



FORESIGHT

Expectations and assumptions for the future in the Work Programme 2021-2022 of Horizon Europe



*Research and
Innovation*

Expectations and assumptions for the future in the Work Programme 2021-2022 of Horizon Europe

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EUROPEAN COMMISSION

**Expectations and assumptions
for the future
in the Work Programme
2021-2022
of Horizon Europe**
Foresight on Demand (FoD)

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Table of Content

List of Figures	3
List of Tables	3
EXPECTATIONS AND ASSUMPTIONS FOR THE FUTURE IN THE WORK PROGRAMME 2021-2022 OF HORIZON EUROPE.....	5
1. Summary.....	5
2. Introduction	8
3. Results	10
3.1. Overview Results all Clusters.....	10
3.2. Results Cluster 1 Health.....	16
3.3. Results Cluster 2 Culture, Creativity and Inclusive Society	33
3.4. Results Cluster 3 Civil Security for Society	53
3.5. Results Cluster 4 Digital, Industry and Space	68
3.6. Results Cluster 5 Climate, Energy and Mobility	93
3.7. Results Cluster 6 Food, Bioeconomy, Natural Resources, Agriculture and Environment.	125
3.8. Crosscutting Observations.....	160
3.9. Lessons for future-orientation of the workprogramme.....	160
3.10. Cluster Specific Findings.....	188
Annex 1: List of assumptions and expectations identified in the workprogramms.....	193
Annex 2: Delphi Survey - Composition of respondents	206

List of Figures

Figure 1: Venn Diagram of challenges for future workprogrammes	6
Figure 2: Setup of Delphi Questionnaire	8
Figure 3: Assessment of time horizon of realisation for all Delphi statements (ordered by cluster).....	10
Figure 4: Assessment of the time horizon of realisation for all Delphi statements across all clusters (ordered by share of now to 2030)	15
Figure 5: Assessment of time horizon for statements in cluster 1 (ordered by share of now - 2030).....	16
Figure 6: Assessment of time horizon for statements in cluster 2 (ordered by share of now - 2030).....	33
Figure 7: Assessment of time horizon for statements in cluster 3 (ordered by share of now - 2030).....	53
Figure 8: Assessment of time horizon for statements in cluster 4 (ordered by share of now - 2030).....	68
Figure 9: Assessment of time horizon for statements in cluster 5 (ordered by share of now - 2030).....	93
Figure 10: Assessment of time horizon for statements in cluster 6 (ordered by share of now - 2030).....	125
Figure 11: Overview assessment of near term challenges	161
Figure 12: Overview assessment of long-term challenges	165
Figure 13: Venn Diagram of challenges for future workprogrammes.....	187
Figure 14: Amount of clusters per expert	207
Figure 15: Map of the countries respondents are most familiar with	208

List of Tables

Table 1: Overview challenge groups and their topics	7
Table 2: Overview Statements and Categorisation	11
Table 3 Assessment of statements in the health cluster - overview	17
Table 4: Distribution of statements across time categories.....	160

Table 5: Distribution of statements across normative orientation categories.....	160
Table 6: Groups of statements to be analysed further	161
Table 7: Overview challenge groups and their topics	188
Table 8: Cluster 1 challenge groups	189
Table 9: Cluster 2 challenge groups	189
Table 10: Cluster 4 challenge groups.....	189
Table 11: Cluster 5 challenge groups.....	190
Table 12: Cluster 6 challenge groups.....	191
Table 13: No of experts approached per cluster	206
Table 14: Gender and Age group of respondents	207

EXPECTATIONS AND ASSUMPTIONS FOR THE FUTURE IN THE WORK PROGRAMME 2021-2022 OF HORIZON EUROPE

1. Summary

This report presents the results of a study on “Expectations and assumptions for the future in the Work Programme 2021-2022 of Horizon Europe”. The study scanned the HE Work Programme 2021-2022 for assumptions and expectations about the future, compared them with the impact chains of the Horizon Europe Strategic Plan, and conducted a Delphi survey of experts on the likely time of realization of those expectations and assumptions. The analysis aims to help improve future work-programmes and the use of foresight and forecasting that shape expectations for the future in the preparation of these work-programmes.

Our analysis revealed three overlapping but distinct types of challenges associated with assumptions and expectations that should be recognised in future work-programmes:

1. Policy challenges

For some topics, our results indicate that the targeted goals are seen as worthy and highly relevant but not altogether realistic. Often in these cases, expert comments suggest that the potential of R&I for contributing to effective responses to challenges is limited and point towards adverse political framework conditions and influence of powerful interests as barriers for achieving progress.

In such cases for future workprogrammes different approaches are conceivable; One possibility would be to focus especially on areas where the frameworks conditions are in place so R&I can play a meaningful role. In such cases the timing of the achievement of the goal can be probabilistically predicted and placed in a near to medium term time horizon.

Another option would be to address these difficulties explicitly by integrating SSH research and setting up stakeholder dialogues that also include policy actors, an approach that is already spearheaded in several programmes. Another approach could be to align R&I policy with other policy areas such as e.g. agricultural policy. And of course these approaches can be combined.

However, it is important to underline that such approaches are not a guarantee of success. Social and policy changes are slow and uncertain processes. When, in the presence of such approaches the achievement of the goal in the medium term is still in doubt, special attention should be paid on the rationale for the suitability of the EU work-programme as a response to policy challenges.

Examples for topics facing this type of policy challenge are sustainable agri-food systems, the decarbonisation in some parts of industry, decarbonisation of transport (especially aviation) and the realisation of personalised health.

2. Diversification challenges

This group includes topics where respondents disagree on the goal and others where they assess the goal as unsolvable. This group is the most populated of the three. For all topics with “diversification challenges” respondents hint at possible alternative framings of the problem and subsequent approaches to tackling it. Some argue that with such re-framings, some seemingly intractable long-term and long-standing problems could turn into solvable ones.

When developing future workprogrammes it may be useful to check for these topics whether different perspectives on the very framing of the topic are well accommodated in the programme. Especially it seems worthwhile to explore whether diversification of trajectories may provide new inroads into “insolvable” issues. In some such cases, experts stress the need to integrate perspectives that view the problem as one of societal rather than only technological change and thereby focus on aspects like human behaviour, social fabric and social innovation. While we often saw that these aspects are indeed addressed in other parts of the programmes, it may be useful to integrate these aspects or at least connect the research teams in the respective programme lines to align

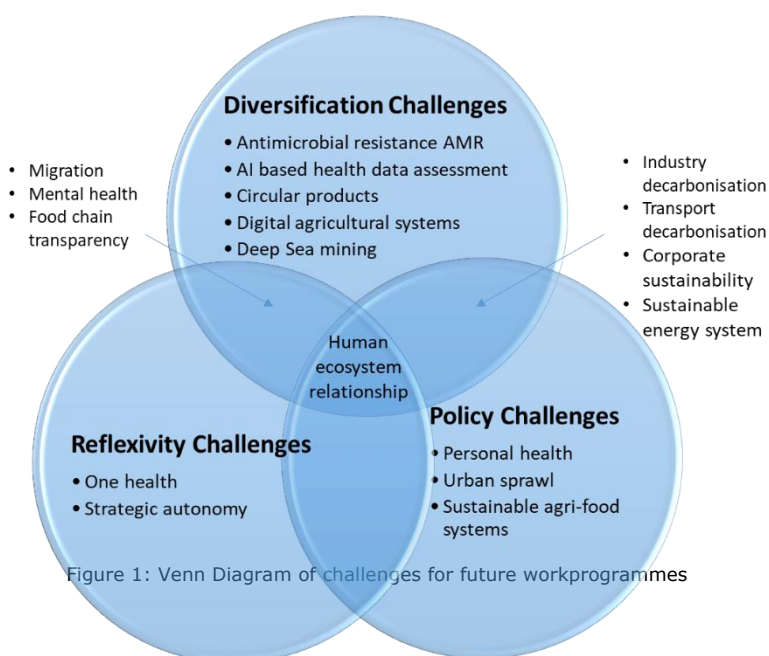


Figure 1: Venn Diagram of challenges for future workprogrammes

their efforts. Examples for topics “diversification challenge” are circular products, sustainable energy and digitalisation of agriculture.

3. Reflexivity challenges

In a few cases, respondents stressed the need to continue sharpening key concepts. This may indicate that it may be useful to consider for future workprogrammes whether the generation of a shared understanding of key concepts

could be integrated possibly with integrating key users such as e.g. patients or CSOs. Examples for such type of reflexivity challenges are “one health” and “strategic autonomy”.

As illustrated in Figure 1 some topics face more than one of these challenges. In particular, topics addressing the relationship of humans and ecosystems are confronted with all three of them. The overview of statements in these groups in Table 1 illustrates the slightly different situation between Horizon Europe clusters. Reflexivity challenges are mostly located in cluster 1 and 6, while clusters 4, 5 and 6 face an equal share of the diversification challenges. Policy challenges occur largely equally in clusters 2, 4, 5 and 6. Overall, cluster 6 (12 out of 14) and cluster 1 (5 of 6) show the largest share of statements assigned to a challenge group. Cluster 2 (3/8) and 3 (0/6) are least represented.

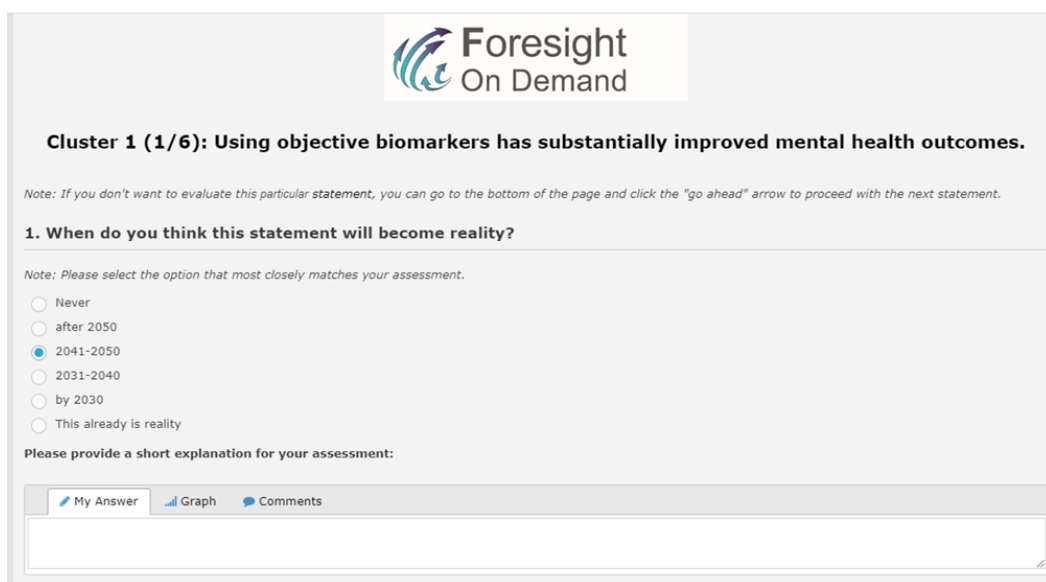
Table 1: Overview challenge groups and their topics

Policy challenges	Diversification challenges	Reflexivity challenges
Personal health (1.4) Migration (2.5) Urban sprawl (2.8) Industry decarbonisation (4.2, 4.7) Sustainable energy system (5.1) Transport decarbonisation/Waterborne (5.8) Transport decarbonisation/Aviation (5.11) Sustainable agri-food systems (6.1) Human ecosystem relationship (6.2, 6.5) Corporate sustainability (6.13)Text	Mental health (1.1) AI based health data assessment (1.3) Antimicrobial resistance AMR (1.6) Migration (2.5) Circular products (4.1) Industry decarbonisation (4.2, 4.7) Deep sea mining (4.5) Sustainable energy system (5.1) Industry decarbonisation (5.4) Transport decarbonisation/Waterborne (5.8) Transport decarbonisation/Aviation (5.11) Human ecosystem relationship (6.2, 6.5) Food chain transparency (6.6) Corporate sustainability (6.13) Digital agricultural systems (6.14)	Mental health (1.1) One health (1.6) Strategic autonomy (4.11) Human ecosystem relationship (6.2, 6.5) Food chain transparency (6.6)

2. Introduction

This report presents the results of a study on “Expectations and assumptions for the future in the Work Programme 2021-2022 of Horizon Europe”. The study scanned the HE Work Programme 2021-2022 for assumptions and expectations about the future¹, compared them with the impact chains of the Horizon Europe Strategic Plan, and conducted a Delphi survey of experts on the likely time of realization of those expectations and assumptions. The analysis aims to help improve future work-programmes and the use of foresight and forecasting that shape expectations for the future in the preparation of these work-programmes.

The Delphi survey comprised 56 statements across six thematic clusters. As illustrated in Figure 2, the main question participants answered was: “When do you think this statement will become reality?”. In addition, participants were invited to provide arguments for their assessment. Finally, participants self-assessed their level of expertise with regard to the statement.



The screenshot shows the 'Foresight On Demand' logo at the top. Below it, the statement for 'Cluster 1 (1/6)' is: 'Using objective biomarkers has substantially improved mental health outcomes.' A note indicates that users can skip the statement by clicking a 'go ahead' arrow at the bottom. The main question is '1. When do you think this statement will become reality?'. A note asks users to select the option that most closely matches their assessment. The options are: 'Never', 'after 2050', '2041-2050' (selected), '2031-2040', 'by 2030', and 'This already is reality'. Below the options, there is a prompt to 'Please provide a short explanation for your assessment:' and a text input area. At the bottom, there are tabs for 'My Answer', 'Graph', and 'Comments'.

Figure 2: Setup of Delphi Questionnaire

For our analysis, we used the responses to the survey to distinguish between

- Near term challenges (now and by 2030)
- Mid-term challenges (2030-2050)

¹ For the purpose of the Delphi survey the assumptions and expectations were transformed into statements. The original formulations from the Workprogrammes can be found in Annex 1.

- Long term challenges 2050-never
- Inconclusive time horizon (strongly diverging assessments or other issues emerging from the comments)

Further, we analysed experts' comments to assess whether the normative orientation of the statement is shared or contested, and classified statements accordingly.

In chapter 0, we give an overview on the results for all statements and then discuss each individual statement for all six clusters. In chapter 0, we then analyse in more depth 27 statements with assessments that point to potentially interesting lessons for future workprogrammes for the following reasons:

- Near term challenges: High shares of "this is already a reality" could imply that an issue addressed by the workprogramme is already close to be solved and so future workprogrammes could adopt an even more ambitious direction
- Long term challenges: Very long time horizons and in particular high shares of "never" could indicate that the goals are not realistic or factors other than R&I play a major role so future workprogrammes could further tailor the approach to make it achievable in the mid-term time horizon targeted by Horizon Europe
- Contested normative orientation: For these statements, diverse normative assessments by experts could indicate a need to integrate deliberative processes into future workprogrammes or to encourage exploration of alternative pathways.

We first draw lessons statement by statement for each of these groups and then derive overarching conclusions for the workprogramme (section 3.4) and in section 3.5 point to some cluster specific findings. The two Annexes provide the originally identified assumptions and expectations from the workprogrammes (5.1) and information on the survey respondents and parameters (5.2).

3. Results

3.1. Overview Results all Clusters

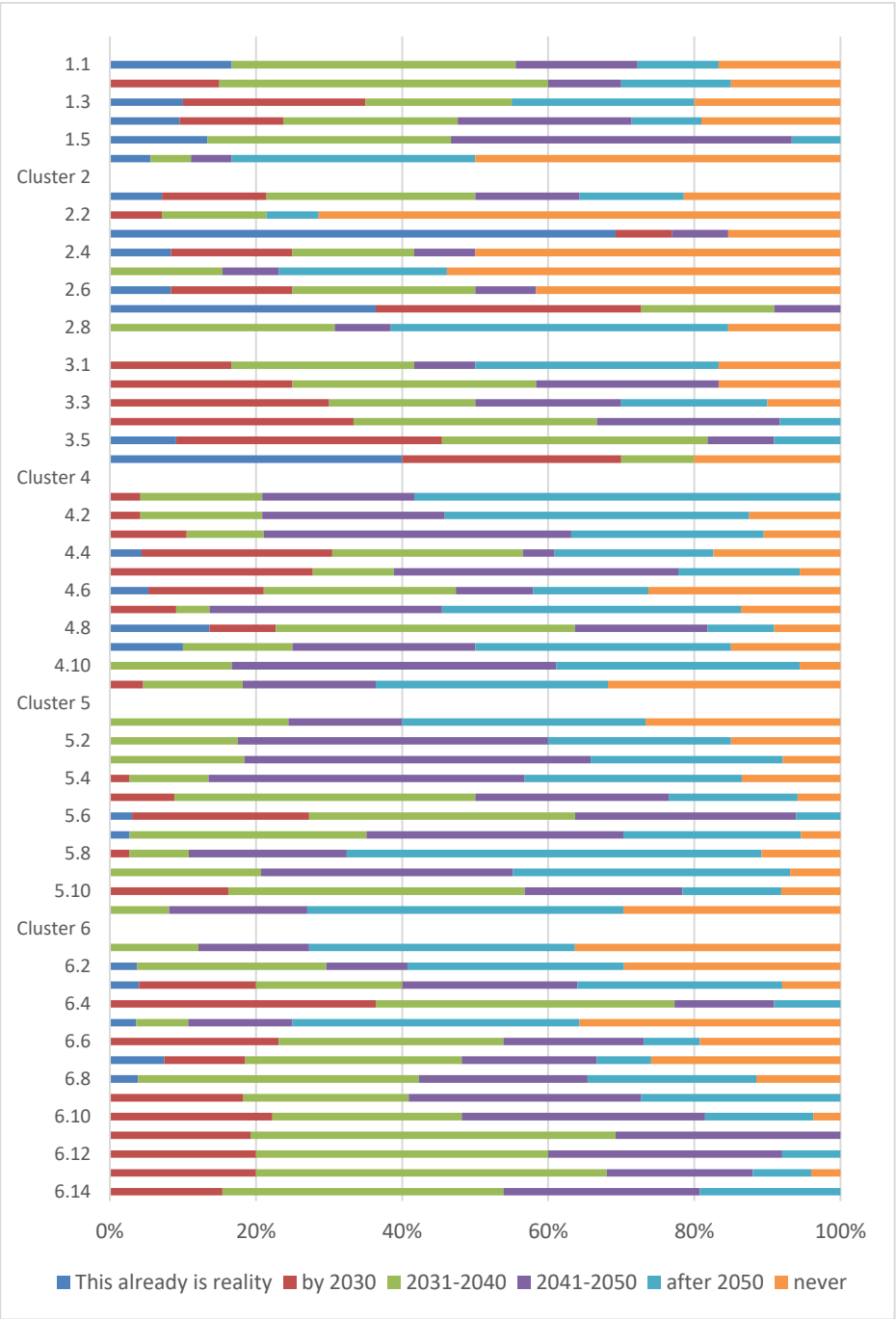


Figure 3: Assessment of time horizon of realisation for all Delphi statements (ordered by cluster)

Table 2: Overview Statements and Categorisation

Cluster 1: Health		Time Categories				Normative Orientation	
Statements (*= Lessons further discussed in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
1.1*	"Using objective biomarkers has substantially improved mental health outcomes."		X				X
1.2	"Healthcare expenditure across the EU reaches 15 % of GDP (from 10% in 2022)."		X			X	
1.3*	"Artificial Intelligence-based health data assessment allows for 90% accurate risk prediction for the majority of non-communicable diseases."				X		X
1.4*	"Comprehensive personalized disease prevention and health risk prediction is widely available as a service in the EU."		X				X
1.5	"Multifunctional biomaterials that are capable of achieving several biological responses simultaneously are routinely used in advanced therapies and medical devices."		X			X	
1.6*	"Antibiotic resistant bacteria are no longer a major health threat in Europe."			X		X	
Cluster 2: Culture, Creativity and Inclusive Society		Time Categories				Normative Orientation	
Statements (*= Lessons further discussed in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
2.1	"European governments have digitalised all their services and largely abandoned paper."				X	X	
2.2*	"European societies are so inclusive that no group considers itself unfairly excluded."			X		X	
2.3*	"Europe is a world leader in cultural heritage research and innovation."	X				X	
2.4	"Europe is a world leader in film-making industries."				X	X	
2.5*	"Migration no longer figures among the top issues on political agendas in Europe."			X		X	

2.6	"Cultural heritage is accessible to all across the EU free of charge."				X	X	
2.7*	"The EU establishes minimum standards for the protection of cultural heritage in its territory."	X				X	
2.8*	"The spread of urban sprawl has been halted, giving way to settlements in line with the principles of environmental, social, cultural and economic sustainability."			X		X	
Cluster 3: Civil Security for Society		Time Categories				Normative Orientation	
Statements (*= Lessons further discussed in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
3.1	"Investment in natural hazard preparedness and protection across Europe has doubled from 2022."				X	X	
3.2	"Individual resilience training is established in school curricula in most European countries."		X			X	
3.3	"Quantum technologies are compromising most non-quantum based cryptography."				X	X	
3.4	"New and emerging risks and risk magnifiers such as climate change, cyber threats, infectious diseases and terrorism are twice as prevalent in Europe as they were in 2022."		X			X	
3.5	"More than 50% of EU cities have installed more than 15 CCTV cameras per 1000 inhabitants (in 2022 the highest number in the EU is 11 in Berlin. In London the number is 68)."		X			X	
3.6*	"Criminal use of end-to-end encryption in social media is posing a major challenge for law enforcers trying to prevent cybercrime."	X				X	
Cluster 4: Digital, Industry and Space		Time Categories				Normative Orientation	
Statements (*= Lessons further disc. in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
4.1*	"More than 80% of products in the market are made from recycled resources."			X		X	
4.2*	"European industry is fully decarbonised."			X		X	
4.3	"100% of fibre reinforced polymer composites is recycled in Europe (compared to a maximum of 20% for glas fibres in 2022)."		X			X	
4.4	"The EU is the world`s most secure and trusted data hub."				X	X	

