycling processes (i.e. reshoring/deglobalisation).

Apart from what we have discussed so far, and **on top of the five key factors mentioned, are there any additional trends or levers for change related to the circular economy that you see**?
- New forms of work will result in additional separation requirements for recycling, etc., and there will be more outsourcing. And those who deal with recycling have highest levels of risk, lowest wages, etc.
- More legal obligations means a higher likelihood of the developing criminal practices, e.g. an online black market in certain chemicals.

What are the **three most significant implications that you see for occupational health and safety** potentially resulting from the circular economy in Europe up to 2040?
1) Whether CE developments are based on market instruments, i.e. price signals, which leads to strong separation of companies who are dealing with high-repetition tasks/bad working conditions. Or whether based more on legal obligations, which leads to more criminality.
2) Upscaling of this type of work by improving the processes, i.e. towards more highly technical machine work, more automation, etc.
3) More everyday OSH risks associated with taking in increased levels of waste and various types of (potentially hazardous) materials for recycling, and for repair.

And finally, when thinking about the circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040?**
- Legal initiatives on supply chain development, i.e. initiatives that, for example, place obligations on workers' rights. Called supply chain law, it places obligations on not only environmental practices, but workers' health and safety.
- Relationship between impact on environment/public health/OSH — where will the priorities be placed?

Additional comment. The legal obligation of the handling of material will become more and more complex and difficult to control. There is a lot of knowledge required (a) from enterprises and (b) from authorities to control the details of the legislation. In my view the current implementing and policing infrastructure is far from being sufficient. We see this in certain aspects of chemical legislation, often

only minor implementation has been achieved, e.g. measuring and control of OEL (occupational exposure limits); or under REACH, downstream users should use chemicals only for those purposes that are documented in the Safety Data Sheet (great idea, but control???). There are plenty of such examples.

Interview write-up: expert on the CE and OSH

In your view, what are the three most significant trends or levers related to the circular economy that could fundamentally or radically change occupation health and safety in the future? (Thinking as far out as 2040.)
1) Emerging risks due to the rise of new technology in a circular economy, such as new technology that is not on the market today. New kinds of technology bring new risks, both for process safety and for OSH.
2) Digitalisation (refer to future study on digitalisation from EU-OSHA). Many, many consequences — not only in rise of data, e.g. workplace algorithms, but also consequences for working arrangements, e.g. remote and flexible work, leading also to increased techno-stress, etc.
3) Rise of AI and autonomous workplace robots.

Below are some of the potential developments — 'key factors' — that we are currently working on:
1. Behaviour: waste prevention (i.e. focus on reuse) leading to increased levels of recycled waste (both consumer and industrial).
2. New forms of work: including the platform, gig and sharing economies, among others.
3. Digitalisation and automation of workplace tasks (including robotics).
4. Increasing inequality: including wage inequality and job polarisation.
5. Localisation of waste management and recycling processes (i.e. reshoring/deglobalisation).

Apart from what we have discussed so far, and **on top of the five key factors mentioned, are there any additional trends or levers for change related to the circular economy that you see**?
- Energy transition — shift from carbon to solar and wind results in different kinds of hazards for OSH.
- Robotics (complete topic on its own, i.e. not just included within digitalisation and automation).
- Human and AI collaboration.
- Dealing with complexity. Everything in the CE will be much more interrelated, increasing the number of both linear and non-linear relationships, increasing the complexity of systems. I do not think humans will be able to oversee the complexity of systems any more.

What are the **three most significant implications that you see for occupational health and safety** potentially resulting from the circular economy in Europe up to 2040?
1) Transition to digitalisation and robotics, and the relinquishing of decision-making power to technology. Technology will be increasingly supportive for decision-making, with machines playing a more prominent role in decision-making.
2) Rise of techno-stress as a result of working more with digital systems.
3) Risk communication and transparency. As everything is becoming more complex, we not only have to make more decisions but we also have to relay why we are making such decisions — are we relying fully on technology or on data-driven models? How do we best communicate risk and on which basis, with stakeholders, public, politics, inspectors, etc.? All lead to the need for higher transparency in communication. On inspections and risk communication: the future will include more data-driven inspections, spot checks on specific processes and in higher detail.
4) 9-5 will be less and less prominent as an employment level. Work will become more flexible, more remote working, any time/anywhere.

And finally, when thinking about the circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040?**
- Privacy and non-disclosure agreements. Many conditions will have to be met: not only focus on hazards etc. and data, but also on conditions that you have to meet and that you have to cope with.
- Social acceptance (by stakeholders, community, politics, etc.). In terms of information dissemination, truth will matter less than trust in the authority delivering the message — instead it's all about acceptance of the information and how you can get that acceptance.
- Balance between private life and work life, with borders between the two eroding.

Interview write-up: expert on the CE

In your view, what are the three most significant trends or levers related to the circular economy that could fundamentally or radically change occupation health and safety in the future? (Thinking as far out as 2040.)
1) Creation of more recycling in the first phase will not immediately result in change in the design; thus, recycling quantities will increase, and some of this recycling waste will be hazardous.
2) New materials (i.e. nanomaterials) and what that means for workers.
3) For some products, a focus on modular design (i.e. design for easy dismantling) will create improved safety for workers, i.e. click-in/click-out components mean less possibility of accidents when dismantling.
4) Digitalisation results in less movement for workers (both on the factory floor and in offices) — leads to more health concerns, e.g. back pain from sitting too long, eye strain from screens, all the way to lifestyle diseases such as diabetes.

Below are some of the potential developments — 'key factors' — that we are currently working on:
1. Behaviour: waste prevention (i.e. focus on reuse) leading to increased levels of recycled waste (both consumer and industrial).
2. New forms of work: including the platform, gig and sharing economies, among others.
3. Digitalisation and automation of workplace tasks (including robotics).
4. Increasing inequality: including wage inequality and job polarisation.
5. Localisation of waste management and recycling processes (i.e. reshoring/deglobalisation).

Apart from what we have discussed so far, and **on top of the five key factors mentioned, are there any additional trends or levers for change related to the circular economy that you see**?
- Related to the above point on localisation of waste and recycling processes: reduction in volumes of second-hand goods (and waste) being sent to developing nations will hopefully reduce some health and safety burdens in these other world regions.
- Overall, the aim is to reduce resource use, leading to less mining. Hopefully, a premium will then be placed on any remaining mining activities, which will be focused on more value and better work conditions.