4.5*	"Globally more than fifteen commercial deep sea mining ventures are operating (at the moment only contracts have been issued)."				X		X
4.6	"Europe is at the cutting edge of quantum capabilities."				X	X	
4.7*	"After successful decarbonisation of the European energy system, energy in Europe is abundant and supply is stable."			X		X	
4.8	"Europe has become a technology and industrial leader of the green and digital twin-transition."		X			X	
4.9	"Biological modes of production have become more important than digital ones."	Not assessed					
4.10	"The majority of ICT based products involve quantum technologies (second generation)."		X			X	
4.11*	"EU`s industrial base has diversified its supply chains so widely that it has no critical material and technology dependencies anymore."			X			X
Cluster 5: Climate, Energy, Mobility		Time Categories				Normative Orientation	
Statements (* = Lessons further disc. in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
5.1*	"Final Energy consumption (i.e. the total energy consumed by end users, such as households, industry and agriculture) in Europe has fallen by 40% compared to 2022."			X		X	
5.2	"The steel industry in the EU has successfully transitioned to climate neutrality."		X			X	
5.3	"The chemical industry in the EU has successfully transitioned to climate neutrality."		X			X	
5.4*	"The cement industry in the EU has successfully transitioned to climate neutrality."		X				X
5.5	"The paper industry in the EU has successfully transitioned to climate neutrality."		X			X	
5.6	"Battery development time is reduced by half compared to 2022."		X			X	
5.7	"CCAM (Cooperative, connected and automated mobility)-services operate without major failures across the EU."		X			X	
5.8*	"The global waterborne transport sector has eliminated all its greenhouse gas emissions."			X		X	
5.9	"More than 50% of maritime and inland waterways feeder services in the EU are fully automated."		X			X	
5.10*	"Biodiesel from algae is commercially viable."		X				X
5.11*	"Aviation has become climate neutral (without using carbon offsets for compensation)."			X		X	

C6: Food, Bioeconomy, Natural Resources		Time Categories				Normative Orientation	
Statements (*= Lessons further disc. in section 0)		Near term	Mid term	Long term/Nvr	Inconclusive	Agreed	Contested
6.1*	"In the EU agri-food production no longer places pressure on natural ecosystems."			X		X	
6.2*	"In the EU use of the seas and inland waters and marine resources no longer places pressure on natural ecosystems."			X		X	
6.3	"Animal welfare in fish reaches the same standards as animal welfare in mammals."				X	X	
6.4	"The share of low trophic species (e.g. algae and herbivores) in EU aquaculture systems has doubled compared to 2022."		X			X	
6.5*	"In the EU human activity has become biodiversity-neutral."			X		X	
6.6*	"Food supply chains in Europe are fully transparent."				X		X
6.7	"Nature based solutions and sustainable ecosystem management account for at least 20% of employment in the EU."				X	X	
6.8	"Tourism, recreational and leisure activity development in coastal areas across EU respect long-term environmental carrying capacity."		X			X	
6.9	"Soil based carbon sequestration has increased twofold in the EU compared to 2022."		X			X	
6.10	"Average per capita meat consumption in the EU has fallen below 30Kg per year (around 54 Kg in 2021)."		X			X	
6.11	"In the EU more than 70% of bio-waste streams are separated from other waste streams for recycling and reuse (In 2022 the average is 50%)."		X			X	
6.12	"The yearly EU consumption of pulses for food (excluding soy beans) has increased to 3 million tons (up from 2 million tons in 2022)."		X			X	
6.13*	"More than half of European companies have integrated natural capital and biodiversity impacts and dependencies into their corporate decision making and risk assessment."		X				X
6.14*	"Advanced internet based digital applications such as remote sensors for crop and livestock monitoring, data analytics and advanced planning and optimisation (e.g. via Farm Management Information Systems), control and execution of production with help of automatic machines (e.g. for milking) or robots (e.g. for weeding and harvesting), are used in more than half of farms in the EU."		X				X

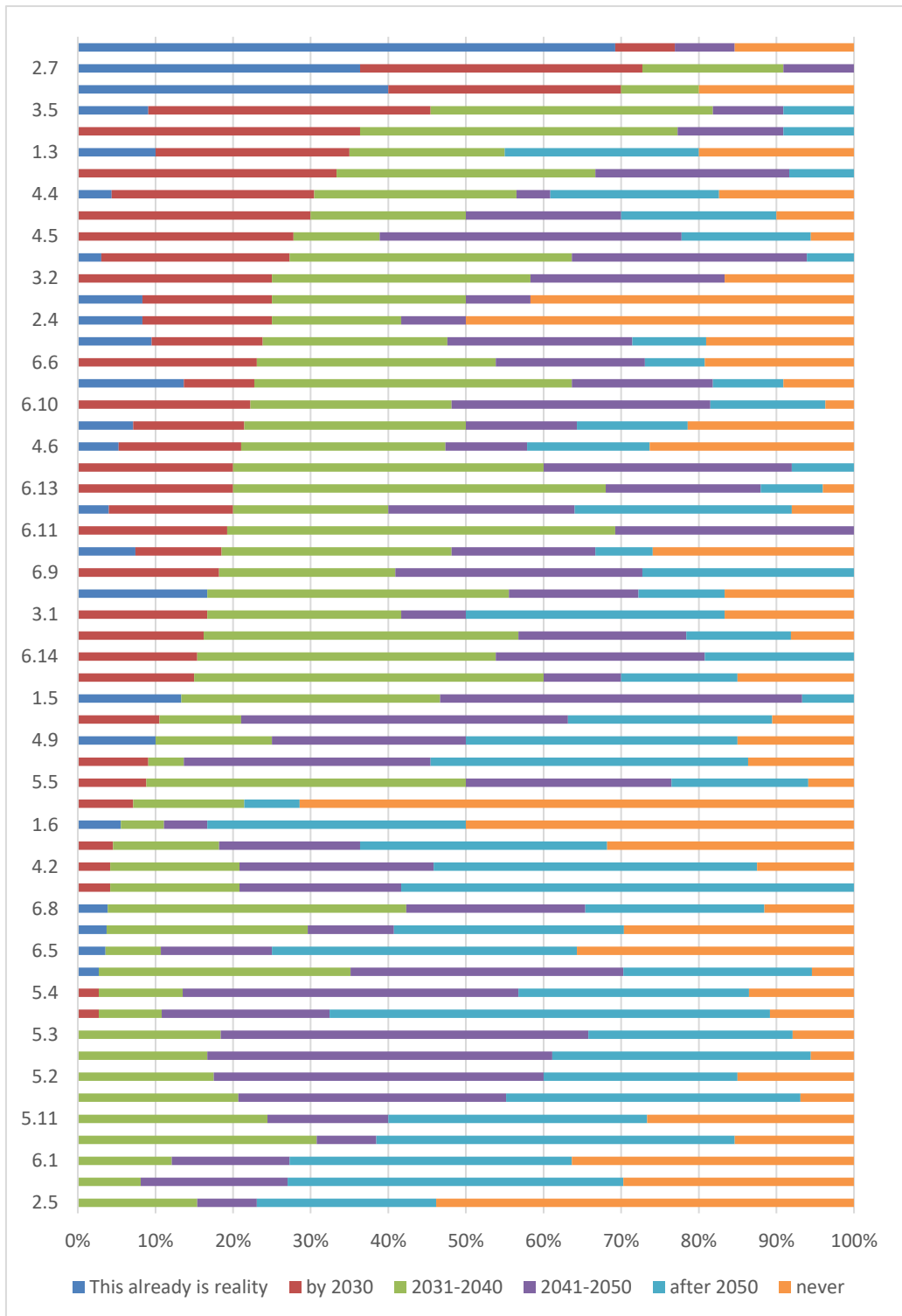


Figure 4: Assessment of the time horizon of realization for all Delphi statements across all clusters (ordered by share of now to 2030)

3.2. Results Cluster 1 Health

Overview

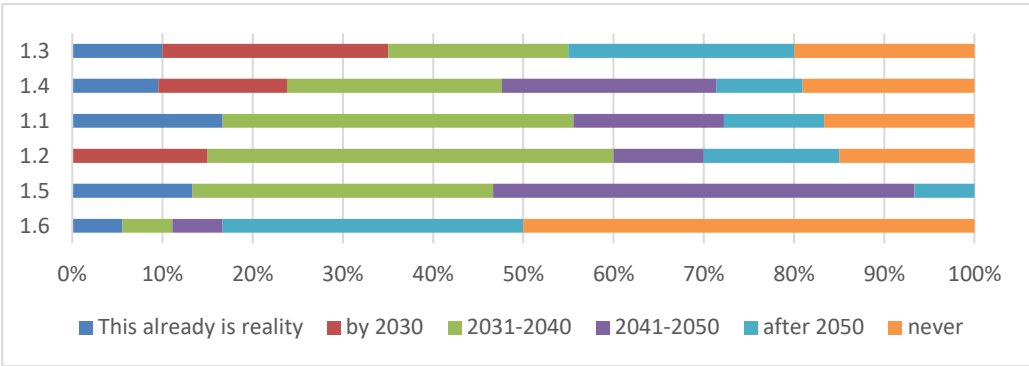


Figure 5: Assessment of time horizon for statements in cluster 1 (ordered by share of now - 2030)

While Figure 5 shows respondents' assessment of the time horizon in this cluster,

Cluster 1: Health		Time Categories				Normative Orientation	
Statements (* = Lessons further discussed in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
1.1*	"Using objective biomarkers has substantially improved mental health outcomes."		X				X
1.2	"Healthcare expenditure across the EU reaches 15 % of GDP (from 10% in 2022)."		X			X	
1.3*	"Artificial Intelligence-based health data assessment allows for 90% accurate risk prediction for the majority of non-communicable diseases."				X		X
1.4*	"Comprehensive personalized disease prevention and health risk prediction is widely available as a service in the EU."		X				X
1.5	"Multifunctional biomaterials that are capable of achieving several biological responses simultaneously are routinely used in advanced therapies and medical devices."		X			X	
1.6*	"Antibiotic resistant bacteria are no longer a major health threat in Europe."			X		X	

gives an overview on the assigned categories. The majority of respondents consider the assumptions and expectations on biomarkers for mental health

(1), healthcare expenditure (2), health prediction services (4) and biomaterials (5) to materialise between 2030 and 2050. The assumption on antibiotic resistant bacteria (6) was largely considered not to materialise. The results of the responses to the assumption on artificial Intelligence-based health data assessment (3) are not conclusive as responses disperse widely. For most statements, comments indicated broad agreement on the normative orientation. In two cases however i.e. objective biomarkers (1) and personalised medicine (4) the normative orientation of the statements is contested.

Table 3 Assessment of statements in the health cluster - overview

Cluster 1: Health		Time Categories				Normative Orientation	
Statements (*= Lessons further discussed in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
1.1*	"Using objective biomarkers has substantially improved mental health outcomes."		X				X
1.2	"Healthcare expenditure across the EU reaches 15 % of GDP (from 10% in 2022)."		X			X	
1.3*	"Artificial Intelligence-based health data assessment allows for 90% accurate risk prediction for the majority of non-communicable diseases."				X		X
1.4*	"Comprehensive personalized disease prevention and health risk prediction is widely available as a service in the EU."		X				X
1.5	"Multifunctional biomaterials that are capable of achieving several biological responses simultaneously are routinely used in advanced therapies and medical devices."		X			X	
1.6*	"Antibiotic resistant bacteria are no longer a major health threat in Europe."			X		X	

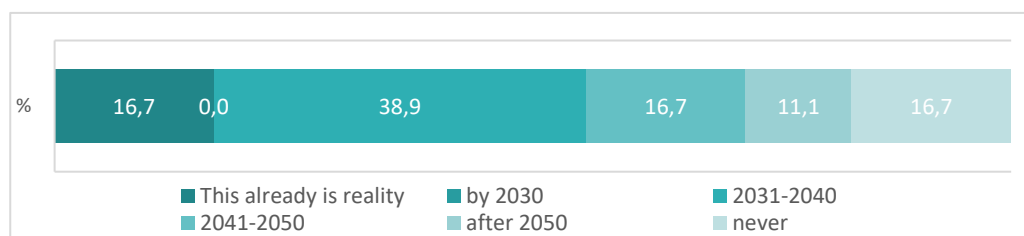
Individual Statements

Statement 1.1: Using objective biomarkers has substantially improved mental health outcomes.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	1	5,6
Average expertise	9	50,0
Low expertise	6	33,3
Very low expertise	2	11,1
Σ	18	100

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	Biomarkers will be in place but therapies with significant impact are not at the horizon yet.	Average
2031-2040	It is a thematic of great importance for overcome some challenges related our health namely those related with mental and/or neurodegenerative disorder such as Alzheimer and Parkinson.	Average
2031-2040	We are still far away from this	Average
2031-2040	Both molecular and behavioural biomarkers are already known in depression and schizophrenia. Although their use in psychiatry is limited by the heterogeneity of the clinical presentation of these diseases, research in this area is holding great promises especially as concerns digital bi-markers.	Average
2031-2040	I believe we are still far from that commercially speaking. But I admit it is a pure guess on my side	Low
2031-2040	I think it will take time for the use of bio markers to achieve full potential.	Low
2041-2050	Much research is needed to identify valid bi-	Average

	omarkers of mental health. In addition, validation may have to reply to subjective reports which bear their own limitations	
2041-2050	In terms of studies with humans we are only just starting to use stratified cohorts, based on the polymorphism we know. Rigorous clinical studies are required to provide the evidence required to link biomarkers to mental parameters. Finally, health is not yet defined.	High
Never	Biomarkers alone do not improve health, they help to diagnose - but to improve a situation needs much more	Average
Never	Mental health is very subjective and I don't expect that biomarkers will significantly improve outcomes. Also, the question is vague because it doesn't specify which types of biomarkers are meant. In current mental health treatment biomarkers don't play much of a role to my knowledge.	Average
Never	it is also a social issue, there is no technological fix	Low

Interpretation

Most of the respondents perceive using objective biomarkers to have substantially improved mental health outcomes somewhere between 2030 and 2050. Focusing only on biomarkers in improving mental health may threaten more integrated approaches to mental health.

Biomarkers are already known in depression and schizophrenia, and they could potentially improve the analysis. However, further development, clinical trials and commercialisation are needed, and this takes time. Nevertheless, 17% considered this is already the case, though no comments seem to support this.

The development of biomarkers may help the analysis of mental health, but the correct treatment and improvement of mental health require also other advances including addressing the social issues. The goal on biomarkers is contested by some respondents, as being too fixated on technology, when there is a need for more holistic care.

Categorisation

Time Horizon	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

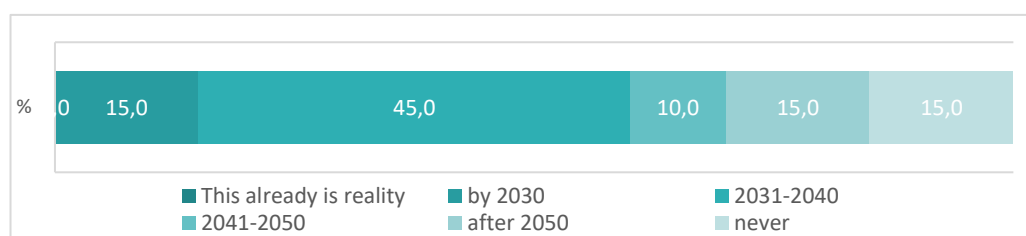
Normative Orientation	Assessment
Agreed	
Contested	X

Statement 1.2: Healthcare expenditure across the EU reaches 15 % of GDP (from 10% in 2022).

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	4	20,0
Average expertise	9	45,0
Low expertise	4	20,0
Very low expertise	3	15,0
Σ	20	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	Cost are steeply on the rise already, given the rate of aging of the EU population, and all the (after) effects of the covid pandemic, 15 % may already be reached earlier than 2030.	Average
by 2030	If the systems do not change, very soon.	Average
by 2030	This is a continent whose proportion of ageing citizens will be even higher	Average
2031-2040	Personalised Medicine approaches are effective but also expansive. Overall health will improve significantly	High
2031-2040	Hope in next two decades this will be a reality	Low
2031-2040	I see it as a sector where investments will focus.	Average
2031-2040	Despite economic downturns the expenditure on health will continue to increase in response to the current health crisis and other pandemics which are likely to arise.	Average
2031-2040	due to pandemic, NCDs, aging...	High
after 2050	Although we have been witnessing a slow but steady increase in the health expenditure in EU, it is very difficult to predict how the healthcare sys-	Low

	tem will respond to the current challenges such as the current and future pandemics, the climate change, a generalized social instability, etc. Smart allocation of resources among prevention and curative care, universal access to quality services, and uptake of artificial intelligence in the health system could help maintain the recommended levels of spending on health and achieve better health outcomes in the future.	
after 2050	In a period of energy crisis and war in Europe it is difficult to be optimistic. I foresee that future expenditures will rely on covering energy needs and unexpected peril	Very low
after 2050	Because of the aging population rate is accelerating	Average
Never	Because the future elderly will be better educated than today's elderly they will also be in better health status and at the same time GDP will grow at least as rapidly as health expenditure	High
Never	I assume that average healthcare expenditure is meant. Averages are not very helpful here because countries with low healthcare expenditure (e.g. Poland, around 5%) really need to catch up to improve the quality of their healthcare services, whereas other countries (e.g. Germany, above 13%) are already close to the 15% now and don't necessarily need to spend a greater share of their GDP on health but rather spend it more effectively (e.g. by investing more in prevention).	High

Interpretation

The majority of respondents expect healthcare expenditure across the EU to reach 15 % of GDP (from 10% in 2022) somewhere between 2030 and 2050. Many respondents refer to the need for system change in healthcare to address future threats and opportunities.

Healthcare costs are rising, the continent is getting older and healthcare systems will need to adapt to future pandemics, climate change and generalized social instability. Personalised healthcare is improving treatment but is still costly. The growing sector will attract more investments and smart allocation of resources among prevention and curative care, universal access to quality services, and uptake of artificial intelligence in the health system could help maintain the recommended levels of spending on health and achieve better health outcomes in the future. Furthermore, healthier elderly will also be contributing more to the GDB growth.

Beyond average expenditure in healthcare across the EU, it is important to consider national differences, especially increasing the expenditure in low performing countries. Still, the majority of respondent seem to assess the increasing healthcare expenditure as expected and reasonable.

Categorisation

Time Horizon	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

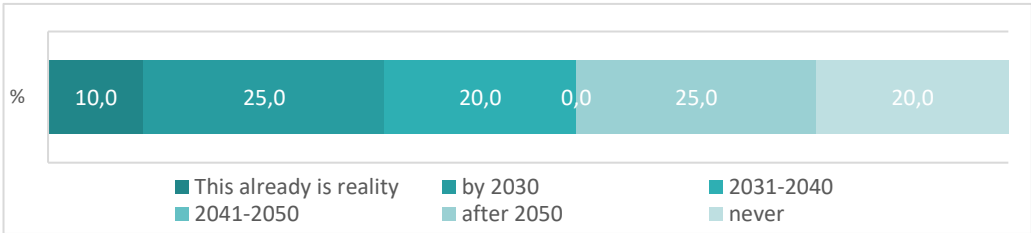
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 1.3: Artificial Intelligence-based health data assessment allows for 90% accurate risk prediction for the majority of non-communicable diseases.

Respondents

Expertise	n	%
Very high expertise	1	5,3
High expertise	7	36,8
Average expertise	4	21,1
Low expertise	5	26,3
Very low expertise	2	10,5
Σ	19	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	AI is significantly improving and will do more in the near future. Obstacles are not AI instruments but heterogeneity of data.	High
by 2030	AI is a field with great importance in the health care systems	Low
by 2030	risk prediction is a percentage - what does it tell you if you have a predicted (and correct) risk of 45% for a certain disease (e.g. cancer)? It is relatively useless... and this information makes people very insecure.	High
by 2030	Today it is a near reality in some diseases, but the management of Big Data (clinical, imaging, genomic data, etc.) with better algorithms, better knowledge of the genetic reality of each family, as well as the expected progress in the advance of ICTs to obtain new forms of diagnosis and increasing the speed of data processing, will undoubtedly create a great impact of progress in the prediction of health risks.	Average
by 2030	We are not far from this	High
2031-2040	We are progressing very rapidly. But a minimum of 10 years seems reasonable to me	High

2031-2040	It is an issue of data accumulation that would enhance the validity (internal and external) of AI applications. Data are steadily increasing	High
2031-2040	I think such a development is not too unlikely but accuracy of results could vary greatly between populations and diseases.	High
after 2050	Despite the monumental advances, the current status of reliability and trustworthiness of AI applications for healthcare and biomedicine as well as the data used to train these systems does not allow to recommend their widespread use in the clinical practice right now. With the exceptions of few examples in medical imaging, text mining, and patient triage, the current lack of AI in the clinics is a demonstration of its current limitations, including discriminatory biases, privacy concerns, infrastructural demands, regulatory challenges, etc.	Very high
Never	there are too many unpredictable factors in cancer	High
Never	I cannot comment on a statement lacking definition. What majority, what do you consider accurate?	Average

Interpretation

The results of the responses are not conclusive as regards when Artificial Intelligence-based health data assessment will allow for 90% accurate risk prediction for the majority of non-communicable diseases. While 55% consider this to happen between today and 2040, 45% consider this would happen after 2050 or never. The diverging views beyond the interpretations on the assumption may relate to the limitations of data and algorithms and the diversity of diseases to be diagnosed. Current limitations, including discriminatory biases, privacy concerns, infrastructural demands and regulatory challenges may continue to difficult the development of AI-based predictions. The new forms of diagnosis and increasing the speed of data processing will speed up progress in the prediction of health risks. All in all, the respondents both have different interpretations of the assumption as well as diverging views on the goal itself. In particular, one respondent remarks: "risk prediction is a percentage - what does it tell you if you have a predicted (and correct) risk of 45% for a certain disease (e.g. cancer)? It is relatively useless... and this information makes people very insecure."

Categorisation

Time Horizon	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

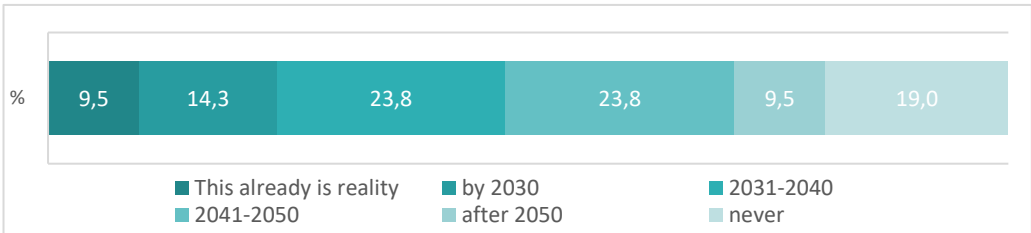
Normative Orientation	Assessment
Agreed	
Contested	X

Statement 1.4: Comprehensive personalized disease prevention and health risk prediction is widely available as a service in the EU.

Respondents

Expertise	n	%
Very high expertise	1	4,8
High expertise	7	33,3
Average expertise	7	33,3
Low expertise	2	9,5
Very low expertise	4	19,0
Σ	21	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	Dietary recommendations fitting your lifestyle and life stage are already available. For the key health risk prediction models already exist. What is missing is the investment in prevention.	High
by 2030	Personalised medicine has been working hard in the EU where many advances have been made, particularly under the umbrella of ICPerMed, where there are several actions that promote research (ERAPerMed) and the promotion and participation of different areas of the world, aligning their policies and strategies regarding personalised medicine (Regions4PerMed, EULAC Permed, Sino-EU PerMed, EU-Africa Permed, etc.). This is in addition to the support of research infrastructures and programmes such as 1MillionGenome. For Horizon Europe, the Personalised Medicine Co-find Partnership is already envisaged for the work programme (2023-2024). In addition, it is ex-	High

	pected that for HE, all destinations will have topics touching on personalised medicine and digitisation. They will be horizontal.	
2031-2040	My answer is very much related to the previous one. I see the two: AI applications and personalised preventive medicine going hand in hand.	High
2031-2040	Hopefully this statement will become true eventually, especially with approaches such as the digital twin (but is likely to still take quite some time).	High
2031-2040	Will come but will take some time	Average
2041-2050	Widely available is an expression leaving a lot of room for interpretation. EU MS and regions show a vast heterogeneity in health services today. Also within a country there are vulnerable groups with limited access to health services. Not the theoretically available health services but real-life access, i.e. equity will be the key question for the EU.	High
after 2050	There has been a huge progress in personalized medicine in recent years (e.g., cancer pharmacogenomics). However, moving beyond the limits of our current knowledge of human diseases is challenged by their inherent complexity and heterogeneity. Technological innovation in omics data generation and analysis as well as removing the current barriers to data accessibility will enable to reach faster the realization of personalized disease prevention and risk prediction.	Very
Never	I believe inequalities will do nothing but grow	Average
Never	Question of who is paying it - it can be a lot of screening if taken as a real task. We need an ethical discussion about health risk prediction as this does not really tell you anything.	High
Never	it is too expensive and the EU will grow with new accession states	High

Interpretation

Almost half of respondents consider comprehensive personalized disease prevention and health risk prediction to be widely available as a service in the EU between 2030 and 2050. The rest of the respondents are divided to those expecting this to happen before 2030 or after 2050/never, indicating strongly diverging views. While some respondents note the need for further development and technological advances, many refer here more to available resources and need for more attention to prevention in general. Some respondents perceive currently a lack of investment in prevention via personalised medicine and digitalisation. This is especially the case in some EU MS and regions because of heterogeneity in health services between MS.

Categorisation

Time Horizon	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

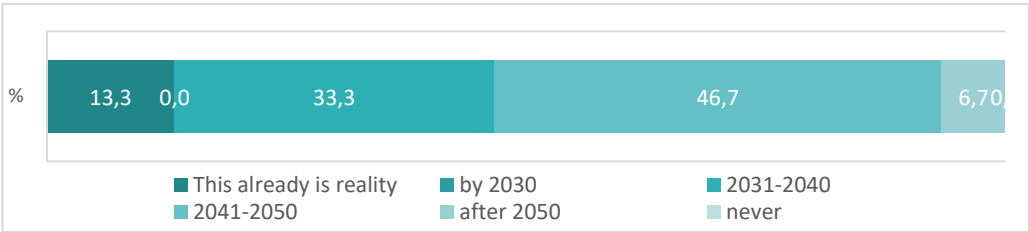
Normative Orientation	Assessment
Agreed	
Contested	X

Statement 1.5: Multifunctional biomaterials that are capable of achieving several biological responses simultaneously are routinely used in advanced therapies and medical devices.

Respondents

Expertise	N	%
Very high expertise	0	0,0
High expertise	0	0,0
Average expertise	3	20,0
Low expertise	9	60,0
Very low expertise	3	20,0
Σ	15	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	do not know much about this	Low
2031-2040	The development of new biomaterials can go relatively fast. The key limiting step will be clinical testing and understanding biological responses in relation to the materials used.	Low
2041-2050	I am afraid my reply is not based on expertise and/or experience. My personal feeling.	Very low
2041-2050	Regulatory and reimbursement issues are limiting implementation into health care services. HTA results are not convincing for broad application.	Low
2041-2050	Research in biomaterials is growing fast and the	Low

	use of implants and tissue engineering solutions for regenerative therapies, microfluidic systems such as organs-on-chips, wearable devices, in-vitro diagnostic tools, have indeed reached a level of technological maturity that could foreshadow their routinely use in the medical practice in the near future.	
2041-2050	It is only a guess	Low

Interpretation

The great majority of respondents consider multifunctional biomaterials, which are capable of achieving several biological responses simultaneously, to be routinely used in advanced therapies and medical devices between 2030 and 2050. One respondent states that "regulatory and reimbursement issues are limiting the implementation of biomaterials into healthcare services". Another argues that "Research in biomaterials is growing fast and it is foreseeable the routine use of implants and tissue engineering solutions for regenerative therapies, microfluidic systems such as organs-on-chips, wearable devices, in-vitro diagnostic tools".

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

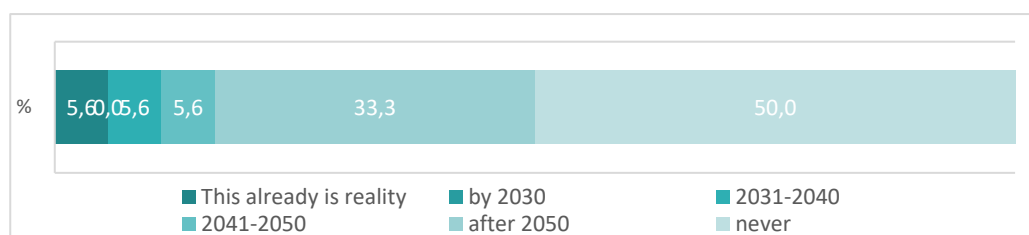
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 1.6: Antibiotic resistant bacteria are no longer a major health threat in Europe

Respondents

Expertise	N	%
Very high expertise	5	27,8
High expertise	0	0,0
Average expertise	5	27,8
Low expertise	6	33,3
Very low expertise	2	11,1
Σ	18	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	The scientific community are hard working in this subject so I hope that within few years it became a reality	Low
after 2050	Again not my field of expertise, but based on my limited knowledge I do not see this as a prospect of the near future.	Very low
after 2050	Political commitment for investment in R&D, cross-sectional regulations for One Health and cross-border actions to reduce AMR is not high enough. The pipeline for new antibiotics is too small to outrun AMR evolution.	Very high
after 2050	Bacteria always change so there will always be different ones, some are threats, others helpful. We may find solutions to cope with them, but that takes time and a new thinking.	Very high
Never	There may always be new resistant bacteria	Average
Never	For the near term I cannot see any developments that would make this possible (quite the opposite) and even in the longer term I don't expect that antibiotic resistance will ever stop or new antibiotics be developed at such speed that resistant bacteria don't pose a problem anymore.	Low

Never	Mutations will continue to present a problem, albeit with viruses or pathogenic bacteria. It is an illusion to think we can develop technology that would take care of all of this.	Average
Never	Antibiotic resistance will always be a major health threat worldwide. It occurs naturally and it is accelerated by the misuse of antibiotics in humans and animals. Devising effective prevention and control measures and improving the surveillance of antibiotic-resistant infections will prevent antibiotics to become less effective, such as in the case of tuberculosis and pneumonia.	Average
Never	There is no way to answer this question. Evolution will mark the projection	Average

Interpretation

The great majority respondents consider antibiotic resistant bacteria to be a major health threat in Europe at least till 2050 and even for good. The pipeline for new antibiotics is expected to be too small to outrun AMR evolution. Those who responded “never”, seem to consider bacteria will always change and create new threats worldwide. Devising effective prevention and control measures and improving the surveillance of antibiotic-resistant infections will prevent antibiotics to become less effective.

Some respondents call for more political commitment for investment in R&D, cross-sectional regulations for One Health and cross-border actions to reduce AMR.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
inconclusive	

Normative Orientation	Assessment
Agreed	X
Contested	

Conclusions

While most of the assumptions and expectations are perceived to materialise between 2030 and 2050, some assumptions and expectations were considered to be already reality suggesting that the major challenge is how to scale up the solutions.

Focusing only on technologies is not perceived suitable as the patients need integrated care and the healthcare systems need holistic management and transformation. Many respondents refer to the need for system change in healthcare to address future threats and opportunities. Healthcare costs are rising, the continent's demographics shift towards an older population and healthcare systems will need to adapt to future pandemics, climate change and generalized social instability.

Beyond average figures on the EU, e.g. the expenditure in healthcare in EU, it is important to consider national differences, especially increasing the expenditure in low performing countries. Regulatory and reimbursement issues are perceived limiting the implementation of new healthcare services.

3.3. Results Cluster 2 Culture, Creativity and Inclusive Society

Overview

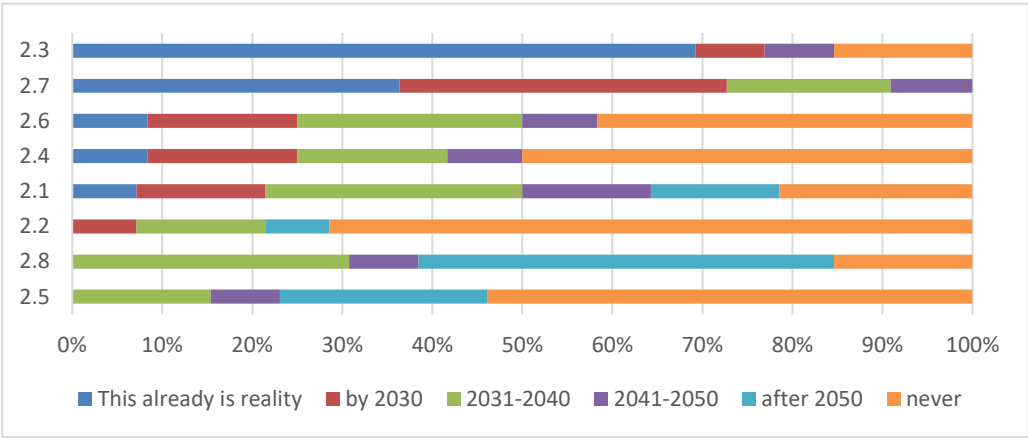


Figure 6: Assessment of time horizon for statements in cluster 2 (ordered by share of now - 2030)

Cluster 2: Culture, Creativity and Inclusive Society		Time Categories			Normative Orientation		
Statements (*= Lessons further discussed in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
2.1	"European governments have digitalised all their services and largely abandoned paper."				X	X	
2.2*	"European societies are so inclusive that no group in society considers itself unfairly excluded."			X		X	
2.3*	"Europe is a world leader in cultural heritage research and innovation."	X				X	
2.4	"Europe is a world leader in film-making industries."				X	X	
2.5*	"Migration no longer figures among the top issues on political agendas in Europe."			X		X	
2.6	"Cultural heritage is accessible to all across the EU free of charge."				X	X	
2.7*	"The EU establishes minimum standards for the protection of cultural heritage in its territory."	X				X	
2.8*	"The spread of urban sprawl has been halted, giving way to settlements in line with the principles of environmental, social, cultural and eco-			X		X	

	conomic sustainability."						
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Cluster 2 incorporated eight statements. As can be seen in Figure 6, the assessment of their time horizon is quite mixed. It is striking that for three statements (no 2, 4, 5) 50% or more of participants thought that this will never become reality. At the same time for one statement (no 3) almost 70% of participants judged "this is already reality". Three statements (1, 6, 7) are largely located within the time horizon 2030-2050. Statement no 8 was assessed especially long term by almost half of participants i.e. after 2050. Furthermore, it is interesting to note that some statements (1, 3, 4, 6) have a rather diverse assessment with substantial shares in both categories "never" on the one hand and "this is already reality"/by 2030 on the other.

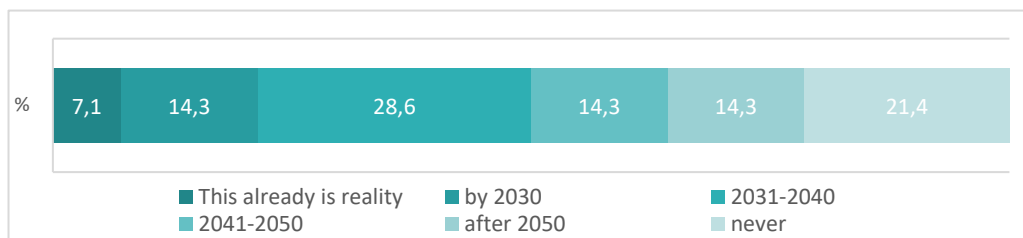
Individual Statements

Statement 2.1: European governments have digitalized all their services and largely abandoned paper.

Respondents

Expertise	n	%
Very high expertise	2	14,3
High expertise	4	28,6
Average expertise	6	42,9
Low expertise	2	14,3
Very low expertise	0	0,0
Σ	14	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	Largely in the question leave a lot for judgement. But if this was almost true before the COVID pandemic then it will be an even more rapid transformation because of the acceleration of on-line communications and tele working. The only retarding force to be considered is the vulnerability to data hacking which has in my experience produced some companies/government departments to return to paper based back-up.	Average
2031-2040	maybe not 100% but 90% of the current member states	Average
2041-2050	it will take at least a generation, given employment rules and priorities. Governments do not have the right incentives	Very high
after 2050	EU governments in some countries are heavily paper based and they do not have the infrastructure to switch all citizens to digital formats quickly.	Average
Never	There is always room for paper	Average

Never	The digitalization of public services should be continuously in development due to the need of implementing the emerging technologies to improve them and to make them citizen-centric and easy for citizens, with the aim at solving digital divide and difficult access to these services. Also, the implementation of emerging technologies can help government to be more efficient.	Very high
Never	The digitalisation and digitisation of public services is very uneven across EU MS. While some countries like EE are well advanced, others like DE have not even started reflecting strategically about the required transitions. Both COVID and Ukraine deviated administrative attention and person power to emergency response through which strategic development will be further delayed. Furthermore, in some countries, data privacy concerns will never allow for a full move to digital services in all sectors.	High

Interpretation

Assessment of the time horizon is highly diverse. It is striking that participants with high or very high expertise agree on the long term nature of digitalising all services and abandoning paper. While none of the respondents questions the desirability of this goal in principle, two respondents mention security and privacy concerns as an impeding factor. Several times the uneven pace across EU countries is stressed with Germany explicitly mentioned as a laggard. One participant with very high expertise emphasises the need to qualify the goal by focusing on citizen-centric implementation and overcoming the digital divide.

Overall it can be said that digitalisation of services has been confirmed as a valid long term goal with a number of challenges to be addressed that go beyond STI.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

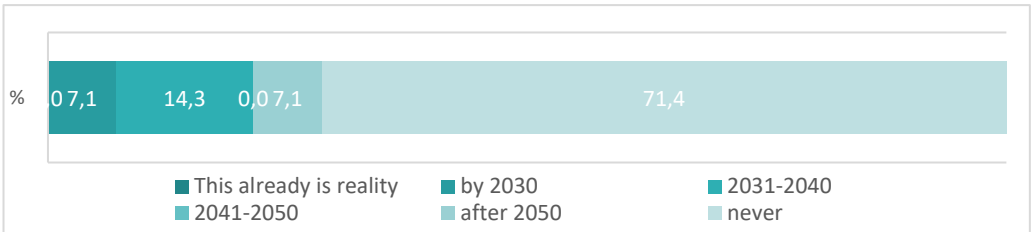
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 2.2: European societies are so inclusive that no group in society considers itself unfairly excluded.

Respondents

Expertise	n	%
Very high expertise	1	7,1
High expertise	4	28,6
Average expertise	9	64,3
Low expertise	0	0,0
Very low expertise	0	0,0
Σ	14	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	New generations are more familiar with technologies. Nowadays, technologies are helping governments to reach citizens but some part of the population (elder populations) do not have necessary technological skills to reach the information and digital services of governments. It makes European societies not to be inclusive nowadays. In addition, other different matters, like immigration problems are not well-addressed nowadays, partly because no collaborative and participative governments are implanted nowadays in European cities. Cities should involve all citizens in their city management decisions.	Very high
after 2050	Europe has lost its leadership in this matter, reacting to present day geopolitics (not leading), in particular immigration.	Average expertise
Never	there will always be migration and new challenges	High
Never	All current trends point to the opposite direction unfortunately	Average

Never	If anything, Europe seems to be drifting further away from inclusivity and back to exclusionary practices which epitomised the turn of the last century.	Average
Never	The excluded will always be with us	Average
Never	The prevalent economic growth level does neither incentives nor support total equality and/or equity. The realisation of the statement will depend on the adaptation of a different economic paradigm focused on sufficiency rather than growth.	High

Interpretation

As it was to expected, this “idealistic” statement received a high rate of “never” assessments and nobody thinks that this is already the case. Several challenges are mentioned, among them most prominently immigration which was singled out as a remaining challenge by three respondents. As underlying impediments respondents point to lack of participatory governance, the dominant economic paradigm and the digital divide between generations. Still none of the respondents questions the goal in principle and some even see it as achievable albeit in a long time horizon. Overall, one could say that the issue of inclusion was confirmed as valid long-term goal, that may however well be never fully achieved. This could be seen as a problematic tension especially if the open character of this goal is not acknowledged.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
inconclusive	

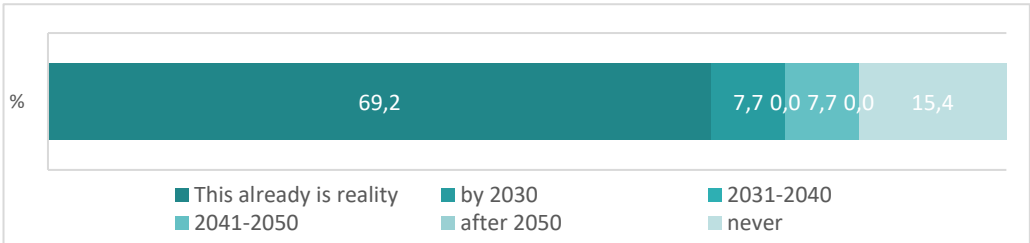
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 2.3: Europe is a world leader in cultural heritage research and innovation.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	3	23,1
Average expertise	9	69,2
Low expertise	1	7,7
Very low expertise	0	0,0
Σ	13	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	It has the multiple resources and (mostly) the will to conducts heritage research and preservation	High
This already is reality	Most UNESCO heritage sites are located in (geographical) Europe, so most probably, also the majority of R&I activities are located and financed here.	Low
by 2030	While cultural heritage research and innovation in Europe is already excellent, there is a lot of waste on projects of varying quality, and it appears that some countries dominate this arena. I would hope that going forward, EU funds would end up distributed more equitably, particularly given the rich heritage across the EU.	High
Never	I think that Europe has a very high research scholar in this subject nowadays. But research is not a concept to stop in a determine period of time. Research is continuously in development and it needs a great attention from the European Government. For example, I am	Average

	listed in the highest-recognized scholars in the world in Smart Cities (smart Governance) and E-government according to the list of the University of Stanford (USA), but it does not indicate that I cannot improve in my research or in updating my knowledge which is continuously changing.	
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Interpretation

This statement received the highest rate of “this is already the case” of all statements. Respondents judge Europe as one of the key actors in cultural heritage research. Still as was pointed out by one of the respondents there is always room for improvement. In particular, as one of the respondents points out, the excellence could be spread more across EU countries to better reflect its rich diversity of cultural heritage. Even though Europe is seen as already excellent striving further in this area is seen as a worthy goal.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	X
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	

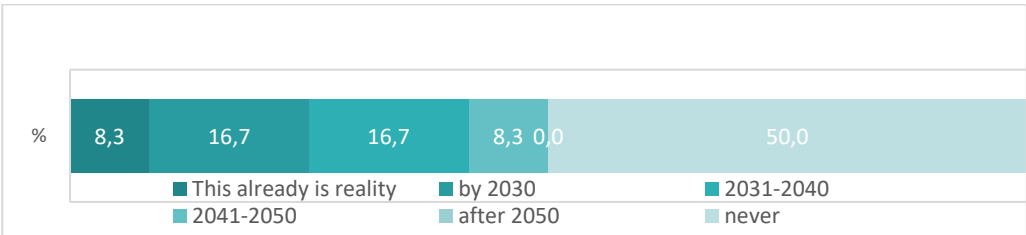
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 2.4: Europe is a world leader in film-making industries.