What are the **three most significant implications that you see for occupational health and safety** potentially resulting from the circular economy in Europe up to 2040?
1) Returning to the point on digitalisation resulting in workers becoming less active, which then has negative impacts on both physical (i.e. lifestyle diseases) and mental health (although this is more a direct result of digitalisation than of CE specifically). We are seeing this already as a result of COVID-19, including decreasing social contact and what that means for mental health outcomes.
2) There is opportunity for better design of products, which could create better safety for recycling and refurbishment. If you take the health and safety of workers into consideration when designing products, you can then also prevent a lot of injuries down the line.

And finally, when thinking about the circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040?**
- The role of consumers and their impact on the CE is often overlooked, but it is their behaviour that is being influenced. Thinking about online shopping for example, a take-back system (i.e. easy return of the product) also removes the physical aspects from the consumer and instead places it on the logistics team (i.e. the courier driver, and so on). It creates a passive consumer society. The CE of 2040 should also focus on using fewer products, and it must move away from the current system, which allows products to be taken directly to consumers with very little effort on the consumers' side.

Interview write-up: expert on the CE and the future of work

In your view, what are the three most significant trends or levers related to the circular economy that could fundamentally or radically change occupation health and safety in the future? (Thinking as far out as 2040.)

1) Waste export ban: China's decision — effective 1 January 2018 — to stop the import of 24 kinds of solid waste (including plastics, paper products and textiles, etc.) from foreign countries highlighted the hidden aspects of the circular economy and the inherent risks to waste workers. Other Asian countries soon followed suit, which has implications for health and safety. Firstly, how sustainable was it in the past to transport waste to other nations, with poor working conditions — which in some accounts amounts to exploitation. Secondly, the longer waste sits (i.e. on long transport journeys), the more contaminated it becomes, resulting in increased health and safety risks for workers. As a result of this 'recycling ban' from Asian countries, the EU is faced with two options/outcomes: (1) more recycling on the local level, leading to more waste incineration, leading to more waste-to-energy, or (2) more illicit trading in waste both inside and outside the EU (and especially to eastern European countries such as Poland).

2) Exploitation of marginalised workers: who is doing the recycling in Europe, i.e. who are we letting do all of the dirty work? Links in with inequality. Those undertaking this work (often in the informal sector) are the ones facing increased risks and poor working conditions. In a similar vein, the COVID-19 outbreaks in Europe occurred in dense factory settings, in areas with poor working conditions and workers' rights, e.g. clothing factories, meat packing factories, etc. There is a clear trend in who is doing the work (i.e. marginalised, lower income workers), and we need to take more notice and better care of the working conditions.

3) The waste-to-energy industry is rising on a global scale, with more and more incinerators being built. There is a large trend towards more private sector involvement, because of the high costs involved with constructing plants. Any PPPs need a 30-50 year time frame of guaranteed waste levels to ensure the viability of the plant — which goes against any incentives to reduce waste streams. There is a question of whether or not waste incineration aligns with the goals of the CE — even if it is waste to energy — as, by nature, it does not promote waste prevention. The central problem being that the waste streams directly compete with each other — waste-to-energy is in direct opposition with waste prevention. And the incinerators need a constant stream of waste to remain profitable/worthwhile for the investment and even subsidies granted. We need to be more focused on waste prevention.

Below are some of the potential developments — 'key factors' — that we are currently working on:

1. Behaviour: waste prevention (i.e. focus on reuse) leading to increased levels of recycled waste (both consumer and industrial).
2. New forms of work: including the platform, gig and sharing economies, among others.
3. Digitalisation and automation of workplace tasks (including robotics).
4. Increasing inequality: including wage inequality and job polarisation.
5. Localisation of waste management and recycling processes (i.e. reshoring/deglobalisation).

- Consumption (separate out from 'Behaviour' above): circular economy leading to less overall waste challenges the whole growth model of the EU. The current push for CE goes against waste prevention because it is still based in an overall setting of increasing growth. Examples of companies, such as Apple and IKEA, that are touted as being proponents of the CE are just using it as a marketing strategy. In reality, Apple goes as far as having limited life cycles built into their devices to ensure that consumers need to regularly buy new products.
- We need to also be clear on what type of waste streams we are talking about — in the manufacturing and construction sector waste is increasing, alongside overall consumption and regardless of changes in behaviour (i.e. towards increased recycling). Overall volumes of waste are still increasing. Waste collection and processing in the manufacturing and construction sector are also some of the most risky and hazardous jobs. When thinking about waste prevention we need a sectoral focus, rather than just focusing on the municipal.

Apart from what we have discussed so far, and **on top of the 5five key factors mentioned, are there any additional trends or levers for change related to the circular economy that you see**?

- Design: waste workers could be incorporated into the initial design phase. Currently we are seeing improvements in design to improve recyclability (e.g. yoghurt pots where the

consumer can separate the cardboard from the plastic). This needs to go further in terms of incorporating thinking about fair worker conditions into the design phase, how things can be dismantled with the least risk to workers. Something similar to a Fairtrade label could be developed that shows workers' rights have been incorporated into the product design. A Fairtrade labelling for the end of the life cycle, for the reuse/recycling/dismantling of the product. This would create a truly holistic system across the entire supply chain.

- Informal economy in Europe: at least the same amount of recycling is going into the informal economy in Europe as is going into the formal economy in Europe, e.g. Pfand on bottles in Germany fuels the informal economy, by encouraging those in need to rifle through rubbish bins to collect the small amount of return cents. So in a way, policy is also creating these informal economies through policies, and, in terms of health and safety, how healthy is it if people need to go through rubbish bins to collect these bottles? Health and safety in the broad sense needs to also consider the risks in the informal economy — and it's the marginalised communities, already facing the most inequality, that are most affected.

What are the **three most significant implications that you see for occupational health and safety** potentially resulting from the circular economy in Europe up to 2040?

1) Increase in privatisation: rather than the quick fix of outsourcing waste to the private sector, how can we make waste sustainable over the longer term? How can the waste industry be truly sustainable if there is a profit to be made from waste? There needs to be a rethinking around recycling in the EU in terms of how it can be made truly sustainable.
2) Scramble for waste: currently, companies are competing for the same waste (i.e. waste as a resource). If we want a waste management system that works, for the environment, for the workers, and for future generations, that waste management system needs to be more holistic (less fragmented). For a good example of how this can happen, look to Slovenia/Ljubljana: they have implemented a truly holistic waste management programme that incorporates (1) public outreach on waste prevention and (2) public procurement policies; and (3) they are all under public ownership and control so that waste streams are not competing with each other, i.e. accountability + control + prevention.
3) Waste in a holistic manner (see above).

And finally, when thinking about the circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040?**

- Consumption and growth model needs to be challenged. There is no profit to be made in waste prevention, which is in direct contradiction of the EU's Green Growth Model. If we really want to implement a sustainable CE in Europe, we should be adopting a public good approach/human economy model (rather than a profit/growth model). The advent of COVID placed the emphasis back on the essential workers. What do we appreciate? Efficiency in terms of profits or efficiency in terms of creating a truly sustainable waste management system?
- Policy needs to be built on solid research that keeps workers' considerations central to its outcomes. We need to think through all the links in the chain when developing policy, and not leave any aspects out, particularly as these policies will affect workers further into the future and the coming decades.

Round 2: Expert interview questionnaires
Expert interview questions

The European Agency for Safety and Health at Work, together with Future Impacts, is undertaking a scenario study to understand **possible developments in the circular economy and their impacts on occupational health and safety (OSH), in the European Union**.

We are focusing on understanding potential developments in the circular economy that could have fundamental — or even radical — implications for OSH. These developments include trends, radical innovations or even disruptions that have the potential to transform the future of work and workplace health and safety in Europe up to 2040. Through putting together different — plausible and consistent — combinations of these developments, we have arrived at a set of scenarios.

In the next steps of the project, themes featured in the scenarios will be developed into full storylines that describe respective development pathways, levers and turning points, and the potential implications for OSH under each scenario world, always reflecting on circular economy perspectives.

It's worth noting that the scenarios themselves are a communication tool, aimed at generating engagement with stakeholders. They are not meant to predict future worlds but are meant to start a conversation (or two).

In your view, what would a successful or fully realised circular economy (CE) look like — if it were to incorporate all the necessary OSH protections and measures? Please describe a positive CE future for Europe in 2040, where OSH considerations are fully embedded into practices and policies. (And how and why is OSH different from today?)

- ...
- …
- ...

For this scenario to be realised, what are some of the most significant measures or levers related to OSH (concerning the CE) that will need to be enabled?

- ...
- …
- ...

Now imagine a more negative scenario — like the one described below — where OSH consequences are rather problematic. *(Authors' note: each interviewee received a different scenario to comment on).* Scenario bullet points:

- ...
- …
- ...

Under this scenario, what do you see as the **most significant implications for occupational health and safety** in Europe up to 2040? How is OSH different from today?

- ...
- …
- ...

When thinking about Europe's transition to a circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040, in the EU?**

- ...
- …
- ...

Finally, what else should we consider for EU future perspectives on the CE and potential OSH consequences? Is there anything we have not spoken about that is important in terms of the CE and its implications for OSH?

Interview: expert on OSH

In your view, what would a successful or fully realised circular economy (CE) look like — if it were to incorporate all the necessary OSH protections and measures? Please describe a positive CE future for Europe in 2040, where OSH considerations are fully embedded into practices and policies. (And how and why is OSH different from today?)

- OSH is a key element in the education and training of people working in the sector.
- Existing OSH knowledge is used by all companies working in the CE; people are well paid.
- Enforcement of EU legislation is improved in all member countries.
- Carbon dioxide storage technologies are safely and routinely used.
- All nuclear waste is finally disposed of with safe technologies for transport and storage.
- Workplaces are safely designed from the very beginning, and PPE is therefore not necessary at the plants.

For this scenario to be realised, what are some of the most significant measures or levers related to OSH (concerning the CE) that will need to be enabled?

- Make health an important value for all people working in the CE.
- Transfer OSH knowledge into new sectors, e.g. electrical engineering for batteries in cars.
- Digitalisation and automation wherever possible.
- Risk assessment for all new working environments: windmills, biogas plants, landfills, sewage sludge, waste shipment.

Now imagine a more negative scenario — like the one described below — where OSH consequences are rather problematic. Scenario bullet points:

- With increased public focus on climate change and the environment, the EU introduces ambitious targets and strict new regulations aimed at hastening the transition to carbon neutrality (and a circular economy). Old, carbon-heavy, energy generators are dismantled as the renewable energy infrastructure is hastily erected. Throughout these hazardous processes, little consideration is given to workers' health and safety.
- Per capita consumption levels continue to rise, but at a slowing pace. A rise in the environmental considerations of individuals in the EU results in flow-on effects in regulation and industry practices. However, this shift does not necessary lead to better OSH outcomes for affected workers, as new, unaddressed, health and safety risks emerge as a result (i.e. from the shift to renewable energy generation, increased recycling volumes, etc.).
- Digital technologies are everywhere, and work is abundant. Workers have become more diverse and dispersed, relying on automation to improve workplace safety; thus, responsibility for OSH is difficult to establish, and even more difficult to oversee.
- Increased uncertainty surrounding the next global catastrophe leads EU governments to enact austerity measures in order to have sufficient funds set aside to manage potential future fallouts. This leads to reduced funding for ensuring health and safety in the workplace — leading to higher overall risks and worsening OSH outcomes.

Under this scenario, what do you see as the **most significant implications for occupational health and safety** in Europe up to 2040? How is OSH different than today?

- OSH under time pressure with too little money during natural disasters.
- OSH in a scenario of a gig economy with isolated, unorganised self-employed people without OSH training, and not aware of most of the risks.
- Migrant workers are used for the most dangerous jobs with high risks. Missing enforcement.

When thinking about Europe's transition to a circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040, in the EU?**

- CO_2 capture and storage will be of high importance.
- Landfills are the mines of 2040 — dangerous and dirty.
- OSH for waste storage in the background of natural disasters like thunderstorms, floods, dyke breaks.

Finally, what else should we consider for EU future perspectives on the CE and potential OSH consequences? Is there anything we have not spoken about that is important in terms of the CE and its implications for OSH?

- The CE needs well-maintained infrastructure. Western industrial countries do not invest in this maintenance because of lack of money.
- Nuclear power plants will be dismantled, and nuclear waste needs to be stored forever. This may create new risks.

Additional questions/discussion points:

Comment: Rather than being a more negative scenario, the orange scenario above is a more typical scenario — a scenario of today (i.e. business-as-usual scenario). There are a lot of aspects in the above scenario that I can see today in the OSH environment.

Education and training, as well as the transfer of knowledge, was touched on as a key element of improving OSH outcomes. Where do you see the responsibility for this lying?
- Responsibility shared by both public education, e.g. schools, and private training, e.g. companies.
- The point being, I do not see totally new risks coming up from a transition to a CE. A lot of the technologies and risks are already known. What is needed, then, is more sharing of existing knowledge to improve OSH procedures.
- A lot of waste and recycling jobs are done by lower skilled and migrant workers; we need to improve education in these sectors. We also need to improve the image of these sectors — they are the gold mines of the future. We can save a lot of money if we invest in these sectors, and are able to eliminate mining in traditional gold mines, e.g. in South Africa, by instead combing the waste sector for reusable resources.