Respondents

Expertise	n	%
Very high expertise	1	8,3
High expertise	2	16,7
Average expertise	6	50,0
Low expertise	2	16,7
Very low expertise	1	8,3
Σ	12	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	Europe is a world leader, though not necessarily in box-office and profits. So it depends what you mean by 'world leader'. As long as it can make good films then that's fine	Very high
by 2030	I am not an expert in this issue but I feel that film-making industries are getting better and balance is even higher nowadays with the use of new technologies.	Low
2041-2050	While several countries in Europe have excellent film making capabilities, cuts to the arts (as seen in the UK) will make quality content harder to produce. Additionally, the global dominance of US cultural content leaves little space in a global marketplace driven by profit over all else.	Average
Never	a leader already in artistical film making but not commercially	High
Never	The US and IND movie industries have too strong a concentration of capital to be surpassed.	Average

As two respondents with high expertise point out a distinction needs to be drawn between lead in artistically terms and profits from commercial film making. Comments indicate that the former may be already well on its way whereas the latter is mainly a matter of investment which many think will never be available in Europe to the same amount as in other world regions. At the same time one respondent with low expertise points to technology as a driver.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

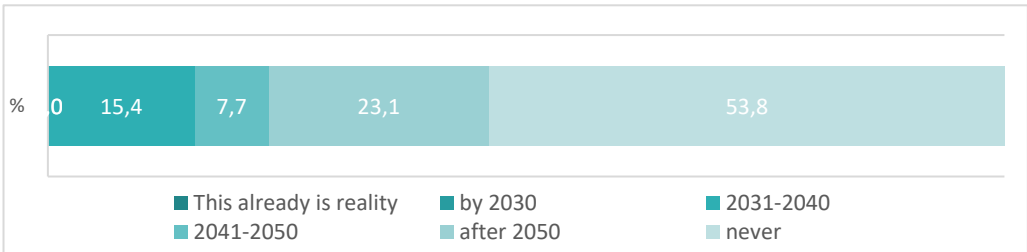
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 2.5: Migration no longer figures among the top issues on political agendas in Europe.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	3	23,1
Average expertise	10	76,9
Low expertise	0	0,0
Very low expertise	0	0,0
Σ	13	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	I hope that this assertion will come true. My feelings are that all persons should be treated the same and in equal opportunities worldwide. I understand the nationalities and Regions, but we are individuals before people belonging to an administrative place.	Average
2031-2040	almost impossible to answer. It depends on how climate change and food security in handled.	Average
after 2050	worldwide population growth forecasts show endless socio-economic imbalance is likely, and environmental factors will continue to drive this. Unrest is a natural fall out of both	High
after 2050	in the very best case, a world improving and reversing current situation, Europe will be a follower. it has completely lost leadership.	Average
Never	Europe is increasingly anti-migrant and with climate change, migration is only going to increase. I fear this will stoke nationalist tendencies beyond what they already are.	Average
Never	With climate change this will only increase	Average
Never	This will only start materialising when migration will	Average

	be positively re-framed and channelled for economic growth, so that HR induced migration and labour migration and be more clearly differentiated and steered.	
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Interpretation

The majority of respondents believes that this assertion will never become reality while nobody thinks that this is already the case or will become true in the next ten years. Influencing factors mentioned are climate change, environmental factors, worldwide population growth, socio-economic imbalance and current framings of the issue in politics. Still, respondents who have commented on their answer seem to confirm this as an important goal.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

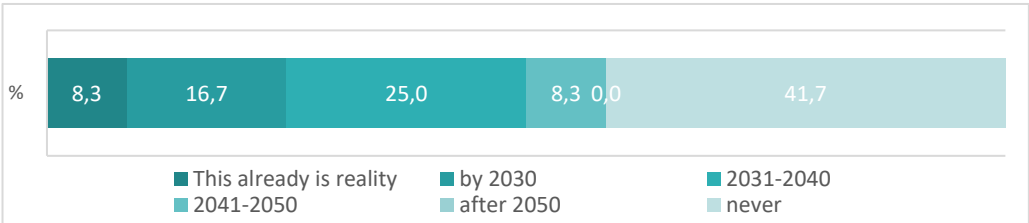
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 2.6: Cultural heritage is accessible to all across the EU free of charge.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	4	33,3
Average expertise	5	41,7
Low expertise	3	25,0
Very low expertise	0	0,0
Σ	12	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	It is accessible, but do people have the capacity and therefore the will, to access it?	High
2031-2040	This sentence should be true. The cultural heritage should be free of charge for European citizens. We all have created this cultural heritage and it owns to the humanity not to governments or private companies. Governments must keep cultural heritage in good health (with the taxes of citizens).	High
2041-2050	maybe not 100% but 80%	Average
Never	This would require all countries to not only have funding available to maintain sites but also be willing to allocate this money to heritage properties. Even in wealthier European countries, heritage is not always viewed as a common good so much as something which must sustain itself, as occurs in the UK at most heritage sites.	High
Never	Public budget post-COVID/Ukraine will require civil society contributions to CH maintenance for a longer period.	Average

Interpretation

On these statement opinions dispersed. A major group believes that this will never be the case pointing to lack of funding and low priority in many countries especially in view of the recent crises. Others think it realistic within the next 10 or 20 year at least for the majority of cultural sites. One person with high expertise also doubts the capacity and will of people to access the sites.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

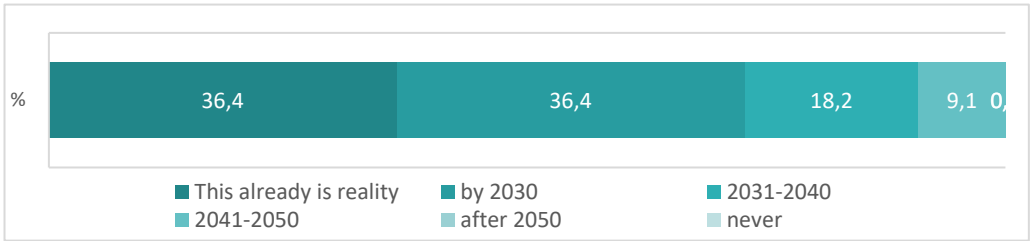
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 2.7: The EU establishes minimum standards for the protection of cultural heritage in its territory.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	3	27,3
Average expertise	6	54,5
Low expertise	1	9,1
Very low expertise	1	9,1
Σ	11	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	Both UNESCO and the EU have a set a protective floor for that.	Average
This already is reality	I think there are minimal standards in place now.	High
2041-2050	This requires a concerted effort and joint deliberation on how to manage heritage, which is currently split across cultural divides (with the napoleonic influence on heritage and cultural management visible in France and Italy).	High

Interpretation

This statement ranks among the most “realistic” as none of the respondents thinks that it will never become reality. The comments show that the assessment depends highly on the definition of “minimum standards”. One person with high expertise maintains that such minimal standards are already in place while another points to major efforts required and expects realisation only within the 2040s.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	X
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	

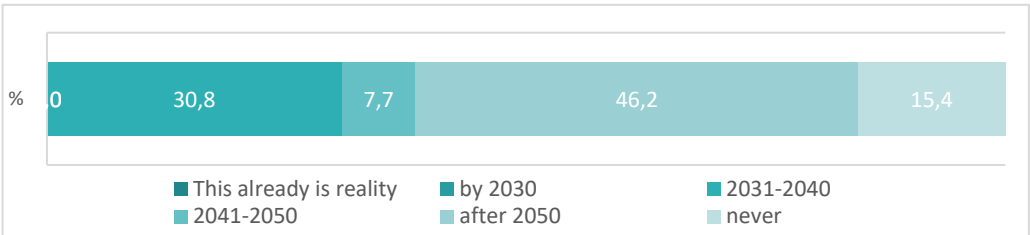
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 2.8: The spread of urban sprawl has been halted, giving way to settlements in line with the principles of environmental, social, cultural and economic sustainability.

Respondents

Expertise	n	%
Very high expertise	1	7,7
High expertise	4	30,8
Average expertise	7	53,8
Low expertise	1	7,7
Very low expertise	0	0,0
Σ	13	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
after 2050	Mobility (together with energetic model) will be a key area of social reshaping. In the very best scenario it will take more than 20 years to converge in an appealing sustainable model	High
after 2050	This would require governments to spend money and/or to treat housing as a common good as opposed to it functioning as a market driven by growth. Most countries will only undertake the required changes to achieve this as a last resort. Countries who rely on the housing market as a key developer of wealth, as in the UK, are unlikely to ever do it without some level of political collapse.	Average

after 2050	Rather than actively steered by EU and national regulation, this will most probably be the outcome of rampant house pricing developments and gentrification at urban level.	High
after 2050	It will take some time.	High
Never	The world is continuously changing, appearing new challenges to be solved. It has made citizens to move from rural to urban areas or vice versa during the different centuries. I think that to be agree with this sentence means that no changes will be the aim of the government policies and I am not agreeing with that. Challenges, urban problems, citizen demands and needs change over time. Government must respond to these challenges in an efficient way. So, I think that settlements will produce problems and challenges over-time. The key question here is whether city governments are prepared to respond them.	Very high

Interpretation

In this statement there is a striking agreement among respondents with high and very high expertise. They all think that establishing sustainable models of human settlement will take decades and remain a continuous challenge beyond 2050. Two answers mention house prices and wealth generation in the housing sector as important drivers. None of the respondents thinks that this is reality or will be solved in the near future. Some respondents however see a realisation already before 2050.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

Normative Orientation	Assessment
Agreed	X
Contested	

Conclusions

This cluster is among the ones with the highest share of “never” assessments. For the following three statements 50% or more of participants thought that this will never become reality:

- 2.2: "European societies are so inclusive that no group in society considers itself unfairly excluded."
- 2.4: "Europe is a world leader in film-making industries."
- 2.6: "Cultural heritage is accessible to all across the EU free of charge."

A closer look at respondents' comments has shown that on the one hand this is due to the idealistic nature of the statements and the strong barriers impeding societal change. On the other hand, however the assessment is also due to the critical stance of the social and cultural sciences relevant for this sector. So e.g. for statement 4 experts pointed out that the notion of leadership needs to be differentiated between artistic and commercial criteria. Also in other statements respondents emphasised that it is in the nature of these issues to be continuously evolving.

At the same time, this cluster also contains one of the nearest term statements. Especially statement

- 2.3: "Europe is a world leader in cultural heritage research and innovation" was seen as already the case. Nevertheless, even here experts pointed to the never ending nature of this challenge.

Even for the one statement that stands out with its controversial assessment of the time horizon:

- 2.1 "European governments have digitalised all their services and largely abandoned paper."

There seems to be agreement between respondents with high expertise.

Especially interesting in terms of orientation for STI programmes could be statement 8:

- 2.8: "The spread of urban sprawl has been halted, giving way to settlements in line with the principles of environmental, social, cultural and economic sustainability."

This statement has been clearly assessed as a long term challenge beyond even 2050 but with aspects to address also by STI along the way.

Also interesting are the two statements relating to cultural heritage:

- 2.6: "Cultural heritage is accessible to all across the EU free of charge."

- 2.7 "The EU establishes minimum standards for the protection of cultural heritage in its territory."

They entail slightly more short-term components to be addressed before 2030 but also contain STI aspects such as the reasons for lack of capacity and willingness to engage with cultural heritage and the diverse patterns in recognising cultural heritage across Europe and inroads for shared standards.

3.4. Results Cluster 3 Civil Security for Society

Overview

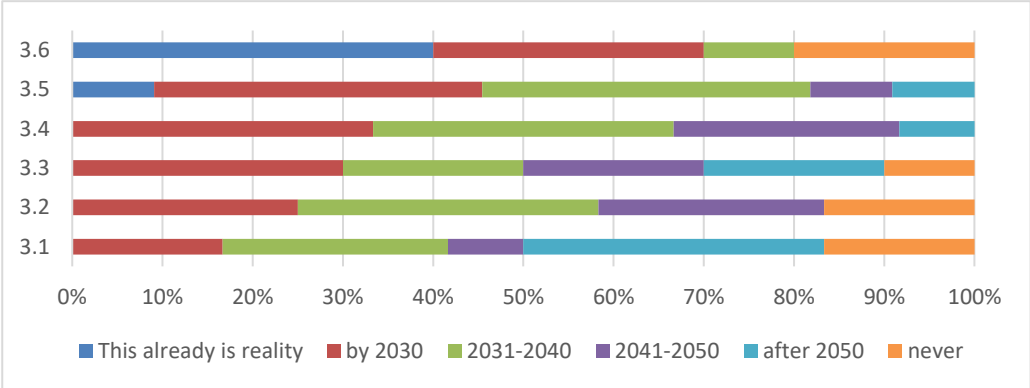


Figure 7: Assessment of time horizon for statements in cluster 3 (ordered by share of now - 2030)

Cluster 3 Civil Security for Society		Time ries		Catego- ries		Normative Orienta- tion	
Statements (*= Lessons further discussed in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
3.1	"Investment in natural hazard preparedness and protection across Europe has doubled from 2022."				X	X	
3.2	"Individual resilience training is established in school curricula in most European countries."		X			X	
3.3	"Quantum technologies are compromising most non-quantum based cryptography."				X	X	
3.4	"New and emerging risks and risk magnifiers such as climate change, cyber threats, infectious diseases and terrorism are twice as prevalent in Europe as they were in 2022."		X			X	
3.5	"More than 50% of EU cities have installed more than 15 CCTV cameras per 1000 inhabitants (in 2022 the highest number in the EU is 11 in Berlin. In London the number is 68)."		X			X	
3.6*	"Criminal use of end-to-end encryption in social media is posing a major challenge for law enforcers trying to prevent cybercrime."	X				X	

Figure 7 gives an overview of the assessment of time horizon of realisation for all six statements of cluster 3 "civil security for society". It is striking that only for statement 6 opinions are strongly divided. Around 40% of respondents answered that "this is already reality" while 20% think that "this will never become reality". For all other statements, assessments are in the range between 10-30 years with statement 1 also thought by several respondents to be realised only after 2050. All in all, this cluster seems to be assessed with relatively high agreement and the time horizon assessment seems suitable for a research programme.

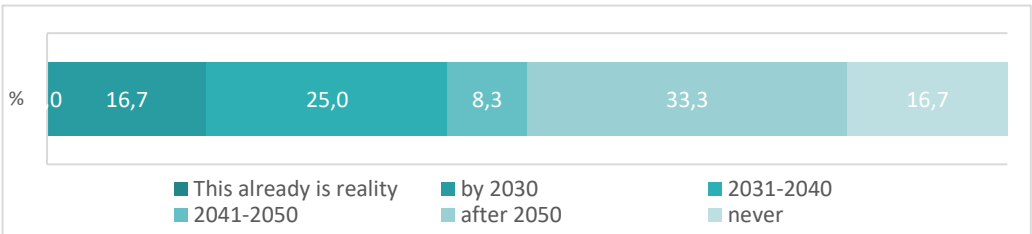
Individual Statements

Statement 3.1: Investment in natural hazard preparedness and protection across Europe has doubled from 2022.

Respondents

Expertise	N	%
Very high expertise	0	0,0
High expertise	2	16,7
Average expertise	6	50,0
Low expertise	2	16,7
Very low expertise	2	16,7
Σ	12	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	people panic now, but it depends what you calculate as investments in preparedness	High
2031-2040	Natural hazards will increase in not only due to impacts of climate change but also due to land use patters (current and of the past). Investments are understood not only as public investments but also as private investments via insurances.	Average
2031-2040	We've seen how the technical specifications of different projects (e.g., nuclear power plants) are being reassessed and different modifications are being studied and implemented. They will take some years to be implemented.	High
2041-2050	The cost of natural hazards is rapidly rising worldwide. This means that Investments in natural hazard preparedness and protection will become increasingly cost-effective, so my thinking is that investments will rapidly grow.	Average
after 2050	Investment is already now remarkable, and in	Average

	the future some hazards do not need extra investments.	
Never	Investment in preparedness is not valued very much by voters	Average

Interpretation

The two respondents with the highest expertise both expect realisation of this statement between 2031 and 2040. Two respondents remark that the answer also depends on the definition of investment. Two other respondents present "counter arguments" i.e. the high level of current investment also covers some future hazards and secondly the lack of incentives for policy makers as preparedness is not appreciated by voters. To sum up, even though the range of time horizons is rather wide the general thrust seems to be aligned across respondents: The number of hazards will grow and the need to prepare for them will remain high throughout the next three decades.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

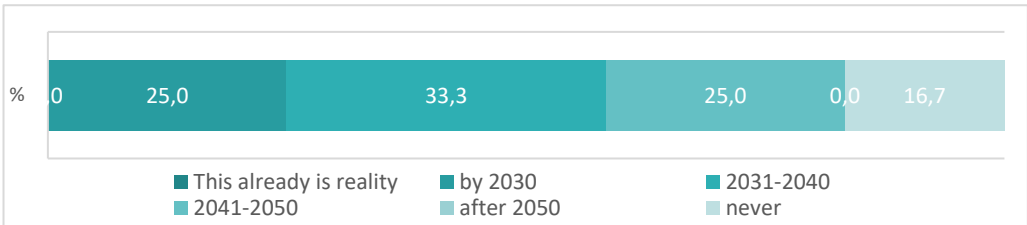
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 3.2: Individual resilience training is established in school curricula in most European countries.

Respondents

Expertise	N	%
Very high expertise	0	0,0
High expertise	0	0,0
Average expertise	6	50,0
Low expertise	4	33,3
Very low expertise	2	16,7
Σ	12	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	Curricula development is a rather slow process. Especially in the Alpine region information material for schools already exist (e.g. https://biberberti.com/kostenloses-lehrmaterial/) but isn't commonly used. Individual resilience training should be included in existing topics and reinforced by outdoor activities e.g. school project hazard zone planning for children of the Government of Carinthia	Average
by 2030	This is not very remarkable investment and many countries are already proceeding with this.	Average
2031-2040	Climate Change + COVID-19 + War in Ukraine have fostered the necessity of some individual resilience training. If you look for Survival skills in Google Trends, you can see that several European countries are in the top 20 in the Interest by region panel.	Very low
2041-2050	first efforts are discussed, the different school systems are the problem	Average
Never	This statement is a bit vague but I don't think that Individual resilience training will be ever considered as a specific subject in school curricula (but some elements of individual resilience will be, depending on the places where someone lives)	Low

Never	Unfortunately this is not high on the agenda in curriculum development	Low
--------------	--	-----

Interpretation

The large majority of respondents expects an increase in individual resilience training in school curricula within the next three decades. One respondent argues that only some aspects will be taken up and only one respondent voices general scepticism. All experts however, including the sceptical one, see this at least in part as a desirable development.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

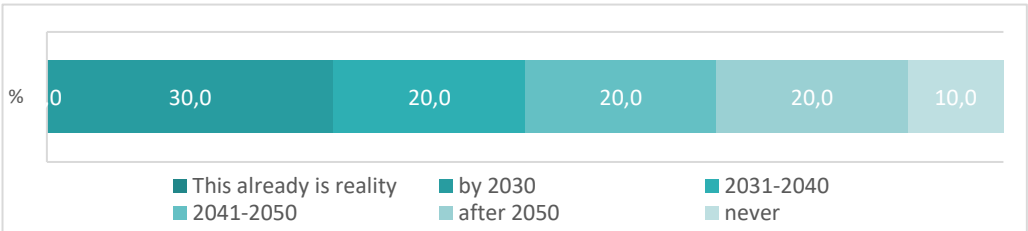
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 3.3: Quantum technologies are compromising most non-quantum based cryptography.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	0	0,0
Average expertise	4	40,0
Low expertise	3	30,0
Very low expertise	3	30,0
Σ	10	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	Because NIST has announced its First Four Quantum-Resistant Cryptographic Algorithms [https://www.nist.gov/news-events/news/2022/07/nist-announces-first-four-quantum-resistant-cryptographic-algorithms].	Average
by 2030	This is already on its way	Average
2031-2040	This technology is already developing	Very low

Interpretation

Apparently, in the field of quantum computing we did not succeed in recruiting respondents with a high expertise, as all respondents rate their expertise as average or lower. While several respondents seem to see this coming in the not too distant future, one respondent pointed to the already existing four quantum-resistant algorithms selected in a recent competition of the U.S. Department of Commerce’s National Institute of Standards and Technology (NIST). This implies that in spite of the rise of quantum technologies safe cryptographic approaches will be available. To sum up the responses are inconclusive in this

case but seem to indicate that this will remain a valid research challenge beyond 2040.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

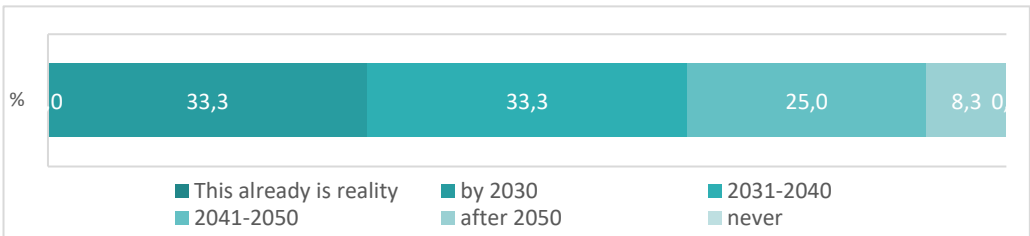
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 3.4: New and emerging risks and risk magnifiers such as climate change, cyber threats, infectious diseases and terrorism are twice as prevalent in Europe as they were in 2022.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	3	25,0
Average expertise	6	50,0
Low expertise	1	8,3
Very low expertise	2	16,7
Σ	12	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	The impacts of climate change will increase especially in the Alpine region and will have also adverse effects on health. Health impacts by infectious diseases and vector borne diseases will increase due to neobiota as well as other factors (e.g. deforestation of rain forests and other habitats, migration, decreasing budget for health care in developing countries, lack of monitoring and early warning systems...). Due to social instability political and/or religious extremist groups will increase to a certain level.	Low
2031-2040	we already see increases and intertwining of the risks	High
2041-2050	These risks are clearly rising, however mitigating actions (already developed and under development) will have some effect.	High
2041-2050	Some of the mentioned emerging risks have (potentially) exponential behaviours and they are *not* growing at a 10% per year (10 years to dou-	Very low

	ble), so a time scale of 20 - 30 years may be more realistic.	
2041-2050	Several risks linked to climate change (especially drought and heat wave risks) are likely to increase fast and become much more prevalent in the near future. I'm not an expert on cyber threats, infectious diseases and terrorism and so my prediction should be limited to climate change-related risks only	High

Interpretation

For this statement none of the respondents has indicated that it will never be the case and only one person thinks it will be after 2050. Four respondents expect a doubling by 2030 and three people with high expertise have placed this within the next 20 years. Experts emphasise especially climate change and highlight the intertwined nature of the risks. One expert points to ongoing mitigation actions that will help to lower the risk. In summary understanding these risks especially their interlinkages and developing measures to mitigate them is seen as a valid long-term challenge.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

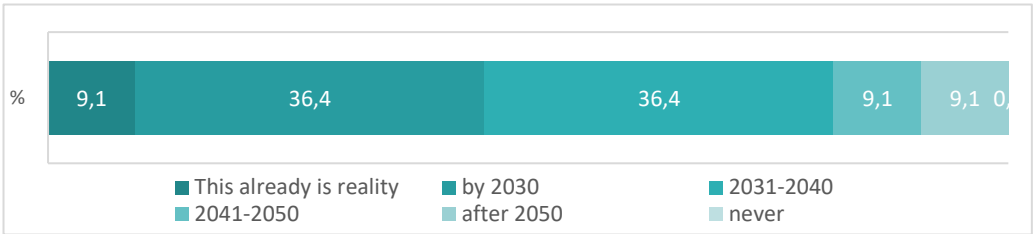
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 3.5: More than 50% of EU cities have installed more than 15 CCTV cameras per 1000 inhabitants (in 2022 the highest number in the EU is 11 in Berlin. In London the number is 68).

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	2	18,2
Average expertise	3	27,3
Low expertise	4	36,4
Very low expertise	2	18,2
Σ	11	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	With the Internet of Things, there are (and will be) *millions* of cameras (e.g., cars, security door-bells) available to EU cities in streets and roads: the cities will not install them, they will tap into this resources.	Very low
2031-2040	it is just a matter of time	High
2031-2040	This hardware technology is already available, and the developing information technology will give new possibilities.	Average
2031-2040	This is already on the rise	Low

Interpretation

The majority of respondents expects an omnipresence of cameras capturing citizens’ everyday life in the not too distant future. One respondent justly points to the vast number of cameras in the internet of things that cities will be able to

tap into. Whether this is seen as a goal or a threat cannot be concluded from the comments given.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

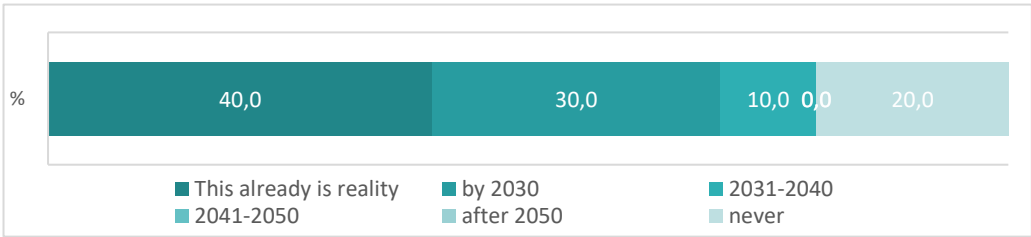
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 3.6: Criminal use of end-to-end encryption in social media is posing a major challenge for law enforcers trying to prevent cybercrime.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	2	20,0
Average expertise	3	30,0
Low expertise	5	50,0
Very low expertise	0	0,0
Σ	10	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	law enforcers are not well equipped, there may be solutions	High
by 2030	This is already remarkable problem, and something has to be done quite soon.	Average
by 2030	This is already on the rise	Low
Never	The cybercriminals we should be worried about don't use social media to communicate.	Average

Interpretation

The assessments of this statement are rather diverse. Four people think that this is already reality and three expect it within the next ten years. One person with high expertise confirms the issues and states that there may be solutions. On the other hand, two people have indicated “never” as a time horizon. The comment of one of them indicates a possible reason: Even though one can expect the use of encrypted media by criminals, this may not be seen as posing “major challenges” as much more severe threats are emerging from other types of cybercriminals that do not use social media to communicate.

To sum up this is most likely a near and mid-term issue but its importance needs to be assessed in the context of the full spectrum of cybercrime. Also it is important to note that ethical considerations are relevant here that require societal deliberations so if this is to be addressed by STI social sciences and humanities would have an important role to play.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	X
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	

Normative Orientation	Assessment
Agreed	X
Contested	

Conclusions

Reponses indicate that this cluster indeed entails important long term challenges for research:

Especially pertinent seems statement 4:

- 3.4: New and emerging risks and risk magnifiers such as climate change, cyber threats, infectious diseases and terrorism are twice as prevalent in Europe as they were in 2022.

Two statements are directly related to this as they address risk mitigation measures:

- 3.1: Investment in natural hazard preparedness and protection across Europe has doubled from 2022.
- 3.2: Individual resilience training is established in school curricula in most European countries.

Together this whole complex of societal resilience to disruptive threats seems to entail a multitude of research and innovation challenges. This ranges from social practice innovation (such as individual resilience training) via basic natural science issues (such as emerging health threats such as neobiota mentioned by one expert) and technologies (such as mitigation of cyberterrorism). One key aspect however highlighted by respondents is the interaction of these threats which indicates the need for transdisciplinary research.

The three remaining statements are also related to this theme but focus more on the aspect of cyber threats:

- 3.3: Quantum technologies are compromising most non-quantum based cryptography.
- 3.5: More than 50% of EU cities have installed more than 15 CCTV cameras per 1000 inhabitants.
- 3.6: Criminal use of end-to-end encryption in social media is posing a major challenge for law enforcers trying to prevent cybercrime.

All three have been clearly assessed as short and mid-term challenges. Nevertheless, opinions on the overall importance of these aspects in the greater scheme of things were diverging. It became clear that these aspects require not only cutting edge STI efforts but also ethical and political deliberations. These could be supported by social sciences and humanities.

3.5. Results Cluster 4 Digital, Industry and Space

Overview

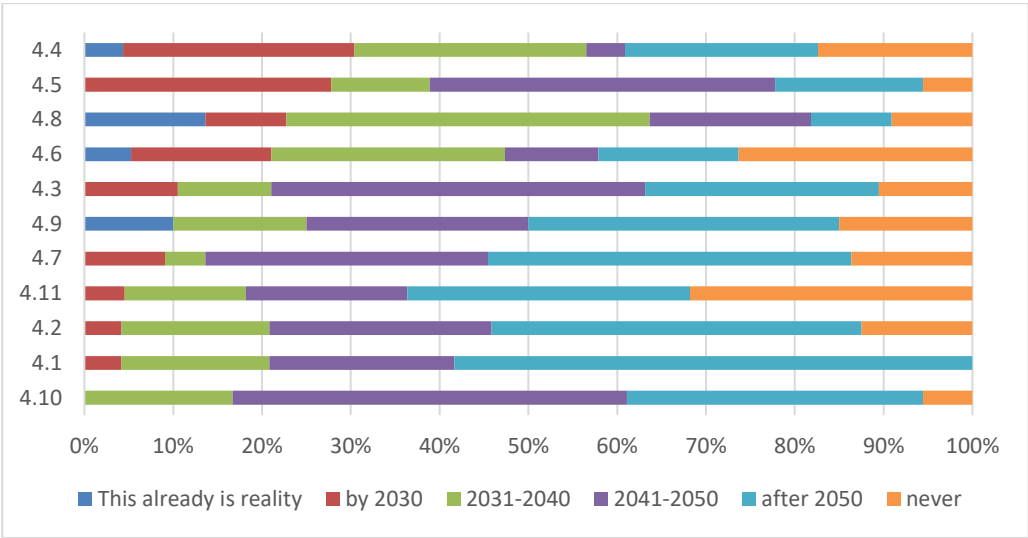


Figure 8: Assessment of time horizon for statements in cluster 4 (ordered by share of now - 2030)

Cluster 4: Digital, Industry and Space		Time ries		Catego-		Normative Orienta- tion	
Statements (*= Lessons further discussed in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
4.1*	"More than 80% of products in the market are made from recycled resources."			X		X	
4.2*	"European industry is fully decarbonised."			X		X	
4.3	"100% of fibre reinforced polymer composites is recycled in Europe (compared to a maximum of 20% for glas fibres in 2022)."		X			X	
4.4	"The EU is the world`s most secure and trusted data hub."				X	X	
4.5*	"Globally more than fifteen commercial deep sea mining ventures are operating (at the moment only contracts have been issued)."				X		X
4.6	"Europe is at the cutting edge of quantum capabilities."				X	X	

4.7*	"After successful decarbonisation of the European energy system, energy in Europe is abundant and supply is stable."			X		X	
4.8	"Europe has become a technology and industrial leader of the green and digital twin-transition."		X			X	
4.9	"Biological modes of production have become more important than digital ones."	Not assessed					
4.10	"The majority of ICT based products involve quantum technologies (second generation)."		X			X	
4.11*	"EU`s industrial base has diversified its supply chains so widely that it has no critical material and technology dependencies anymore."			X			X

Interpretation

As Figure 6 illustrates the time horizon of the 11 statements in this cluster has been assessed with relatively little tension. Four statements (4, 6, 8, 9) contain both "this is already reality" and "never" assessments but the share for the near term end are rather low. Only three statements (4, 6, 11) have major shares for "never". Several statements have been assessed with "after 2050" an assessment that is relatively rare in other clusters. This may indicate that this cluster is especially oriented towards long-term challenges. In particular, for statement 1 a large majority of respondents selected "after 2050" without anybody opting for never, a combination that is unique not only in this survey as it is well known that very often long term developments tend to be discarded as unlikely.

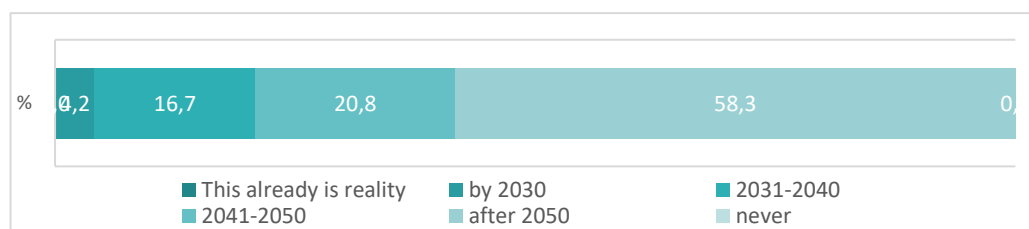
Individual Statements

Statement 4.1: More than 80% of products in the market are made from recycled resources.

Respondents

Expertise	N	%
Very high expertise	1	4,2
High expertise	6	25,0
Average expertise	12	50,0
Low expertise	5	20,8
Very low expertise	0	0,0
Σ	24	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	in 2030 there will be many products combining second material and new materials for extending functionalities with affordable costs	Average
2031-2040	We seem to be going in the right direction	Average
2041-2050	For a long time, products will contain at least some components that are not made from recycled resources. So, 80% is a high aim.	Average
after 2050	Though circularity is slowly getting into the psyche of people, it's a slow process; with too much worldwide economic activity influencing EU consumers	Average
after 2050	Takes a long time to change production and consumption patterns. Holds mainly, if raw materials are not available anymore.	Average
after 2050	Creation of the supply chains	High
after 2050	As long as we have complex and complicated products made of very different materials, 80% is very ambitious. For some products, no problem if	Very high

	they are properly collected...	
after 2050	Maybe after 2050 there will be no other choices	Average
after 2050	The infrastructure is not yet there to support this, and it will take several years to realise this. Also the mindset of people is not evolved enough to realise this change on the short term.	High

Interpretation

This statement is unique in that not one respondent completely dismissed the possibility that this will happen but a large majority expects this only after 2050. The comments provide convincing reasons why 80% of recycled products is a very ambitious goal including from three respondents with high and very high expertise. They emphasise the complexity of products and subsequent supply chains and the lack of adequate infrastructure as reasons for long time to change production and consumption patterns. Also, two respondents highlight people's mind-set as an important factor impeding change. Interestingly two respondents mention that by 2050 scarcity situations may enforce the realisation of this statement.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

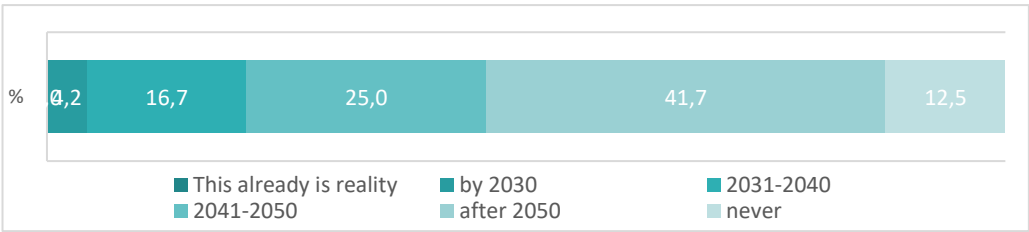
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 4.2: European industry is fully decarbonized.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	7	29,2
Average expertise	11	45,8
Low expertise	6	25,0
Very low expertise	0	0,0
Σ	24	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2041-2050	For different reasons European industry has, generally, the obligation and also the wish to become decarbonised. The date is, of course, unknown, but it should not take more than 20 years	Average
2041-2050	Hopefully ...	Average
2041-2050	20 years are the time period that requires the Union to prepare effective policies for a structural change for industry generating big impacts onto socio-economic and cultural systems	Average
after 2050	Fully decarbonised is a big claim. I guess you mean fossil raw materials based carbon. Wood is also a carbon based product. Hence, I find the initial statement imprecise.	High
after 2050	Energy policy	Average
after 2050	There is a lot of technology development, but the technology deployment is lacking. In HEU, more support for technology infrastructure and pilot& demonstration infrastructure is foreseen; but there is a lot of catching up to do. The required infrastructure to fully decarbonise the EU industry will take time to build and EU is typically rather slow in this.	High

after 2050	Too little focus on fundamentally changing the incentive structure for widespread deployment (e.g. by phasing out fossil fuel subsidies, stringent regulations) and too reluctant in establishing global climate competitiveness (e.g. continued free allocation to industry in ETS, WTO rules insufficiently tackled for level playing field)	Average
Never	the notion decarbonized is misleading and impossible if taken for granted	Average

Interpretation

The EU has the ambition to combat climate change and decarbonise its production and consumption patterns. A large share of respondents sees this happening only after 2050. Three respondents opted for “never”. Comments indicate that the reason for this may be the vagueness of the term “decarbonisation”. Two comments indicate that appropriate policy framework condition could achieve this within 20 years. Two others doubt that policy focus on this is sufficient and point out that EU measures are too slow. Overall most experts stress the importance of policy measures such as legislation and financial incentives. To sum up, respondents agree on the urgency of this goal and on the enormity of the challenge. Assessment on whether and when the goal can and will be achieved differ. Only half of the respondents think that this will be achieved before 2050.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

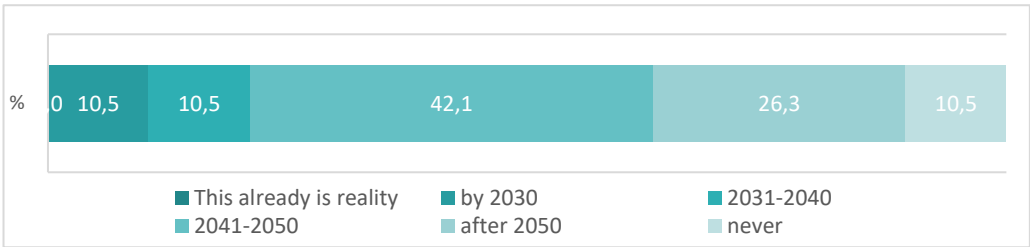
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 4.3: 100% of fiber reinforced polymer composites is recycled in Europe (compared to a maximum of 20% for glass fibers in 2022).

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	2	10,5
Average expertise	7	36,8
Low expertise	7	36,8
Very low expertise	3	15,8
Σ	19	100,0

Time Horizon:



Comments

Time Horizon	Comment	Expertise
by 2030	In several Manufacturing products (textiles, automotive...) this will increasingly be part of a business model for cost reduction also including Natural RFC. Value chains in this direction need to be available. This is totally different and critical in the world manufacturing of the enormous sector of medical devices for therapeutic biomaterials.	Average
2041-2050	You talk e.g. of windturbine blades? Question seems to be to open.	High
2041-2050	There will be a need to organise the recycling cycle in a very efficient way to enabled this to happen	Average
2041-2050	Composites are difficult to reuse or recycle as available technologies are either not environment friendly or economically unattractive. EU-funded projects in the area and suitable EU legislation may speed up the process.	Average
Never	100% can be recycled but I cannot see any system, in which 100% of the fibres are brought back/ collected	Average

Never	100% will never be achieved. The values will rise asymptotically.	Low
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Interpretation

The assessment of this statement is differentiated. The largest share of respondents expects this between 2031 and 2040. Comments however point to the severe technical, organisational and economic difficulties involved in recycling of fibre composites and argue for longer time horizons or even reject the possibility altogether. One respondent emphasises the special challenge of achieving this in the medical device sector. The same person is however rather optimistic and sees this happening by 2030 partly due to the application of natural fibres.

To sum up - as one expert explicitly states EU research and regulation can make difference here to achieve this earlier but the net should be thrown widely including also natural fibres as an alternative and other than the "usual suspect" sectors.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

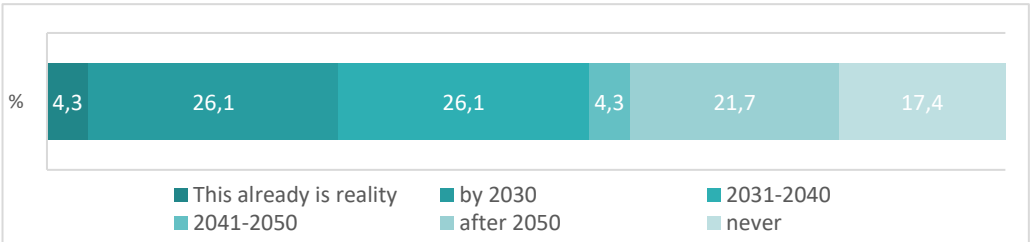
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 4.4: The EU is the world`s most secure and trusted data hub.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	5	21,7
Average expertise	14	60,9
Low expertise	3	13,0
Very low expertise	1	4,3
Σ	23	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	If it is not reality yet I believe we are close to it. However, to be the most secure and trusted hub goes along with leadership in the field. I am not sure we have that leadership yet.	High
by 2030	we're almost there	High
by 2030	most - but not fully	Average
2031-2040	Yes, ten years from now will be a time-period to implement applications that extensively exploit this Key enabling Technology in the field of digital security	Average
2041-2050	This can become a reality if this is put forward as an important goal to reach, and appropriate investments are done to accompany the realisation of this hub.	Average
after 2050	Digital security is a highly volatile area prone to external, global threats and thus hard to control. On one hand side, the effectiveness of technologies of digital security keeps improving, on the other hand the growing prevalence of IoT devices could be a factor that accelerates cyberattacks. For the EU to become the most secure	Average

	and trusted data hub, technological advancements should go hand in hand with activities that would raise societal awareness (e.g. school training, on the job training) of cybersecurity threats and ways to minimize cybersecurity risks.	
Never	Seems unrealistic. Would be nice, but well, I doubt this would even change by 2050.	Average
Never	Not with current vision and killing bureaucracy. Total lack of understanding and future vision. Only a radical change in leadership would change expectations	High

Interpretation

This statement is highly contested. Roughly a third of the respondents thinks that “we are almost there” or even that this is already the case while roughly 40% think that this is far away or may even never happen. Among both groups are people with high expertise. One possible explanation of this diverse timeline is that Europe is close to reaching this goal but its relative position is deteriorating.

Comments provide additional reasoning especially for the critical group. One element is the role of external threats that cannot be controlled. The most sceptical respondent raises lack of adequate “leadership” and “vision” in the current bureaucracy as main impediment. In the same vein, another expert stresses the importance of adopting this vision as a goal with a clear focus. Nevertheless, some comments also highlight the technology challenges that would need to be addressed by research. One comment convincingly argues that “technological advancements should go hand in hand with activities that would raise societal awareness (e.g. school training, on the job training) of cybersecurity threats and ways to minimize cybersecurity risks”.

To sum up, this goal is confirmed by all respondents but the realisation seems to depend strongly on the leadership capability of the EU. A coherent strategic approach to developing appropriate cybersecurity capabilities seems key to achieve this goal.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

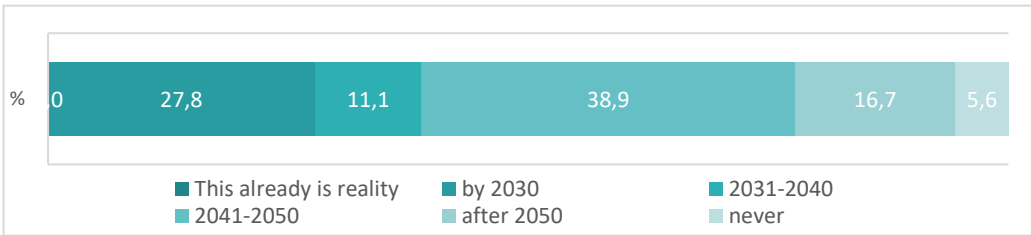
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 4.5: Globally more than fifteen commercial deep-sea mining ventures are operating (at the moment only contracts have been issued).