How can we increase enforcement of OSH standards in the informal economy?
- By improving the economics behind it, i.e. providing fair pay to workers in the waste sector.
- Proactive policies (and politics) as opposed to reactive.
- Increase the number of enforcement officers.
- Reduce differences in enforcement in the EU member countries.

Can you comment on pandemics (current and future) and the increase in single-use products — and what this might mean for workers and OSH:
- The best way to protect workers and improve OSH outcomes is automation.
- In the big companies this is easier, as they have the money for this; however, this can be a problem in the gig economy and with small companies.

What are the potential new risks from the digitalised/gig economy?
- As fields change or collapse, different types of workers are facing new risks. However, these risks are not exactly new — but just new to that sector (e.g. the automobile sector moving to electric batteries — information on electric batteries is already known by electrical engineers, but perhaps not by traditional automobile sector workers. Thus, education is needed).

Carbon capture and storage is one area where there are new risks.

Can you comment on the new risks associated with carbon capture and storage when it is combined — for example — with climate change and increasing natural disasters?
- When you look at the statistics on safety and health during a natural disaster, this is also poor. While people might be educated to work safely with materials under normal circumstances, they are not always aware of the heightened risks of, for example, extreme temperatures, fires, flooding, power cuts. Workers (except emergency responders) are not trained for these environments.
- We will have more natural disasters in Europe in the next 20 years, and the combination of the risks coming from the CE and from climate change will be new.

While designing safer workplaces from the beginning is the ideal, what about the need to retrofit existing plants, factories, etc?
- Retrofitting is what we do very often, and in these cases we then give the workers PPE (i.e. masks, ear plugs, etc.), thus making OSH the problem (or responsibility) of the individual worker. But if you want to have a truly safe environment, you need to do more than just

protect the individual worker with PPE. You instead have to change the workplaces. OSH needs to be a topic from the beginning, when you design the workplaces. Furthermore, if you do it from the beginning, individual workers do not need to use a lot of the PPE — because they are working in a safe environment.

- Increased automation is the best solution in such an old environment; more machines, more technology (i.e. robots) that reduces the need for workers in such dangerous environments.

Interview: expert on the CE and OSH

In your view, what would a successful or fully realised circular economy (CE) look like — if it were to incorporate all the necessary OSH protections and measures? Please describe a positive CE future for Europe in 2040, where OSH considerations are fully embedded into practices and policies. (And how and why is OSH different from today?)

- The design of products must take into account their entire life cycle, including repair, dismantling, recycling, etc. If these operations cannot be carried out under satisfactory health and safety conditions, the design of the product must be reviewed.
- Significant progress in the field of task automation that allows for:
  a) keeping workers away from pollutant emissions (in the event that the circular economy leads to the reshoring of certain polluting activities that have hitherto been relocated to countries with low labour costs);
  b) making automation much more skilful and reliable (especially for replacing humans in operations to deconstruct property or sort waste);
  c) etc.
- In the same vein, the development of cobotics, the most physically demanding tasks being reserved for the machine under human control.
- To ensure that, overall, it is the man who sets the pace and not the machine.
- Significant progress in new materials that are easily recyclable under good conditions for workers.

For this scenario to be realised, what are some of the most significant measures or levers related to OSH (concerning the CE) that will need to be enabled?

- All is already in the European Directive 89/391 on health and safety at work. All that is needed is to actually follow and implement it. This must not remain a text, but it must be implemented in practice on the ground with the necessary means of advice and control.
- And in order for it to be fully applicable, the transformation of existing installations so that they can be integrated into the circular economy and the design of new installations should make possible this full application of the directive.
- The actual work (not only the theoretical prescriptions) must therefore be taken into account, and workers must be involved in the design of these new installations.

Now imagine a more negative scenario — like the one described below — where OSH consequences are rather problematic. Scenario bullet points:

- With other issues, such as pandemics and economic crises, stealing public and political attention, the transition towards sustainable societies goes on the back-burner. The ability of workers to safely keep the economy running is prioritised, however, and workers' rights increase as a result.
- Eco-consciousness is on the rise, but people have not fallen out of love with shopping. However, increased caution around the sharing of products, due in part to the COVID-19 pandemic, has led to a significant reduction in the sharing and leasing economy.
- As a result, there has been a rise in waste and recycling volumes. Workers have to tackle more waste than ever before, with myriads of inputs, and are forced to go to extreme lengths to meet the recycling targets set — all at a considerable risk to themselves.
- Excessive caution concerning new materials has resulted in very few new materials being approved for use in the EU. However, use outside the EU has increased dramatically. Now, workers come across illegal or 'grey' imports of products involving (undeclared) new materials during recycling and repairing activities, yet they lack the necessary OSH practices to handle them safely.
- Within the EU, policies continue to be driven by free trade and market forces, leading to the outsourcing of waste processing to poorer southern EU nations, while richer EU nations enjoy the benefits. This leads to significantly worse OSH outcomes in the waste sector in poorer EU states, especially in the informal economy.

Under this scenario, what do you see as the **most significant implications for occupational health and safety** in Europe up to 2040? How is OSH different from today?

- Another plausible hypothesis for point 5 ('Within the EU, policies ...') is that labour is being transferred from the poorest countries to the most favoured countries in Europe to carry out

the most devalued work (such as waste recycling): in this case, it is difficult to imagine an increase in the rights of all workers.

- Another hypothesis consistent with the first is that there is an 'import' of workers from low labour cost countries to EU countries to work on deconstruction or recycling tasks in conditions not acceptable to EU workers. There have already been examples of this in the UK of textile workers working for Boohoo.

When thinking about Europe's transition to a circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040, in the EU?**

- The issue of traceability of goods and materials. If we want to be able to reuse them under good conditions for workers (but also for consumers), it will be necessary to make very great progress in this area if a circular economy is to be set up: the current traceability systems are high energy consuming. This is not very compatible with the circular economy.
- The nature of professional statuses must also be taken into account: with few exceptions, a self-employed worker (such as those in the platforms) does not have the means today to practically organise his or her own occupational risk prevention. However, we have seen an increase in the number of such contracts in recent years.

Finally, what else should we consider for EU future perspectives on CE and potential OSH consequences? Is there anything we have not spoken about that is important in terms of the CE and its implications for OSH?

The establishment of a circular economy hardly seems compatible with the increase in inequalities that we are currently witnessing in Europe. It is unlikely that basic commodities and junk food can remain at the current low prices. We would therefore see the development of a circular economy reserved for the richest, while the poorest would remain in a linear pattern. This is fairly compatible with the fifth hypothesis (in the scenario outline above) of the less favourable scenario ('Within the EU, policies continue to be driven by free trade and market forces ...').

Additional questions/comments from the discussion: What are some of the differences between the outcomes from the INRS study focused on France and what is applicable on the EU level?

At the EU level there is a higher level of social inequalities between countries, for example in wages (i.e. eastern Europe vs. western Europe). These differences could have an impact on recycling behaviour etc.

Automation has been slated as one of the main topics or ways in which OSH outcomes can be improved. However, do you see any additional risks to workers as a result of increased automation?

Automation needs to take into account the worker; it is hard to imagine a CE without big progress in automation. But automation can have a big impact on workers, i.e. if the economy (and efficiency) is more important than the health of workers there will be no positive outcomes.

If the aim of new technology is to protect the worker — then there will be positive outcomes. But, if automation is only focused on improving efficiency (or solely improving environmental outcomes), it could have a very negative impact on OSH.

It is hard to imagine a CE without a big progress in automation, but this progress can be bad for workers.

Challenge: To take into account all different strains (i.e. economic, environmental and OSH) into the development of new enterprises.

Traceability: In your answers above you mentioned that Europe would need to significantly improve traceability to successfully implement a CE in Europe. Can you elaborate on this, i.e. how can this be achieved; are there any factors holding back the successful development of a traceability system, etc.?

It's a very important point, as many products today include an array of chemicals and can be enriched with dangerous products. If you do not eliminate some of these chemicals, it can be very dangerous to workers. The risk of these kind of compounds increases the more times a product is recycled — e.g. impurities increase the more times a product is recycled, and this obviously has negative health outcomes for consumers, but particularly for the health of workers.

Blockchain is one technology that could increase the traceability of components in products; however, blockchain is very energy intensive — which goes against the principles of a CE. We need some new type of low-energy technology that can conduct a speedy analysis of a product and its individual components. A new technique needs to be found.

A circular economy is very technical — we need more sophisticated techniques than we currently have, e.g. speed analysis of components before analysis (although this could be very costly).

Is our current infrastructure up to the challenge? Or would it need to change in terms of the value chain, i.e. would we need more specialised workers? Local collecting stations? An urban mining-type set-up? An intermediator to sort waste?
This will depend on our ability to analyse the materials — and at what level, i.e. what size. From a small-scale local level, up to perhaps — at the other end of the scale — this level of a city. Note: maybe a little bit bigger for some particular compounds: Kreis (in Germany) or département (in France). Or maybe even Land (Germany) or région (France). It is more a view than something based on a current reality that could provide concrete examples.

The traceability issue also brings up the question of information, e.g. the car industry has databases of all components and materials in all different models of cars down to the minutest level. By contrast, when you have products at the end of their life in a treatment centre, such as small electronic equipment from, for example, China or Japan, it is near impossible to know the composition. It's a problem of lack of information in some cases.

How can we remedy this situation? Is it regulation?
Perhaps best a role for standardisation. But this standardisation can respond to precise orders from the public authorities (states).

Implications arising from the platform economy: who should have the oversight for ensuring workers in the platform economy take care of their personal health and safety while they work?
From our experience, it cannot work on an individual level. Platform economy workers do not have the means to organise their own OSH. A self-employed worker will not have the means to apply 'prevention'.

Everything depends on the economic model. All recycling hangs on the price of a barrel of oil. If the price of oil is high, recycling makes sense. If the price falls, it no longer makes economic sense to recycle. The same situation applies to the role of the workers in the platform economy. When you can get low-cost workers without having to invest in them (i.e. OSH prevention) then you cannot expect to see better health and safety outcomes. We would need to see a shift towards a social and solidarity economy to see health concerns (and prevention) flow onto platform workers. Social and solidarity economy structures are also inherent in the CE economy. But today we are a long way from adoption of these models.

Interview: expert on OSH

In your view, what would a successful or fully realised circular economy (CE) look like — if it were to incorporate all the necessary OSH protections and measures? Please describe a positive CE future for Europe in 2040, where OSH considerations are fully embedded into practices and policies. (And how and why is OSH different from today?)

- We live in times of use and discard, i.e. linear economy and linear production; the future will be more focused on the environmental impacts — whatever terminology is used, i.e. CE, green economy, CSR, reuse, recycle, repair, etc. However, in the more environmentally conscious future it is hard to see much difference for OSH. Future jobs will be similar to today; there will be the same or similar risks and hazards (perhaps only slightly different by sector etc.).
- The main aspect of a change to jobs and OSH in the future will come from new technology, which can bring about new hazards and risks for workers, making retraining even more necessary. The future challenges faced by workers as a result of new technologies will mean that workers will need to become increasingly multiskilled, with an increased ability to multitask; they will operate in small rooms, sometimes remotely, with roles more focused on controlling (i.e. machines), and thus this could lead to a rise in loneliness, boredom, posture problems from sitting for extended periods of time, etc.

For this scenario to be realised, what are some of the most significant measures or levers related to OSH (concerning the CE) that will need to be enabled?

- Good risk assessment — consideration of OSH from all aspects, including in the individual design of every element in the system.
- The question of whether the CE is focused on (or encompasses) one sector, or whether it includes a mix of sectors (e.g. if construction and demolition sector reuses and recycles within the sector, or does it also include waste and by-products from the agricultural sector and vice versa, and so on).
- The CE (whatever form it takes) will need excellent planning and diffusion of hazards. Furthermore, it will be vital that only certified technologies are used.
- Extra care will need to be taken in the reuse of some materials, and parts of the system may need to be reshaped to accommodate this.
- The health of workers needs to be placed in the centre, with an increased use of IT in processes.
- A closed system will be needed in the management of chemicals and hazardous materials.
- For a closed system to exist, it will need good technology, good control, good workers and good communication between companies (i.e. communication strategies and standardisation).