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	1	5,6
Average expertise	7	38,9
Low expertise	6	33,3
Very low expertise	4	22,2
Σ	18	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	Unfortunately this will be driven by the rush in batteries	Average
2031-2040	the business is booming	Average
2041-2050	It is important to take the proper time to assess R&T&I impacts considering a multidisciplinary perspective that still is lacking behind	Low
2041-2050	It will depend on the benefits versus the risk for the environment	Very low
2041-2050	no idea.	Very low
after 2050	There is scarce research data and lack of clear, unbiased information on whether deep-sea mining should go ahead or not. Think about biodiversity loss, toxicological aspects, safety, general environmental impact such an exploration might cause. What about the ethical stance of scientists who are for deep-sea exploration: are they research results credible? Or are we talking about subjective research results sponsored by commercial mining companies?	Average

Interpretation

This statement is characterised by a high uncertainty and several experts skipped it altogether. Respondents indicated low or even very low expertise. One respondent clearly states the reasons for the uncertainty: "lack of clear, unbiased information" with transparent ethical considerations. Other comments put forward the commercial promise of deep-sea mining and the rush for batteries as a major driver. Also, assessments of timing vary from 10 to 20 years and longer it is notable that all respondents expect this to happen at some point in time - none opted for "never". To sum up results seem to indicate that due to high environmental risks deep-sea mining is restricted by ethical and legal boundaries. Research must therefore be carefully designed to respect these boundaries.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

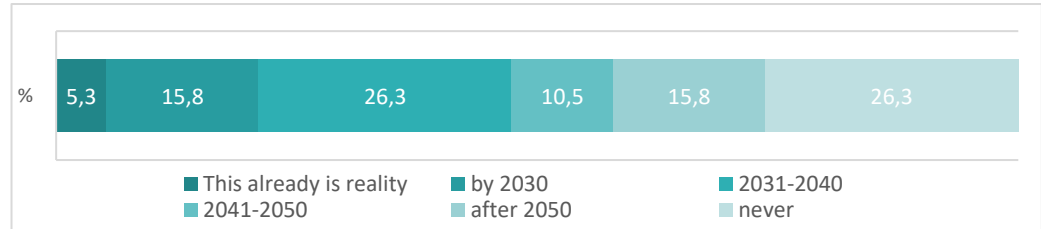
Normative Orientation	Assessment
Agreed	
Contested	X

Statement 4.6: Europe is at the cutting edge of quantum capabilities.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	1	5,3
Average expertise	10	52,6
Low expertise	5	26,3
Very low expertise	3	15,8
Σ	19	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	EU should invest in this strategic area of Frontier science and to accelerate breakthrough science & innovation. High benefits and growth are expected. However the digital society perspective will face a deep technological and expensive change.	Average
2031-2040	It will depend on the deployment of this technology into concrete products, processes and systems; but there is the capability in EU to do this, if properly supported.	Average
2041-2050	What are quantum capabilities? Again the question seems rather open. I guess you mean quantum computing. Yet, could be quantum physics.	Very low
2041-2050	Quantum Technologies EU Flagship initiative and Digital Europe funding may speed up scientific developments in the area and the uptake of quantum tech by industry. However, the scale of China's and US investments in the area may result in the European players only trying to catch up with the developments made elsewhere.	Average
after 2050	As a follower, more than 10 years behind leaders.	Average
Never	there are many capabilities, not only computing, there will be many very good players in the world	Average

	and not necessarily Europe leading in this field	
Never	I am very pessimistic unless Europe decides to make a tremendous effort. Actually I see the rival in the private sector through the big technological platforms	High

Interpretation

This is one of the statements with the largest share of “never” assessments. Comments give some indications for the reasons. Respondents (including one with high expertise) see other actors, in particular from the private sector, far ahead and therefore do not believe that the EU will be able to catch-up. One comments stresses that the distribution of capabilities is not necessarily a bad thing. Optimistic commentators expect catch up rather than leadership. At the same time, roughly half of respondents sees this happening even before 2040.

Even though some respondents are rather pessimistic about the EUs prospects for cutting-edge quantum capabilities, comments indicate that most consider investment in this area as useful. They highlight however that attention needs to be paid not only to the science side but also to adoption in industry and society and its implications.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

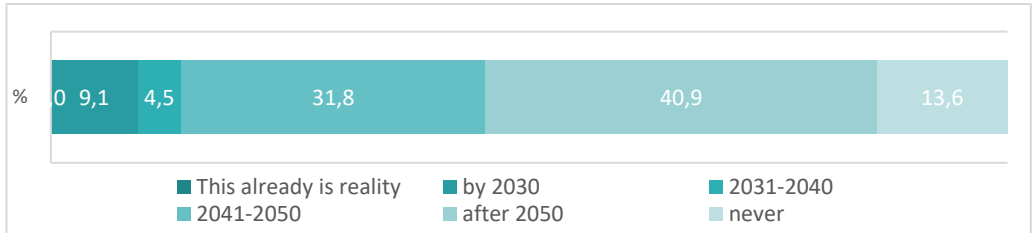
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 4.7: After successful decarbonisation of the European energy system, energy in Europe is abundant and supply is stable.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	5	22,7
Average expertise	13	59,1
Low expertise	4	18,2
Very low expertise	0	0,0
Σ	22	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	This is possible and require the design and implementation of EU policies based on EU Governments' Agreements and Common Initiatives supported by EIB, as in the history of European Countries during the 50's of the XIX century.	Average
2041-2050	If Member States collaborate well on the aspect of energy, it is possible to obtain sufficient energy in EU and a stable supply.	Average
2041-2050	I still hope that renewables and fusion are European ways towards stable energy.	Average
after 2050	Russian attack on Ukraine and its consequences has certainly contributed to prioritising diversification of energy supply across Europe. However, due to differing advancement of EU members' energy transformation process it will take time. Future global conflicts and particular interests of some EU Member States may also impede the fulfilment of the EU decarbonisation strategy by 2050.	High
after 2050	I see stability a plausible possibility. Not Full decarbonisation. So the statement depends on what we understand by successful decarbonisation	Average

Never	Energy will not be abundant. If it is available in a stable manner, this would be great already.	Average
Never	successful carbonisation is the problem, therefore never	High

Interpretation

This statement has received rather sceptical assessments from half of the respondents. Three respondents think that carbon free energy will never be abundant in Europe. After decarbonisation, experts expect that even stable supply will be a challenge and much more abundance. The decarbonisation itself however is seen as the biggest challenge. Most experts think that if it will happen at all, it will take a long time. A slightly smaller group of respondents is more optimistic. They stress the potential of cooperation among Member States and investment initiatives such as the EIB agreement to drive this forward. In any case, this is clearly seen as a policy challenge, demand for R&I is not explicitly mentioned in the comments.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

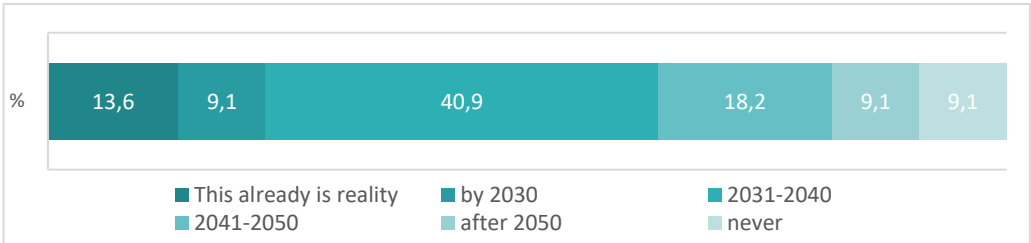
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 4.8: Europe has become a technology and industrial leader of the green and digital twin-transition.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	6	27,3
Average expertise	14	63,6
Low expertise	2	9,1
Very low expertise	0	0,0
Σ	22	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	Important investments in R&T&I made in the last 15 years (2 cycles of Framework Programme), enabled the green industry to develop a sustainable market. This EU green and digital Leadership needs R&T&I funding to improve technologies and to improve High Quality, which is the European Union High Value.	Average
2031-2040	We are not there yet. But Europe's trajectory makes me think that we are not far from it	Average
2031-2040	EU strategic orientation goes in the right direction to achieve the goals by 2040. But EU is not Europe....	High
2031-2040	Again to open as a statement.	Average
2031-2040	It also could be never, really depends on a new understanding and acting upon green industrial policy within EU and its MS, requiring a fundamental change in belief systems (e.g. active role of state, end to technology openness narrative, fundamental tax and policy reforms)	Average
2041-2050	It will be possible in certain niches of the green and digital twin-transition	Average

Never	green maybe, but that also takes longer than expected, digital: never And what does leader mean?	Average
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Interpretation:

For this statement, the number of respondents who see this becoming reality before 2050 is a clear majority. The largest share of respondents expects it to happen between 2031 and 2040, three people see this already being the case. This assessment is also confirmed by several comments. Respondents especially stress the EU’s strategic orientation pointing in this direction, presumably including the Framework Programmes. One sceptical argument is the lack of EU digital leadership. This fits with another respondent’s expectation that leadership will be confined to niches. Another expert sees current in belief systems and narratives such as “technology openness” as a major barrier. One respondent stresses that the statement is very open and another one points to the unclear meaning of leadership.

To sum up, results seem to indicate that twin transition leadership is achievable within the next twenty years as a minimum in some niches. This requires however not only further RTI investment but mostly a sustained strategic focus which includes a possible rethinking of the meaning of leadership and current belief systems.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

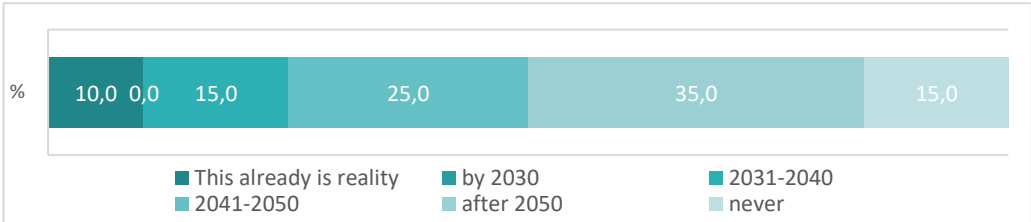
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 4.9: Biological modes of production have become more important than digital ones.

Respondents

Expertise	n	%
Very high expertise	1	5,0
High expertise	1	5,0
Average expertise	8	40,0
Low expertise	7	35,0
Very low expertise	3	15,0
Σ	20	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	The statement is nonsense. Is agriculture a biological mode of production? By now I question, who has put this study together. There are far too many ambiguities in the terminology, so it cannot be answered in a clear manner. Depending on the number of responses, it would be interesting to see, how certain statistical test work out.	Very high
This already is reality	This production area is currently very important. Said that, it is important EU to develop the awareness that key factors are fundamental and have to be assessed during the full cycle productivity. Knowledge based approach with related models, technologies, practices need to be funded. Digital tools should be integrated as soon as possible and from scratch. Among the common Key factors: energy input, temperature, carbon dioxide levels, nutrient availability, role of communities,... but a Framework Conditions requires other key factors emerging.	Low
2041-2050	Sustainable fabrics, sustainable ways of production are becoming more and more widespread. Textile industry is definitely a frontrunner. Once transportation modes, and whole value chains are optimized this might be a change maker example to follow.	Average

2041-2050	Due to devastating impact of climate crisis and ecosystem/biodiversity collapse; but digital will remain nearly equally important.	Average
2041-2050	food systems and industry can both use biological production - they really produce a physical good digital does not really produce in this sense and needs also biological resources for physical goods.	Average
Never	I believe this will not happen. Both will run in parallel	Low
Never	I expect that they will rise in importance but never dominate	Average

Interpretation:

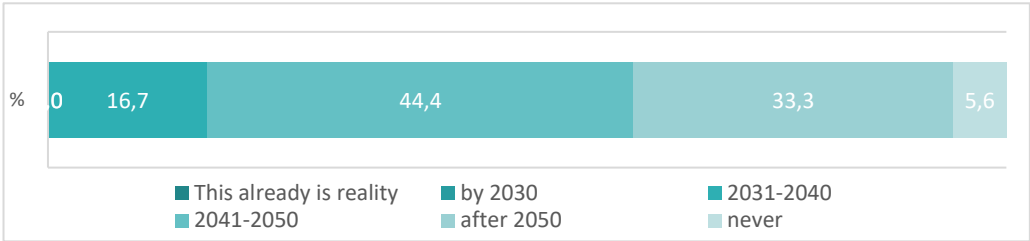
This statement was heavily criticised due to the ambiguity of the term “biological modes of production”. Also, comments indicate that interpretations were highly diverse. Still what seems to be emerging is that biological modes will rise in importance and run in parallel to digital modes. But, whether they will surpass digital modes is highly uncertain and if there is such a point it will come around 2050.

Statement 4.10: The majority of ICT based products involve quantum technologies (second generation).

Respondents

Expertise	N	%
Very high expertise	0	0,0
High expertise	1	5,6
Average expertise	9	50,0
Low expertise	4	22,2
Very low expertise	4	22,2
Σ	18	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	This is expected, big niche markets may start	Very low
2041-2050	Currently, there is no infrastructure to enable widespread interaction with quantum computers through information and communication technologies, as there is with digital computers. Without an established ICT structure, quantum computing cannot be extended to the devices, networking, and components that are commonplace in today's digital world.	Average
2041-2050	European efforts are oriented in that direction. I am a believer of both technologies.	High
2041-2050	Why would this be relevant? There is no clear evidence of a consequence you point to. Honestly, who constructed this survey. We employed the Delphi-method multiple time (and published it in very high ranking journals in our field). I see to many flaws in the setup of the questionnaire.	Average
after 2050	that takes time	Average
after 2050	The adoption of technologies takes time	Average

Interpretation

Most respondents expect this to be a mid to long term development that will occur from 2040 on or even after 2050. One respondent remarks that big niche markets may well start already from 2031.

Comments stress that the adoption of these technologies takes time especially given that new infrastructure are needed to interact with quantum technologies. Most comments given give no indication whether this is perceived as a goal or a threat.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

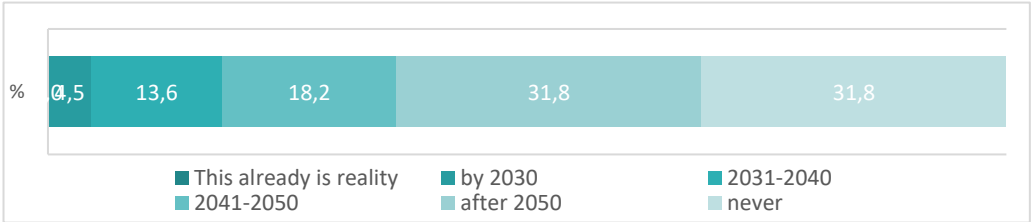
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 4.11: EU`s industrial base has diversified its supply chains so widely that it has no critical material and technology dependencies anymore.

Respondents

Expertise	n	%
Very high expertise	1	4,5
High expertise	6	27,3
Average expertise	12	54,5
Low expertise	3	13,6
Very low expertise	0	0,0
Σ	22	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	The scenario of EU industries will be divided into those survivors and big innovators and their capacities to develop value chains with related markets based on SMEs. The EU industrial history and behaviour has a great capacity to build effective community efforts around a high-level objective such as get rid of dependences and to co-design with EU Commission the R&T&I investments for value-creation.	Average
2031-2040	It is already happening but it takes time	High
2041-2050	Rather a question of good hope... concrete policies still largely insufficient or missing	Average
2041-2050	This is more hope than founded expectation. Current plans and leadership make it difficult to extrapolate. Yet the high priority of this matter makes it will happen yes or yes (or there will be no Europe)	Average
2041-2050	Maybe never, as there is always something critical or missing, but we can be creative	Average
Never	I believe strategic autonomy will be reached.	High

	However, it does not mean that we will not have technological dependencies. In reality I believe that technological independence will not happen in Europe, nor anywhere else (including china and the USA).	
Never	We do not have all global resources in Europe. Do you want to eat Sauerkraut all winter? No Smartphones and no Lithium batteries?	Very high
Never	Several critical raw materials are not available in Europe, so there will always be a dependency	High

Interpretation:

Respondents are largely sceptical of getting rid of all critical dependencies. In line with this, a large majority expects this never or after 2050. Three respondents with very/high expertise give good reasons for their “never” assessment by stating that no country and especially not European ones with their lack of many resources will be able to become fully independent as important products depend on imports. At the same time, there are well founded arguments that strategic autonomy will be reached in the sense that critical dependencies on single actors can be avoided. Some respondents are confident that this can be achieved within the next twenty years. Enabling factors mentioned are leadership and policies but also the collaborative capacity and creativity of European innovators in particular SMEs.

Finally, it seems that in spite of the negation of full autonomy the issue of risk diversification is seen as highly critical up to the point that without it “there will [be] no Europe”. Still, some respondents emphasise that this is “more hope than founded expectation”.

To sum up, there seems agreement that strategic autonomy is a goal worthy to pursue but that will never be fully attained. It seems important to focus this debate on diversification rather than on full elimination of critical dependencies. Interpreted in this sense, it is clearly seen as a key issue requiring political attention and creativity from all actors including RTI ones.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

Normative Orientation	Assessment
Agreed	
Contested	X

Conclusions

This cluster entails some of the key goals of the European Green Deal and HE Strategic plan i.e. full decarbonisation circular economy and green-digital twin transition. These are important goals for respondents of this survey, but really challenging for the short and medium term future.

This is especially true for the circular economy. While for statement 4.1 nobody thought it fully impossible that "More than 80% of products in the market are made from recycled resources." the overwhelming majority judged that this would only happen after 2050. Another statement 4.3 that dives deeper in one aspect of circular economy namely the recycling of fibre reinforced polymer composites received only slightly more mid-term assessment and some respondents even think that it will never become reality.

The same holds, albeit to a slightly lesser extent, for the full decarbonisation of EU industry 4.2 and the decarbonisation of the European energy sector 4.7. Most people see this happening only after 2050 and some even do not believe in it at all. Only half of the respondents think that this can be achieved before 2050.

At the same time the assertion that Europe will take leadership in the twin green and digital transition 4.8 was assessed as a mid-term possibility by many. Slightly more contested is the EU's capacity to become the world's most secure and trusted data hub 4.4 many respondents see this as close to realisation while others don't believe in it at all.

In the area of quantum-computing the situation is slightly different. While most respondents believe that these technologies will be deployed widely in the mid to long term 4.10 EU's capacities to take leadership 4.6 is doubted by many. Across statements many respondents stressed the importance of political will, strategic focus, investment and leadership as well as attention to belief systems, mind-sets and cultural changes to bring these ambitious goals closer to realisation. Also in several cases infrastructure development was stressed.

The role of RTI and its funding was explicitly mentioned for the circular economy, industrial decarbonisation, data security, twin transition, quantum technologies and supply chains underpinning strategic autonomy. For two statements i.e. becoming a secure and trusted data hub 4.4 and responding to the rise in deep sea mining 4.5 the importance of ethical deliberation and transdisciplinary research with a strong RRI orientation were emphasised by some.

Finally, the one statement tackling strategic autonomy was at first sight the most contested in this cluster. A closer look however revealed that more autonomy and diversification are widely thought important and possible for Europe in contrast to complete independence which was clearly seen as unthinkable.

3.6. Results Cluster 5 Climate, Energy and Mobility

Overview

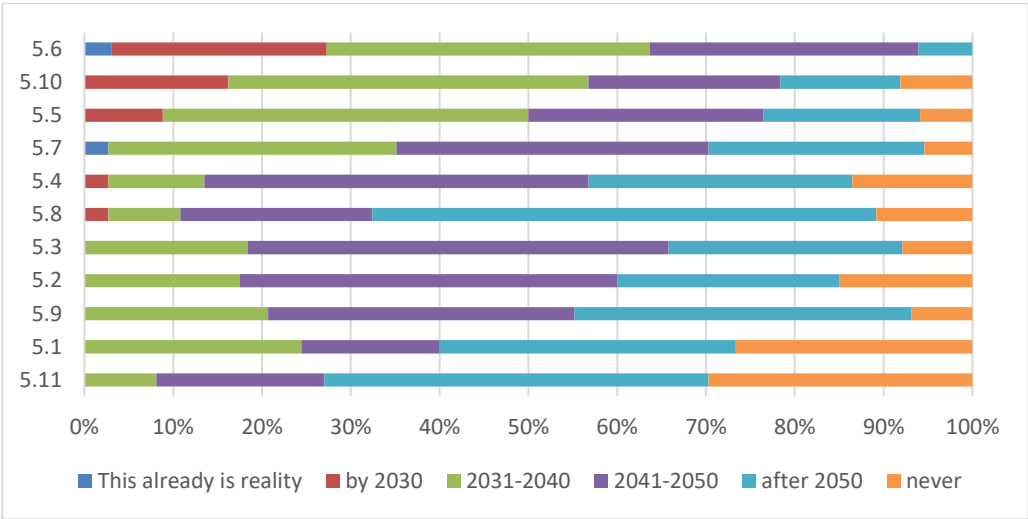


Figure 9: Assessment of time horizon for statements in cluster 5 (ordered by share of now - 2030)

Cluster 5: Climate, Energy, Mobility		Time ries				Catego- ries		Normative Orienta- tion	
Statements (*= Lessons further discussed in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested		
5.1*	"Final Energy consumption (i.e. the total energy consumed by end users, such as households, industry and agriculture) in Europe has fallen by 40% compared to 2022."			X		X			
5.2	"The steel industry in the EU has successfully transitioned to climate neutrality."		X			X			
5.3	"The chemical industry in the EU has successfully transitioned to climate neutrality."		X			X			
5.4*	"The cement industry in the EU has successfully transitioned to climate neutrality."		X				X		
5.5	"The paper industry in the EU has successfully transitioned to climate neutrality."		X			X			
5.6	"Battery development time is reduced by half compared to 2022."		X			X			

5.7	"CCAM (Cooperative, connected and automated mobility)-services operate without major failures across the EU."		X			X	
5.8*	"The global waterborne transport sector has eliminated all its greenhouse gas emissions."			X		X	
5.9	"More than 50% of maritime and inland waterways feeder services in the EU are fully automated."		X			X	
5.10*	"Biodiesel from algae is commercially viable."		X				X
5.11*	"Aviation has become climate neutral (without using carbon offsets for compensation)."			X		X	

Interpretation

The majority of respondents considered the 11 assumptions and expectations of the cluster 5 to materialise either between 2030 and 2050 (6, 10, 5, 7, 4, 3, 2, 9) or after 2050/never (8, 1, 11).

Only the batteries (6), algae-based biodiesel (10) and paper industry (5) assumptions and expectations were considered by several to materialise even before 2030. This long timeframe indicates the complexity of the energy transition being not only a techno-economic but also a social and political issue. The diversity of the three statements with the longest time Horizon (8, 1, 11) illustrates this complexity. For statement 1 the issue is the increasing demand for energy, statement 8 points to a lack of political pressure for decarbonisation and 11 is technically very challenging. In both 8 and 11 the industries have very long investment cycles.