Now imagine a more negative scenario — like the one described below — where OSH consequences are rather problematic. Scenario bullet points:

- With other issues, such as pandemics and economic crises, stealing public and political attention, the transition towards sustainable societies goes on the back-burner. The ability of workers to safely keep the economy running is prioritised, however, and workers' rights increase as a result.
- Eco-consciousness is on the rise, but people have not fallen out of love with shopping. While increased caution around the sharing of products, due in part to the COVID-19 pandemic, has led to a significant reduction in the sharing and leasing economy.
- As a result, there has been a rise in waste and recycling volumes. Workers have to tackle more waste than ever before, with myriads of inputs, and are forced to go to extreme lengths to meet the recycling targets set — all at a considerable risk to themselves.
- Excessive caution concerning new materials has resulted in very few new materials being approved for use in the EU. However, use outside the EU has increased dramatically. Now, workers come across illegal or 'grey' imports of products involving (undeclared) new materials during recycling and repairing activities, yet they lack the necessary OSH practices to handle them safely.
- Within the EU, policies continue to be driven by free trade and market forces, leading to the outsourcing of waste processing to poorer southern EU nations, while richer EU nations enjoy

the benefits. This leads to significantly worse OSH outcomes in the waste sector in poorer EU states, especially in the informal economy.

Under this scenario, what do you see as the **most significant implications for occupational health and safety** in Europe up to 2040? How is OSH different from today?

- Currently, the standards in the EU are the same — but the implementation of those standards differs. This includes implementation of legislation, social reporting, enforcement, control, inspections, etc.
- Social reporting can help (e.g. CSR); however, it needs to be clearly communicated and available for everyone (e.g. published on company websites). CSR reporting leads to better performance and outcomes.
- It's also a question of materials. In times of larger and more urgent considerations, e.g. COVID, the use of cheap materials and cheap machines etc. is more likely to slip through the net.
- To avoid this, we need standardisation, enforcement, repercussions (i.e. punishment), etc.
- There will be a rise in the exposure to hazardous conditions if regulation is not enforced and workplaces are not adequately and regularly inspected.

When thinking about Europe's transition to a circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040, in the EU?**

- Question: how can we use waste that is not reusable (i.e. nuclear waste)?
- Regulation in social legislation, i.e. working conditions and workers' rights.
- We could end up in a scenario where social outcomes become more important than OSH, i.e. injuries matter less than the structures around the workers, such as good pay, retirement benefits, etc., in the case of an accident the companies' insurance company will pay compensation, etc.

Finally, what else should we consider for EU future perspectives on the CE and potential OSH consequences? Is there anything we have not spoken about that is important in terms of the CE and its implications for OSH?

- Question of maintenance of elements of production systems (i.e. once a closed-loop system has been set up, how does maintenance of that system function?). Maintenance is necessary, but is it included under the CE principles?

Interview: expert on OSH

In your view, what would a successful or fully realised circular economy (CE) look like — if it were to incorporate all the necessary OSH protections and measures? Please describe a positive CE future for Europe in 2040, where OSH considerations are fully embedded into practices and policies. (And how and why is OSH different from today?)

- Integrates health and safety into all aspects at the very beginning, i.e. making OSH considerations mainstream and ensuring processes are well thought through from the start, from an OSH perspective. This is important, as it's been shown that add-ons (after the fact) do not produce the best outcome.
- Health and safety considerations integrated into all aspects of design, i.e. cradle to cradle.
- Important to avoid contact between workers and heavy metals at all times.
- Sustainability needs to include not just environmental considerations, but also incorporate social sustainability (i.e. fair pay and fair work conditions, etc.).
- New technologies can improve OSH, but this will not occur by itself. Instead, it needs to be in focus, and OSH considerations need to be integrated from the beginning when developing new technologies.

For this scenario to be realised, what are some of the most significant measures or levers related to OSH (concerning the CE) that will need to be enabled?

- The Biological Agents Directive (2000/54/EC) needs to be revised, also in the light of lessons learnt from COVID, but especially before any real shift to a CE. For example, organic agents are currently excluded from the directive.
- The Asbestos Directive (2009/148/EC) needs to be revised in the light of a potential increase in renovations to housing, e.g. for improved energy efficiency.
- Wind energy and wind turbine projects are quite dangerous and hazardous for workers — this needs increased attention.
- Enforcement: guidelines for labour inspections (e.g. the ILO, the EU's Senior Labour Inspectors' Committee) need to be extended to enforce OSH, especially with regard to migrant workers, platform economy, etc. Increased cooperation between OSH and the ELA (European Labour Authority) is needed, and the ELA needs to include OSH in its inspections of cross-border labour conditions.
- Ensuring collective bargaining rights from the beginning is also important.
- We also need to focus on waste from the beginning, not just how to deal with it but also how to avoid it. This also needs to include the design of waste processing plants, and the increased need for a higher number of sorting containers (for a growing array of inputs).
- To improve OSH outcomes, processes dealing with waste need to be automated as much as possible.
- A focus needs to be placed on the quality of green jobs, not just the quantity of new green jobs.
- Responsibility for OSH should never be placed on the individual worker.
- Supply chains and public procurement should include OSH requirements (i.e. as many now do for environmental considerations).
- We increasingly need to protect workers from the effects of changing climate conditions. For example, global warming will have significant impacts for workers in, for example, southern Europe.
- There is a strong need to look at the workplace much more broadly. Regulations currently cover only official employer workplaces, but work is being done much more frequently outside of traditional workplaces (i.e. at home, at a client's house, outside, etc.).
- We need to ingrain OSH into the ILO Declaration on Fundamental Principles and Rights at Work — being safe at work is a fundamental right.
- We need to invest in proper waste management in Europe and ban the exportation of waste to other world regions. Waste is becoming more hazardous and less reuseable, as it is transported and stored for long periods of time.
- We need to improve research on health and safety, and in particular include invisible workers (i.e. lower skilled, poorly paid, migrant workers, etc.) in the research.

Now imagine a more negative scenario — like the one described below — where OSH consequences are rather problematic. Scenario bullet points:

- As international supply chains (and relations) break down, EU countries are forced to process waste within the European bloc. With limited public funding and a workforce inexperienced in managing (and ill-equipped to manage) such levels of waste, OSH outcomes worsen in the waste industry of poorer EU states.
- Per capita consumption continues to rise alongside the consumption of one-time-use products as a result of a new focus on hygiene and increasing health concerns. This throw-away culture leads to higher risks to workers as they grapple with increased waste and recycling volumes.
- Business is ultimately conducted according to cost-effectiveness and profits above all else. Across most EU industries, environmental and ethical practices including CSR are paid lip service only. Industry push-back and weak political will thwart attempts at strengthening regulation across the board.
- Digitalisation has brought the promised rationalisation gains — and the feared job losses. Insufficient retraining has resulted in a vast pool of underqualified workers who lack the qualifications necessary for employment in the new digital world.
- For those lucky enough to have the right skills, platform and gig work has increased tremendously — but with very little regulatory oversight. This has resulted in a fractured and uneven employment landscape, with the 'Russian doll effect' of sub-contracts within sub-contracts — meaning that responsibility for OSH ultimately rests with the workers.

Under this scenario, what do you see as the **most significant implications for occupational health and safety** in Europe up to 2040? How is OSH different from today?
- It is vital to retrain and involve workers in the development of OSH principles and procedures.
- This scenario has the worst outcomes for those at the bottom (i.e. the lowest paid and least skilled).
- Workers who work without sick pay and other labour rights have the worst outcomes: as shown during the COVID outbreak, workers without sick pay were often unable to take time off when sick and as a result fuelled spread of the virus in some instances (e.g. German slaughterhouses). As demonstrated, we risk creating bigger problems for the whole of society when we do not treat workers fairly. We cannot continue to hide such practices away from the public view; in many cases the way lower paid workers are treated amounts to exploitation.
- We need to better regulate sub-contracting and platform economy: sub-contracting is a huge problem for OSH (i.e. as per last point in red scenario). To obtain good OSH outcomes, responsibility needs to be taken for every link in the chain. In a sub-contracting setting, employers are able to send the problems (and responsibilities) further down the supply chain. Furthermore, self-employed persons are not covered under current directives, and the longer we wait, the more the number of those self-employed grows, and thus the number of workers covered by the legislation decreases.
- It is necessary to align enforcement measures across Member States. We also need more knowledge about what is being enforced in different Member States — i.e. is it just OSH or does it also include labour rights (such as holiday pay etc.).

When thinking about Europe's transition to a circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040, in the EU?**
- Workers and OSH perspectives must be included in policy from the beginning.
- Missing elements of social sustainability and the fair/just transition.
- Need to create good, safe and healthy jobs, i.e. quality jobs not just quantity jobs.

Finally, what else should we consider for EU future perspectives on the CE and potential OSH consequences? Is there anything we have not spoken about that is important in terms of the CE and its implications for OSH?
- Psychosocial risks (i.e. stress, mental health, etc.) need to also be covered — especially in relation to work-life (im)balance. There are currently gaps in legislation in terms of covering mental health and occupational stress. Thus, more discussions need to be had around the way of organising work, and how it can be better organised for workers' (mental) health.
- Secondly, the fact that there is no traditional workplace any more leads to questions around how we can make sure we look out for workers' health and safety (i.e. a new way of thinking about 'workplace' safety is needed).

Interview: expert on OSH

In your view, what would a successful or fully realised circular economy (CE) look like — if it were to incorporate all the necessary OSH protections and measures? Please describe a positive CE future for Europe in 2040, where OSH considerations are fully embedded into practices and policies. (And how and why is OSH different from today?)

- To look for OSH protection and measures throughout the full life cycle of a product or material.
- Conventionally, OSH regulation is activity/scenario based and primarily focused on one single substance in a certain activity or process.
- The CE looks in a broader spectrum to OSH throughout the full life cycle of a product and balances the benefits and risks.

When thinking about integrating OSH throughout the full product life cycle, where should the responsibility lie, i.e. who should be the regulators? Should original producers also be reasonable for OSH outcomes at the end of the product cycle etc.?

In the current set-up, OSH practitioners are often solely concerned with the hazards or risks in their own sector, and not the risks that the product might pose in other sectors (i.e. the waste sector). Thus, there is currently no clear responsibility for the health and safety dimension of products throughout the whole product life cycle. Although it's more a theoretical approach than a practical approach at this stage, there needs to be a way to integrate the OSH aspects associated with a product throughout its whole life cycle. Producers need to think about the associated safety concerns (and benefits) of the product throughout the whole life cycle.

For this scenario to be realised, what are some of the most significant measures or levers related to OSH (concerning the CE) that will need to be enabled?

- Safe-by-design or sustainable-by-design are important (novel) principles that have the highest ranking in the STOP strategy and are the best way of preventing OSH-related issues.
- Integration of life cycle assessment (LCA) with health risk assessment (HRA) is essential to combine the best of both.

Please elaborate on your point regarding integrating life cycle assessment (LCA) with health risk assessment (HRA).

LCA practitioners are not necessarily aware of the individual OSH risks associated with products, instead sometimes viewing individuals just as consumers rather than thinking on the level of individual risks associated with a product throughout its life cycle.

When talking about integrating LCA and HRA, do you imagine this taking place on a local level, EU level or global level?

Idealistically speaking, this can really be achieved only on a global level. However, practically, it can be achieved on an EU level. Putting it on a more local level (e.g. national level) will not make enough of an impact (especially when considering the small size of some nations).

Now imagine a more negative scenario — like the one described below — where OSH consequences are rather problematic. Scenario bullet points:

- With increased public focus on climate change and the environment, the EU introduces ambitious targets and strict new regulations aimed at hastening the transition to carbon neutrality (and a circular economy). Old, carbon-heavy, energy generators are dismantled as the renewable energy infrastructure is hastily erected. Throughout these hazardous processes, little consideration is given to workers' health and safety.
- Per capita consumption levels continue to rise, but at a slowing pace. A rise in the environmental considerations of individuals in the EU results in flow-on effects in regulation and industry practices. However, this shift does not necessary lead to better OSH outcomes for affected workers, as new unaddressed health and safety risks emerge as a result (i.e. from the shift to renewable energy generation, increased recycling volumes, etc.).
- Digital technologies are everywhere, and work is abundant. Workers have become more diverse and dispersed, relying on automation to improve workplace safety; thus, responsibility for OSH is difficult to establish, and even more difficult to oversee.
- Increased uncertainty surrounding the next global catastrophe leads EU governments to enact austerity measures in order to have sufficient funds set aside to manage potential

future fallouts. This leads to reduced funding for ensuring health and safety in the workplace — leading to higher overall risks and worsening OSH outcomes.

Under this scenario, what do you see as the **most significant implications for occupational health and safety** in Europe up to 2040? How is OSH different from today?

- I feel that this momentum of sustainability could also provide a good opportunity to focus not only on the environment but also on human health. As stated above, the integration of LCA and HRA is essential and shall go hand in hand.
- The recent COVID pandemic has elucidated that human health (and worker protection) is crucial. The world has seen that OSH is very important and we have ways to protect workers.
- The scenario above is more of a passive scenario, i.e. things just happen and we do not have any agency to change or affect outcomes. The scenario would benefit from becoming more active, i.e. actors having a role in changing outcomes for the better.