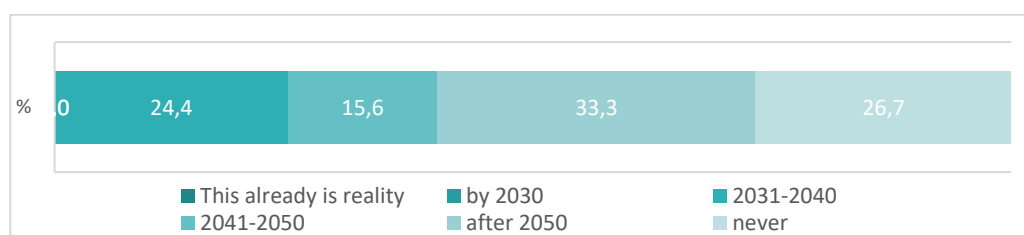
Individual Statements

Statement 5.1: Final Energy consumption (i.e. the total energy consumed by end users, such as households, industry and agriculture) in Europe has fallen by 40% compared to 2022.

Respondents

Expertise	N	%
Very high expertise	3	6,7
High expertise	9	20,0
Average expertise	25	55,6
Low expertise	6	13,3
Very low expertise	2	4,4
Σ	45	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	Total energy consumption by households will be influenced by the pace of digitalization in the consumption of goods and services and by behavioural change. Reaping the benefits from all these requires significant capital investment: digital appliances, smart homes, and saving practices. Assuming that recovery packages actually manage to invest in the relevant infrastructure, and are accompanied by the proper policies and education programs, including in primary schools and above, these changes may happen over a period of 10-15 years.	Average
2031-2040	I am not sure about the timing. But it will happen sooner rather than later.	Average
2031-2040	This is a reasonable time to build infrastructure, technology and public understanding that energy saving is important	Average
2031-2040	There will be lack of energy of different types in various countries, therefore not just proclamations, but real savings will have to be realised.	High
2031-2040	Global Change is crucial ecologically - societal today	High
2031-2040	Either never, or faster, largely dependent on continuing responses to war in Ukraine and resulting energy efficiency / sufficiency policies and their take up.	Average

2031-2040	Several EU countries have taken commitments to improve energy use. Effort to decarbonized energy and transport are currently in place.	Average
2031-2040	The energy crisis caused by the invasion into Ukraine will have delayed the energy transition severely	Low e
2041-2050	I do not see the political or industrial leadership, or societal resolve and understanding to step up to the plate knowledgeably and purposefully to deliver on this. All will build however I fear it will require many downside events to force real systemic change.	High
2041-2050	The implementation of the EU climate neutrality target will require important final energy reductions to be achieved through energy efficiency improvements and sufficiency measures.	Average
2041-2050	So far substantial energy reductions haven't materialised despite general intentions and strategies. It will require bold policy measures which may be driven by the current energy crisis, nevertheless, transition of industries or mobility sector will require time to show results	High
2041-2050	Energy efficiency in buildings or industry can allow that but it takes time.	Average
after 2050	Countries are not making fast progress in developing feasible strategies to help households move to greener energy options and the war in Ukraine is an example of how unforeseen geopolitical events can derail even where strategies have been developed.	High
after 2050	Not for the foreseeable or model-able future, but never isn't really appropriate as an answer to this question.	High
after 2050	In 15 years (2006-2020) energy use per person in the EU (27) dropped by 20%. A 40% drop compared to the 2022 level will be feasible by full conversion to electricity in heating (heat pumps) and mobility (electric vehicles and e-micro-mobility).	Average
after 2050	Change is too slow, technofix dominant, not delivering.	High
after 2050	The question is not just about carbon-free energy, but about a real reduction in consumption. So far all improvements in energy efficiency have been eaten up by increases in demand. Thus a very fundamental behavioural change or outstanding innovation would be required to accomplish such a strong reduction. This will take a long time.	Average
after 2050	People are unwilling to be less comfortable to help the environment. For example, hotter summers will require more air conditioning in more places, and until such time as low energy technology is provided at low cost to households to combat heat, this means more energy for longer periods in more places.	Low
after 2050	For the sector of transport, I don't have the impression there is a sufficient fast transition happening. We are getting cleaner, but are not looking at 'avoid' strategies.	Average
after 2050	International companies who make products are going to resist such change to lower consumption by that much	Very high
after 2050	Inertia of total energy consumption is large, and it will	Average

	mainly decline as a result of population decrease	
after 2050	Policy and practice is not ambitious enough.	Low
after 2050	There are plans to decarbonise, there are plans to increase efficiency, but consumption of energy consuming goods is growing, floor space is growing, person and ton kilometres are growing. Due to efficiency there might be a decrease, but only very slowly. Sufficiency strategies would need to be employed to change this, they are almost non-existent.	Very high
after 2050	Unless climate action steps up, we may be seeing bold reductions until mid-2030s, before stabilisation and rebounds.	Average
after 2050	the costs and scarcity of energy will motivate parts of EU nations to reduce energy and implement fossil free energy but other members will seek privileges at the world market	Average
Never	Unless Europe becomes uninhabitable, I don't think this will happen.	Average
Never	Cannot energy efficiency cutting that deeply	Very high
Never	Energy is key to almost all activities	Average
Never	Final energy consumption will rise.	High
Never	This is a guess based on the difficulties of reducing energy consumption and an increasing global demand	Very low
Never	Unless we reduce the European population. I think it is more important to think about what new and cheaper ways of generating energy we can develop.	Average

Interpretation

The clear majority considers that final energy consumption in Europe will not fall by 40% compared to 2022, or if it did it would have to be after 2050. Respondents tend to note that technological solutions are not enough for curbing energy demand and there are no major signs of needed behavioural changes and international companies may try to block such developments.

Technological opportunities to curb energy demand mentioned include, for instance digitalization in the consumption of goods and services and the conversion to electricity in heating (heat pumps) and mobility (electric vehicles and e-micro-mobility). Some respondents perceive also a need to connect better policy and practice.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

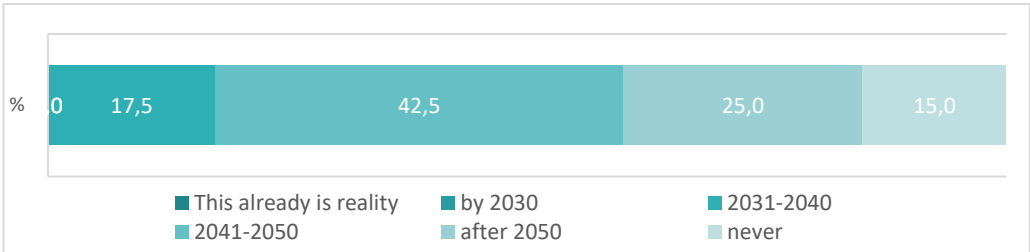
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 5.2: The steel industry in the EU has successfully transitioned to climate neutrality.

Respondents

Expertise	n	%
Very high expertise	2	5,0
High expertise	3	7,5
Average expertise	19	47,5
Low expertise	11	27,5
Very low expertise	5	12,5
Σ	40	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	Same as before. It will happen soon	Average
2031-2040	Global Change is the crucial ecological and societal phenomenon of current world	High
2031-2040	Part of the EU steel industry has already taken high efforts to reduce energy demand. The current energy crisis calls for higher speed for such transitions, enhancing use of renewables and reducing energy demand further.	Low
2031-2040	Needs Green H2 to achieve this	Very high
2041-2050	climate neutrality in the steel sector (excluding the mining of the primary material, i.e. focusing only on the processing) will require electrification and potentially other new technological solutions, such as hydrogen. The first is potentially possible now, as few technologies for electric steel productions exist and are used in some metal producing firms, but they are not widespread. improving this will require significant capital investment. The latter, to the best of my knowledge, are not proven on the market and/or are very far from being cost-competitive. Steel is a very hard sector to	Average

	decarbonize, and I think that change in this sector will require a long time.	
2041-2050	With the lack of energy, part of the steel industry will move outside of EU.	Average
2041-2050	The EU is very slow in deciding reforms and transition pathways due to its structure as such. National governments again are slow in implementing climate neutral measures.	Average
2041-2050	Hydrogen can be the most effective mitigation option for the Steel sector, but carbon free hydrogen production will take time due to storage cost in the power sector	Average
2041-2050	I think that technologies are available/under development to enable this to happen, though it depends on governments providing clarity on how this will be assessed and disincentives to staying with the status quo	Low
2041-2050	Steel production is energy intensive, but here the question is about climate neutrality. With considerable political efforts this might be possible before 2050.	Average
2041-2050	Alternative energy forms to fossil fuel carriers like hydrogen will be used, implementation will need some time.	Average
2041-2050	It is an ambition but a difficult one	Average
after 2050	I guess it is very difficult	Low
after 2050	The steel sector is hard to abate, and depending on the definition of climate neutrality this might also never be achieved.	Average
after 2050	Currently, the steel industry is among the three biggest producers of carbon dioxide. Every ton of steel produced in 2018 emitted on average 1.85 tons of carbon dioxide, making the steel industry a big producer of global carbon dioxide emissions. Full decarbonisation strategies are feasible, using green hydrogen-based steel production, but at a very high cost. Check https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel	Average
after 2050	Lack of political will and a focus on growth will prevent climate neutrality in most industries.	Very low
after 2050	Lack of ambition and technology.	Very low
after 2050	If policies eventually match EU's pledges, we might be seeing close-to-neutrality towards 2050, provided hydrogen plays a vital role and is proactively supported early this decade to complement RES/electrification, but even so process-related emissions may prove harder to abate before mid-century.	Average
Never	I expect that low-carbon technologies will be used in upcoming decades, but the zero-carbon technologies (hydrogen based DRI) are very expensive and won't be competitive for this globally traded commodity. Instead the low-emission manufactur-	High

	ing technologies will be EAF with scrap and blast furnace with CCS.	
Never	climate neutrality for steel is very difficult, using less steel is more realistic	Average
Never	Very subjective in terms of what the steel industry believes climate neutrality to be	Very high
Never	International competition will create a niche market for sustainable steel but not the bulk product. Europe will maintain self-supply capacity also for bulk steel	Average
Never	Difficulties in accommodating steel production with reduced energy use	Very low

Interpretation

The clear majority of respondents consider the steel industry in the EU to successfully transition to climate neutrality between 2030 and 2050, and none before that. Respondents considering this will never happen refer especially to the cost of abatement technologies and lack of economic incentives. This will require electrification and potentially other new technological solutions, such as using (costly) green hydrogen-based steel production or electric arc furnace (EAF) with scrap and blast furnace with CCS. Some respondents perceive reducing the use of steel more effective than costly low emission steel production. The policies and strategies are called for to be more ambitious and implemented faster.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

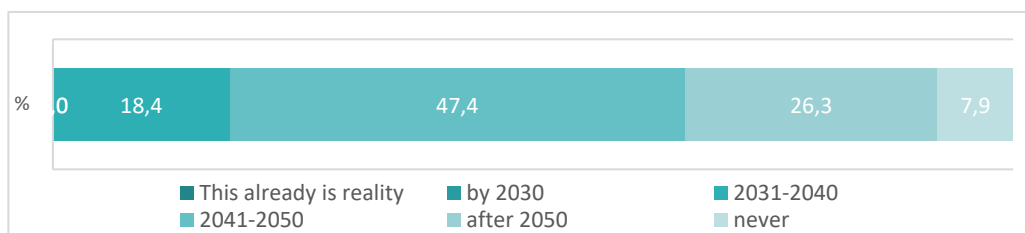
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 5.3: The chemical industry in the EU has successfully transitioned to climate neutrality.

Respondents

Expertise	n	%
Very high expertise	2	5,3
High expertise	0	0,0
Average expertise	16	42,1
Low expertise	14	36,8
Very low expertise	6	15,8
Σ	38	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	Again this will happen soon	Low
2031-2040	High priority for GC mitigation	Average
2031-2040	It is achievable by then	Average
2041-2050	Petrochemicals are a very tough nut to crack	Very high
2041-2050	The chemical industry is very large as for different products, therefore recycling is complicated and often plastics recycled are used for energy production.	Average
2041-2050	If pressures from policymakers and decision makers fails to have effect on chemical industries and if the agricultural sector and industry does not embark soon on regenerative and sustainable development, the chemical industry will have failed to transition in time!	Low
2041-2050	Technologies are known though scaling up of the production of sustainable chemicals will depend on clarity from governments on incentives and disincentives to give confidence for investment.	Average
2041-2050	Very uncertain issue. Depends as well on (energy demanding) carbon capture technologies. Export orientation and the wish to compete on international markets will play a role.	Average
2041-2050	There are good opportunities to reduce emissions in the chemical industry, including the creation of long-	Average

	lasting, carbon-storing substances.	
2041-2050	54% decrease in EU27 GHG emissions between 1990 and 2019, while at the same time, production in the EU27 chemical industry expanded by 47%. If this trend continues the chemical industry will be carbon neutral by 2040.	Average
2041-2050	easier to achieve	Average
2041-2050	Process technology is better suited than steel production to make this transition	Low
after 2050	The chemical industry uses large amounts of fossil fuels, but its CO2 emissions are less than that of other sectors such as steel. This is because some of the emissions from chemicals are produced (attributed to) the downstream sector that uses them. First, I believe the statement about carbon neutrality applies not only to the sector per se, but also to the chemicals (i.e. that they do not release GHG downstream). I believe this is very hard to achieve, but to be honest I know too little about the chemical sector to be sure.	Very low
after 2050	As chemical products are very diverse, I think that a complete decarbonisation of the chemical industry will be really difficult	Low
after 2050	Very difficult - too much energy needed	Low
after 2050	As with my last answer, political will and a focus on capitalist economics prevents climate neutral solutions.	Very low
after 2050	Lack of ambition and leadership.	Very low
Never	To me climate neutrality implies zero net GHG emissions. I don't expect this to occur in this industry, which instead will aim for approximately 80-90% reductions in emissions.	Average
Never	Again very difficult to see it happening given their understanding of what the definition of climate neutrality is. Currently the chemical industry is very resistant to change.	Very high
Never	same as before	Very low

Interpretation

The clear majority of respondents consider the chemical industry in the EU to successfully transition to climate neutrality between 2030 and 2050, none before that. In line with the numeric responses, several comments note the chemical industry being closer than the steel industry to the carbon neutrality. Those who consider carbon neutral chemical industry to never happen refer also to the impact of the use of products in the downstream. Recycling is complicated and often plastics recycled are used for energy production with major emissions. Scaling up of the carbon-neutral production of sustainable chemicals will depend on clarity from governments to incentivise investments.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

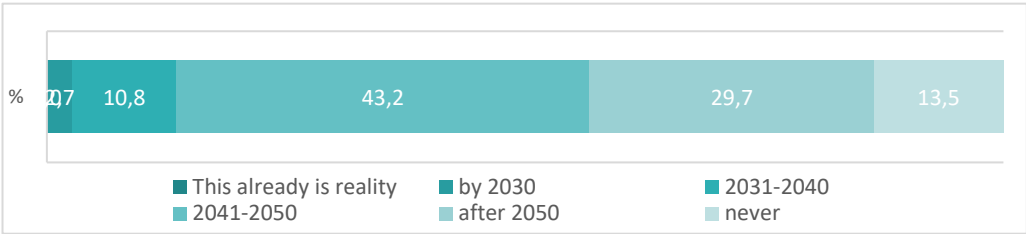
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 5.4: The cement industry in the EU has successfully transitioned to climate neutrality.

Respondents

Expertise	n	%
Very high expertise	1	2,8
High expertise	1	2,8
Average expertise	17	47,2
Low expertise	10	27,8
Very low expertise	7	19,4
Σ	36	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	They use recycled plastics for energy production in their premises, thus helping to get rid of waste and save energy at the same time.	Average
2031-2040	big importance	Average
2031-2040	Options for this sector are well advanced	Average
2041-2050	It will take longer than expected	Low
2041-2050	This has to happen but I am not sure we know yet how to do this	Average
2041-2050	The building sector needs to be transformed quickly and sustainably and this can only happen by top down policy regulations and strict controls on national level. Circular economy needs to be implemented in this field and fostered by governments.	Low
2041-2050	As for the last two answers technologies exist but achievement depends on governments and industry engaging and governments providing incentives and disincentives.	Low
2041-2050	While challenges remain for cement to become decarbonised, process innovation and CCS can result in the	Average

	cement industry even becoming a net sink.	
2041-2050	There are some promising technologies and approaches (including recycling of materials) that can be applied to the cement sector and that can help bring it closer to climate neutrality. However, more innovations are needed. An important point there is if the regulation regarding the percentage of recycling allowed per kg of cement will support the use of recycled inputs: as I understand it, there is a limit to the ability of mixing recycled inputs into cement (for very good reasons indeed, of course). However, the technologies have evolved over time and regulation should keep this in mind.	Average
2041-2050	Several mitigations options could help Cement industry to decarbonise, such as CCS, but, perhaps substitute to cement will be the best option.	Low
after 2050	NB I consider offsets not a particularly valid step - it feels like passing the buck	Average
after 2050	More complicated. As long as annual concrete demand stays as high as it is, it is difficult and associated with many other environmental problems (biodiversity losses).	Average e
after 2050	the European Cement Association, published in 2020 its new Carbon Neutrality Roadmap, setting out its ambition to reach net zero emissions along the cement and concrete value chain by 2050.	Average
after 2050	High energy consuming sector	Low
after 2050	As with my last answer, political will and a focus on capitalist economics prevents climate neutral solutions.	Very low
after 2050	Lack of ambition and leadership.	Very low
Never	climate neutrality for cement is not possible, lower consumption is possible	High
Never	It will only factor out CO2 emissions by compensation elsewhere, and the market for viable compensation programs is way too competitive to give cement production a priority share	Low
Never	Again very difficult to see it happening given their understanding of what the definition of climate neutrality is. Currently the chemical industry is very resistant to change.	Very high
Never	same as before	Very low

Interpretation:

The slight majority of respondents consider the cement industry in the EU to successfully transition to climate neutrality between 2030 and 2050, and only one before 2030. Several mitigation options help the cement industry to decarbonise, such as CCS and reusing materials in cement production. Some suggest that substituting cement could be a better option. Low-carbon cement technologies are considered to have evolved over time and regulation may need to be updated to support diffusion of such options.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

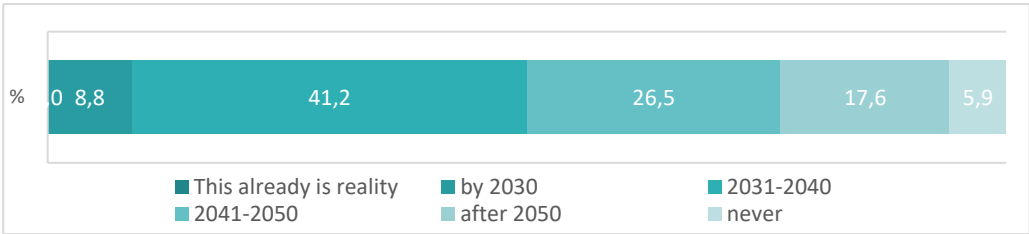
Normative Orientation	Assessment
Agreed	
Contested	X

Statement 5.5: The paper industry in the EU has successfully transitioned to climate neutrality.

Respondents

Expertise	n	%
Very high expertise	2	5,9
High expertise	1	2,9
Average expertise	13	38,2
Low expertise	12	35,3
Very low expertise	6	17,6
Σ	34	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	Sustainable feedstock and the use of waste heat can decarbonize this sector rapidly.	Average
2031-2040	no professional knowledge	Low
2031-2040	Options for this are well advancing	Average
2031-2040	This industry is already part of the way there. The non-integrated mills are the challenge and probably need green H2 for their steam raising	Very high
2031-2040	In my view circular economy has already a standing here and consumers have already had the time to change their behaviour by buying recycled paper and wood from sustainable sources.	Low
2031-2040	i know little about the paper industry to be honest, but my assumption is that it would be easier for it to transition towards climate neutrality if the paper was not bleached and if more circular approaches were chosen. On this, I could be completely off, however. Sorry	Very low
2031-2040	Use of biomass energy as well as recycling are feasible and reachable medium-term mitigation options	Low
2031-2040	The paper, pulp and print sector is one of the lowest industrial emitters of greenhouse gases, accounting for 0.8% of European emissions. It is probable to become carbon neutral the coming	Average

	decade	
2031-2040	probably using biofuels for it, so can be questioned	High
2031-2040	This is well achievable by renewable energy	Average
2041-2050	This is an easier task. Paper industry will need to compete with plastic industry, therefor they will be faster than others. A complete transition will need time. It needs to be questioned if current size of paper industry is in any ways sustainable.	Average
2041-2050	I don't know very well this sector	Low
2041-2050	The whole lifecycle of products must be taken into consideration, lot of paper is wasted for advertising, when only part of the printed material is recycled, a lot is simply thrown away causing the need of extra cleaning of cities and villages.	Average
2041-2050	Easier (though not cheap) to decarbonise, technologies already exist so it is not necessarily a matter of innovation or tech miracles.	Low
after 2050	As with my last answer, political will and a focus on capitalist economics prevents climate neutral solutions.	Very low
after 2050	Lack of ambition and leadership.	Very low
Never	gain very difficult to see it happening given their understanding of what the definition of climate neutrality is. Currently the chemical industry is very resistant to change.	Very high

Interpretation

The clear majority of the respondents consider the paper industry in the EU to be successfully transitioned to climate neutrality somewhere between 2030 and 2050. This is perceived easier than in chemical, cement and steel industries. The non-integrated mills are the challenge and probably need green H₂ for their steam raising. Sustainable feedstock and the use of waste heat can decarbonize this sector rapidly. The whole lifecycle of products must be taken into consideration.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

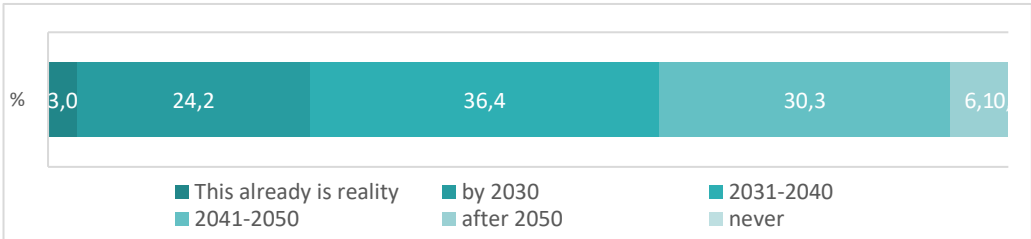
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 5.6: Battery development time is reduced by half compared to 2022.