When thinking about Europe's transition to a circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040, in the EU?**

- Electricity/batteries will become more and more important for our economy, especially batteries containing a lot of heavy metals and other hazardous chemicals.
- The 'business model' for sustainability is usually unbalanced for the employer and employee versus society. The costs are located differently from the benefits, which hinders good implementation. Here lies a role for governments and the EU.

How can we hope to balance the costs versus benefits dilemma inherent in the business model to ensure that we research more sustainable outcomes?

We need to start incorporating the benefits of new products and technologies into the dialogue, rather than just focusing on the risks. That will help ensure that we can really view the costs of investments versus the benefits, and incorporate these learnings into better, more balanced, outcomes for the environment and OSH. Additionally, there is a need to lower the portion of waste as much as possible, i.e. by applying monetary pressure, e.g. user pays.

Finally, what else should we consider for EU future perspectives on the CE and potential OSH consequences? Is there anything we have not spoken about that is important in terms of the CE and its implications for OSH?

Currently, the division between sectors/departments/ministries is inhibiting the achievement of better social and environmental outcomes. These outcomes would improve if more collaboration between fields was sought, with different fields of expertise working hand in hand. By merging departments or ministries, it would ensure the relevant players talked to each other, and cross-sectoral solutions would be encouraged. This would all result in better OSH outcomes. Even within individual fields (i.e. the environmental field) there's so many buzzwords going around, but no clear communication and cooperation.

COVID could be used as opportunity to push for better OSH outcomes, as witnessed by the health and safety of workers being placed into the spotlight during the pandemic. However, rather than just campaigns and public awareness programmes, benefit would be felt through combining and streamlining regulation (i.e. combining OSH and environmental regulations rather than having multitudes of separate legislation covering separate fields). Enforcement is also an important field that deserves increased attention. And, as we have seen in the past, real change is often achieved by making monetary incentives (i.e. feel-good campaigns have little impact on the longer term effects).

Interview: expert on OSH

In your view, what would a successful or fully realised circular economy (CE) look like — if it were to incorporate all the necessary OSH protections and measures? Please describe a positive CE future for Europe in 2040, where OSH considerations are fully embedded into practices and policies. (And how and why is OSH different from today?)

- New risks associated with increased use of lithium-ion batteries — for workers, firefighters and the environment. Even once the fire is contained, the residue left behind can be dangerous.
- New companies and start-ups see a lot of opportunities in the CE, but often do not understand — or consider — any of the associated risks.
- Education and improved training could reduce risks but, no matter how well trained workers are, the number and size of risks is increasing.

For this scenario to be realised, what are some of the most significant measures or levers related to OSH (concerning the CE) that will need to be enabled?

- Although there are actors signalling the upcoming shift towards a more CE in some sectors, risks are assessed sector by sector, and often in silos. The big picture is not being considered. There is a lack of communication between, for example, OSH departments and environmental ministries. On top of that, the economy is driving these market shifts, with little communication/consideration of any other sectors. Thus, for any positive change to come about, sectors (and ministries) will need to improve communication between themselves and take more of a 'whole picture' view.

Now imagine a more negative scenario — like the one described below — where OSH consequences are rather problematic. Scenario bullet points:

- As international supply chains (and relations) break down, EU countries are forced to process waste within the European bloc. With limited public funding and a workforce inexperienced in managing (and ill-equipped to manage) such levels of waste, OSH outcomes worsen in the waste industry of poorer EU states.
- Per capita consumption continues to rise alongside the consumption of single-use products owing to a new focus on hygiene and increasing health concerns. This throw-away culture leads to higher risks to workers as they grapple with increased waste and recycling volumes.
- Business is ultimately conducted according to cost-effectiveness and profits above all else. Across most EU industries, environmental and ethical practices, including CSR, are paid lip service only. Industry push-back and weak political will thwart attempts at strengthening regulation across the board.
- Digitalisation has brought the promised rationalisation gains — and the feared job losses. Insufficient retraining has resulted in a vast pool of underqualified workers who lack the qualifications necessary for employment in the new digital world.
- For those lucky enough to have the right skills, platform and gig work has increased tremendously — but with very little regulatory oversight. This has resulted in a fractured and uneven employment landscape, with the 'Russian doll effect' of sub-contracts within sub-contracts — meaning that responsibility for OSH ultimately rests with the workers.

Under this scenario, what do you see as the **most significant implications for occupational health and safety** in Europe up to 2040? How is OSH different from today?

- Regulation: it's important that regulation catches up with the market (i.e. ideally it would keep up or even be ahead, but, realistically, it would be acceptable to be only a very small step behind).
- Risk of growing inequality in Europe (i.e. between southern and northern Europe). Currently, although many northern European countries have found ways to make recycling etc. cost-effective, some other European countries are five to six years behind. To bring all EU countries up to the same level, leading countries need to show examples (i.e. on how to best manage and recycle plastic, aluminium, etc.), highlight the benefits, increase education and communication, invest in machinery and display creativity.

When thinking about Europe's transition to a circular economy, are there any **blind spots (developments not on the mainstream radar) that you believe may have a significant impact on occupational health and safety up to 2040, in the EU?**

- Maintenance: metal with asbestos and metal with lead coatings can be found in many bridges and factories that are in need of maintenance, repair and replacement. Currently, there is a lack of discussion around this, including how these metals can best be separated (from the asbestos or lead) and recycled. The Netherlands has recently opened the first factory that can clean metal with asbestos for recycling.

- A recent Senior Labour Inspectors' Committee survey was sent to all EU nations, and received only 12 responses. This highlights the need for more engagement from some countries.

- Companies are continually trying to improve processes, innovate and come up with new products and services. However, policy and government are too far behind these new developments.

- What is often not discussed enough is how long-term exposure to certain substances, e.g. aerosols, can result in significant health implications for workers.

- COVID can be an opportunity to lift the health and safety of workers, i.e. through improved practices and communication. The Netherlands has already tried to expand health and safety communication on the back of the pandemic.

Finally, what else should we consider for EU future perspectives on the CE and potential OSH consequences? Is there anything we have not spoken about that is important in terms of the CE and its implications for OSH?
Always be aware that there are blind spots. New developments are happening at such a fast pace we will never be able to entirely keep up, and at times there will be issues that regulators will be unaware of.

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The European Agency for Safety and Health at Work (EU-OSHA) contributes to making Europe a safer, healthier and more productive place to work. The Agency researches, develops, and distributes reliable, balanced, and impartial safety and health information and organises pan-European awareness raising campaigns. Set up by the European Union in 1994 and based in Bilbao, Spain, the Agency brings together representatives from the European Commission, Member State governments, employers' and workers' organisations, as well as leading experts in each of the EU Member States and beyond.

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