Respondents

Expertise	n	%
Very high expertise	1	3,0
High expertise	2	6,1
Average expertise	19	57,6
Low expertise	9	27,3
Very low expertise	2	6,1
Σ	33	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	Battery industry is currently making fast progress in EU and the demand push from electric vehicles can accelerate it.	High
by 2030	A highly dynamic and still accelerating sector	Average
2031-2040	no professional knowledge	Low
2031-2040	There is rapid progress in this area	Average
2031-2040	There is a lot of investment in the sector. I am optimistic it will happen relatively soon	Average
2031-2040	battery technologies FOR VEHICLES have seen drastic reductions in cost over time, due to both innovation and to learning by doing effects. I assume the statement to be about these batteries, as opposed to large scale batteries, where more innovation is needed. For car batteries, I believe more learning-by-doing effect are in store, provided we can overcome the issue of rare metals (also linked with human rights issues in places like Africa). If this is the case, we could witness some fast developments.	High
2031-2040	Intense activity and pressure will stimulate innovation, and we see many innovative technologies	Average

	being explored	
2031-2040	Hopefully	Low
2031-2040	Batteries of various types are needed both for electric vehicles and for energy storing, therefore the concentrated efforts can bring reduction of time necessary.	Average
2041-2050	Not sure if the development time is the most crucial aspect for future batteries - compared to ensuring that future batteries are based on sustainable materials and components and don't cause additional environmental and social problems. With planned European investments, battery development and test facilities and capacities will be enhanced. However, the development of new materials or components, replacement of non-sustainable elements, etc. is not really predictable.	Average
2041-2050	Electric cars and new technologies have developed slowly in producing innovative reusable batteries. Storage of renewable energies is not yet developed successfully.	Low
2041-2050	There is clearly a technological and economic revolution in this industry	Average
2041-2050	The statement is a bit unclear. What battery development time is meant here?	Average
2041-2050	Don't know this sector	Low
2041-2050	Better developments in battery technology compared to other sectors.	Low
2041-2050	Possible but depends on encouraging innovative technology and ensuring IP law is reduced so costs can be lowered to increase the likelihood of wide-scale commercial deployment	Very
2041-2050	Of course there will be more pressure to reduce battery development time. This will be a stimulus for the development of new battery technologies, but the selected option is an opinion based more on hope and optimism than on in-depth knowledge of the different battery types and their respective production technologies.	Average
after 2050	As with my last answer, political will and a focus on capitalist economics prevents climate neutral solutions.	Very

Interpretation

The majority of respondents consider battery development time to be reduced by half compared to 2022 somewhere between 2030 and 2050, and one fourth consider this to happen already before 2030. The production of batteries is perceived to depend on overcoming the need for rare metals (also linked with environmental and social problems like human rights violations). Battery technologies, especially for vehicles, are noted to have seen drastic reductions in cost over time, due to both innovation and to learning by doing effects, battery development and test facilities. Some respondents also observe that the develop-

ment time may not be the most crucial aspect for future batteries - compared to ensuring that future batteries are based on sustainable raw materials. One respondent highlights that the speed of battery development depends on encouraging innovative technology and on ensuring that IP laws are in place to lower cost and increase the likelihood of wide-scale commercial deployment.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

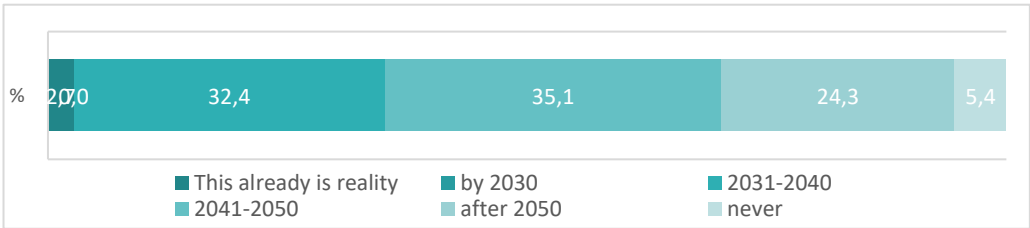
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 5.7: CCAM (Cooperative, connected and automated mobility)-services operate without major failures across the EU.

Respondents

Expertise	n	%
Very high expertise	1	2,7
High expertise	5	13,5
Average expertise	17	45,9
Low expertise	10	27,0
Very low expertise	4	10,8
Σ	37	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	all depends on the kind of CCAM systems you envisage.	High
2031-2040	especially young generation is involved	Low
2031-2040	We will have to do it. But we are not there yet	Average
2031-2040	across the EU...assuming 'across' does not mean everywhere. This is achievable in 80% of places in EU.	Average
2031-2040	Mobility as a Service is already a reality in many cities. Platforms for MaaS are available and every city can start implementing MaaS. Technologies for automated mobility are mostly available. The question for CCAM is mainly about investments than technology.	Average
2041-2050	If lucky - this is challenging as you impact on individuals' choices	Average
2041-2050	Unfortunately the energy crisis and the climate crisis will have backfalls in implementing automated mobility solutions in cities.	Low
2041-2050	Need to develop infrastructure	Low

2041-2050	not sure if 'without major failures' ...	Average
2041-2050	There exists several level of connected and automated vehicles, but I think last level (level 5 - Full automation) will not be reached before 2040.	High
after 2050	While I believe that Mobility as a service will see much improvement in the coming years, I am more sceptical about automated vehicles for both technical and social acceptance reasons. I think the technology is not there yet, I believe conditions in different EU countries are very heterogeneous, there is different potential for rural and urban areas, and legislative frameworks and regulation will have to be put in place.	Average
after 2050	I expect the developments in limited areas, e.g. for transport in factories, for transport from airports/warehouses/railway stations to city centres, with a route reserved to this type of transport.	Average
after 2050	Different technologies needed for CCAM are available, however, large scale implementation across Europe requires also regulatory and organisational innovation as well as societal acceptance. While CCAM may be realised earlier for freight and delivery, full scale implementation for private cars is more complex. In view of climate neutrality transitions it is also not a matter of just replacing current mobility (patterns) by electric or automated ones. New mobility models need to anticipate new mobility solutions which are not available today.	Average
after 2050	This is a tremendous task involving many actors, new business models etc. Therefore, it will take many years. The issue across the EU is in most of your statements the big challenge. Just consider newer and new accession.	Average
after 2050	It is possible that pragmatic models will be operative before. But the key question is the model and pragmatic models will need to evolve. It is more about reframing cities and ways of doing (e.g. 15 minute model city)	High
after 2050	No idea, very clustered and confusing statement. What about collective mobility or public transport per se? Why the focus on failures?	Very low
after 2050	The cost to implement the changes necessary across different types of infrastructure will be substantial, particularly in areas where infrastructure is under developed or in a state of heavy decay. This will require significant political will to implement.	Low
Never	Diversity across mobility needs and European infrastructure will be extremely difficult to overcome	Average

Interpretation

The majority of respondents consider that CCAM (Cooperative, connected and automated mobility)-services will operate without major failures across the EU somewhere between 2030-2050. Respondents have different opinions on the maturity of the technology but there is common perception that regulatory, business model, organisational and city-level changes are bigger barriers than the technology.

While CCAM may be realised earlier for freight and delivery, full scale implementation for private cars is more complex. The respondent with high level of expertise considers that the level 5 of full automation will not be reached before 2040. The conditions in different EU countries are very heterogeneous and there is different potential for rural and urban areas.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

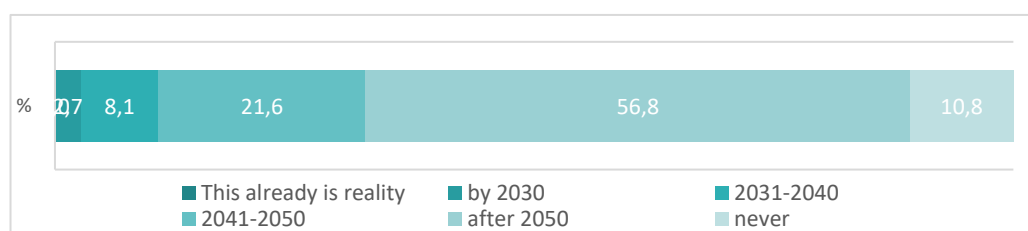
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 5.8: The global waterborne transport sector has eliminated all its greenhouse gas emissions.

Respondents

Expertise	n	%
Very high expertise	1	2,7
High expertise	3	8,1
Average expertise	21	56,8
Low expertise	7	18,9
Very low expertise	5	13,5
Σ	37	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	I believe we are not there yet	Low
2031-2040	Technology is quite ready	Average
2041-2050	only my personal feeling	Low
2041-2050	Hopefully hydrogen and its use through fuel cells has already been standardised, and perhaps for short journeys the energy stored in batteries will come from deep geothermal approaches such as the one being done by https://www.quaise.energy/ .	Average
after 2050	A large part can be eliminated by 2050 but not all	High
after 2050	The current prognosis for Europe's waterborne transport greenhouse gas (GHG) emissions is poor. Already representing around 13 % of overall transport emissions, waterborne transport emissions are expected to increase rapidly by 50 % to 250 % by 2050 if no steps are taken towards decarbonisation.	Average
after 2050	China etc. may be slow to convert and ship ownership/registration mitigates rapid change	Average
after 2050	This is only effective when targeted globally. I doubt that global collaboration will be at this point in the near future.	Low
after 2050	It seems challenging, as batteries are not relevant, biofuels production will be limited for sustainability reasons and e-fuels are expensive and their effectiveness for as a large mitigation option remain highly	Average

	uncertain	
after 2050	I am sceptical that the waterborne transportation will be able to cover long distance travel around the globe completely using renewable forces. Perhaps with hydrogen. in any case, I expect the change to take much time.	Low
after 2050	It is difficult to control this type of transport, there may be two types of fuels used, one official, one hidden.	Average
after 2050	Globally? Fossil energy needs to become a scarce and expansive fuel. This is unlikely, depends more on the geopolitical future and what business models countries like Russia will have in the next decades.	Average
after 2050	Lack of ambition and leadership.	Very low
after 2050	This requires significant investment in green technologies as well as financial assistance for companies to make the switch to these technologies.	Very low
after 2050	China and India will not make the required speed for this transition	Average
after 2050	Answer based on life cycle thinking aspects	High

Interpretation:

The majority of respondents consider the global waterborne transport sector to have eliminated all its greenhouse gas emissions only after 2050 or never. Some consider batteries are not relevant for long distance, biofuels production will be limited for sustainability reasons and electrofuels are expensive and their effectiveness for as a large mitigation option remain highly uncertain.

Others note hydrogen and its use through fuel cells as promising having already been standardised, and perhaps for short journeys the energy stored in batteries will work. One respondent considers that foreign fleets (e.g. Chinese) may be slow to convert and ship ownership/registration mitigates rapid change. Another respondent notes that the mitigation is only effective when targeted globally.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

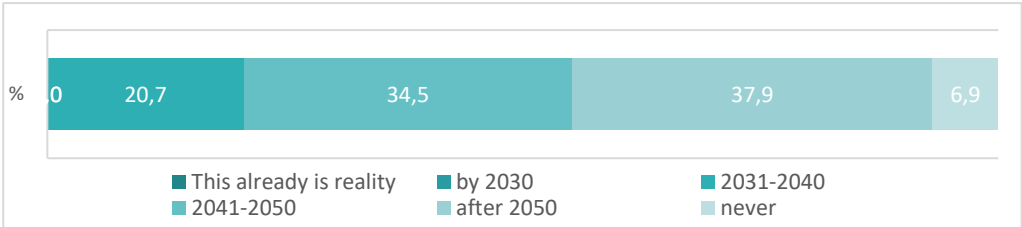
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 5.9: More than 50% of maritime and inland waterways feeder services in the EU are fully automated.

Respondents

Expertise	n	%
Very high expertise	1	3,4
High expertise	0	0,0
Average expertise	12	41,4
Low expertise	7	24,1
Very low expertise	9	31,0
Σ	29	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	Technology quite ready	Average
2031-2040	no deep knowledge	Low
2041-2050	Full automation is expensive	Very low
after 2050	There is need to follow the changes in water level, to wind speed etc., therefore it may be cheaper to use workforce. And people like to work on water.	Average
after 2050	This seems to be a more simple task, but waterways are heavily impacted by climate change, this my mitigate investments in this area.	Low
after 2050	Lack of ambition and leadership.	Very low
after 2050	Political will and a focus on capitalist economics prevents climate neutral solutions.	Very low
after 2050	I assume bulk transport ways in economic hotspots will enable this target, but smaller transportation channels will not be able to make this transition in time	Low
Never	This statement is hard for me to assess, and since there is not option to opt out, I have chosen never	Very low

Interpretation

The 56% of respondents consider that more than 50% of maritime and inland waterways feeder services in the EU are fully automated somewhere between 2030 and 2050, whereas 44% consider this will happen only after 2050 or never. Climate change may affect heavily on water ways making automation more difficult. The full automation is perceived tricky due to changing conditions like the wind and water levels, though the comments question more the actual need to automate completely, which is expensive.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

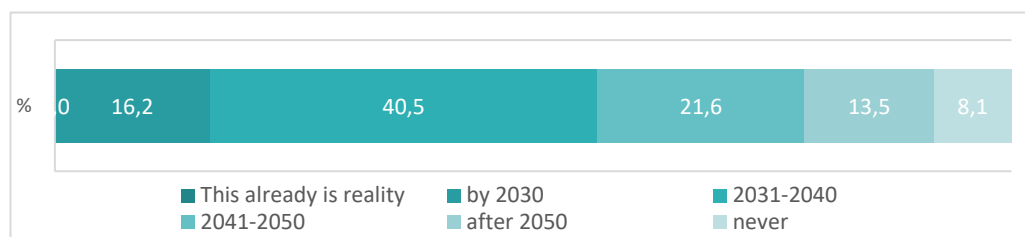
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 5.10: Biodiesel from algae is commercially viable.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	2	5,4
Average expertise	19	51,4
Low expertise	11	29,7
Very low expertise	5	13,5
Σ	37	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	big potential and lot of results from experiments	High
by 2030	but not in all European countries	Average
by 2030	Still will be a small part of the transition	Average
by 2030	Better development from this sector.	Low
by 2030	Biofuel from Algae is being experimented on since quite a while. I believe if the incentives are there, firms will increase their investments and reach a technology breakthrough	Low
2031-2040	we need real scale and it is unlikely to be located in EU. it needs to be in warmer climate	Average
2031-2040	Maybe in a decade or less, but we should ask ourselves whether diesel-based engines have a future for 20 years or more?	Average
2031-2040	It might be commercially viable in some parts of the world, hopefully replacing more and more fossil fuel diesel globally.	Very low
2031-2040	Some quantity of commercially viable biodiesel may be produce rather soon, question is which percentage of the needs can be covered.	Average

2031-2040	This does not seem technically too demanding and only requires a few companies to be able to do that. However, if this is a sustainable solution needs to be investigated.	Average
2031-2040	Largely depends on funding and, in turn, support for other relevant niches (alternative biofuels).	Very low
2031-2040	question is for what vehicles they would still be used...	Average
2041-2050	These technologies already show a fair amount of promise, and work will be needed for these technologies to approach scale, reducing transaction costs to become viable with increasingly expensive conventional diesel. Long term challenges could arise if combustion engines get increasingly replaced by electric and other technologies reducing the demand pull for biofuels.	Average
2041-2050	Commercializing microalgae-derived biofuels at a competitive price of \$2.50/GGE as per the 2030 target set by the US Department of Energy (DOE) would need a technological breakthrough. Current price estimates range depending on the producer and the scale, but so far nothing is close enough to compete with the current national average of \$3.53 a gallon of gasoline at pumps. Some projects are trying to produce algae biofuel for \$5 per gallon at a commercial scale.	Low
2041-2050	Commercially available but not necessarily used	Low
after 2050	There needs to be greater research into this area and how to make it workable on a larger scale.	Very low
after 2050	Mainly guessing, not well aware of current development status	Low
after 2050	Early pilot projects on this technology have been abandoned, indicating the challenges in making this work economically at scale. Potential side effects for biodiversity will lead to societal pushback.	Average
Never	I hope never. It would have a major environmental impact	Average
Never	it is unrealistic to produce that much biodiesel from algae. Whatever we (as society) are able to produce of algae should be used in pharma, food or feed industries	High

Interpretation

The majority of respondents consider biodiesel from algae to be commercially viable somewhere between 2030 and 2050, the rest of the responses disperse widely. Comments align that technologies are available, but the challenge is to scale it economically. Long-term challenges could arise if combustion engines are increasingly replaced by electric and other technologies reducing the demand-pull for biofuels.

Some respondents suggest that Europe may not to be the best for algae production and there are possibly better uses for algae like pharma, food and feed industries. Others question the sustainability of using algae based fuels. Comments indicate that if one wishes to get algae-based diesel into the markets, public funding and other incentives are needed.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

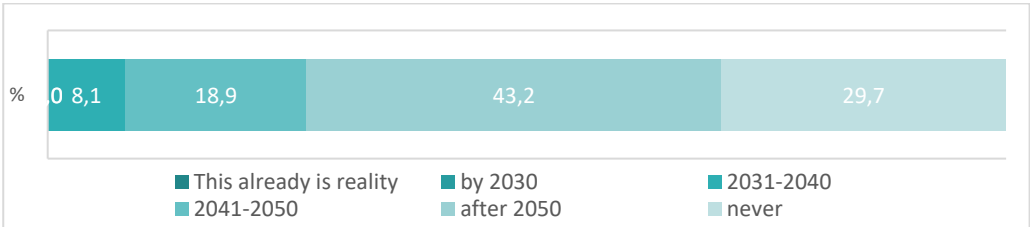
Normative Orientation	Assessment
Agreed	
Contested	X

Statement 5.11: Aviation has become climate neutral (without using carbon offsets for compensation).

Respondents

Expertise	n	%
Very high expertise	1	2,8
High expertise	4	11,1
Average expertise	17	47,2
Low expertise	9	25,0
Very low expertise	5	13,9
Σ	36	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	technical improvement	Low
2041-2050	If the time needed to go through the airport will stay at present level - four hours for travels within EU, the need for flights may go down and for the rest the efforts can be more concentrated. For the time being, the airplanes as well as the support from the land consume a lot.	Average
2041-2050	Need to encourage more technology innovation but I think other transport areas should be targeted first before aviation.	Very high
2041-2050	Possibilities with hydrogen fuel.	Very low
2041-2050	In this issue I am optimistic that technology is advancing rapidly. But there is a long way to go	Average
after 2050	Again, topdown regulations will be needed here on global scale in order to avoid unfair competition.	Very low
after 2050	This is one of the most difficult sectors	Average
after 2050	Depends on the definition and what other externalisation of environmental pressures will be accepted. If this is done with little emphasis on other issues than direct emissions of aircrafts, it might be earlier.	Average

after 2050	Carbon emissions from the aviation industry in Europe increase over the period 2000-2020 and the projection is for further increases by 2050. However, by turning to biofuels, the industry can become carbon neutral by 2040.	Low
after 2050	Decarbonisation of aviation is really challenging, e-fuels could be the option but it will take time.	Average
after 2050	The aviation industry has to be offered a viable alternative to current fuel options which are also deemed safe by consumers. Additionally, we need to move away from placeholder flights and private aircraft used by the super wealthy. Furthermore, a shift towards train transport for shorter distances, as is already being discussed at the EU level.	Average
after 2050	Unclear whether this refers to Scope 1, 2 or 3 emissions. The production of airplanes and air travel infrastructure, combined with their operations, will definitely only become climate neutral after 2050.	High
after 2050	Based on life cycle thinking aspects	Average
after 2050	I guess we are very far in terms of technology	Low
Never	I am not convinced that we can measure all the climate impacts of aviation yet so we may think we are getting there and then find some impact which we were not previously aware of	Low
Never	impossible and technology hopes are too high	High
Never	Competition for sustainable and low weight energy sources is large and at the expense of too precious land area and other production resources	Average
Never	In a pro-climate aviation will become an elitist means of transport. its use globally reduced	High
Never	Unless the amount of air traffic is cut dramatically	Average
Never	I am very sceptical about the aviation sector being able to go carbon neutral without offsets	Low

Interpretation

The clear majority consider aviation to become climate neutral (without using carbon offsets for compensation) only after 2050 or never. Some anticipate continuing growth of air travel, while others question its future competitiveness, especially within Europe, and anticipate a possible reduction of flights. Views disperse on the technological maturity of alternative fuel solutions like hydrogen. Some perceive that regulations will be needed at a global scale in order to avoid unfair competition due to air travel emissions mitigation measures.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

Normative Orientation	Assessment
Agreed	X
Contested	

Conclusions

All the expectations on the climate neutrality of industrial sectors are anticipated to materialise between 2030 and 2050, indicatively in the following order: paper (5.5), cement (5.4), chemical (5.3) and steel (5.2). Order was influenced mainly by techno-economic aspects, and in all cases, it was considered the role of policy support crucial for energy transition. Some respondents consider it relevant to extend the assessment of the environmental impact of the industries or products by considering the whole life cycle of products and their impact, for instance the recycling of cement, paper, steel, chemical and batteries as well as the impacts of biofuels. Climate neutrality in waterborne transport (5.8) and air travel (5.11) is a major challenge because of long investment cycles and lack of economically viable technological alternatives to current practices.

The need for full automation, which can be expensive and ignore the benefits of human-machine interaction, was questioned in relation to CCAM (5.7) and waterways (5.9). Some respondents suggested that instead of focusing on reducing the emissions of a specific sector, it may be more effective to scale down the industry and replace it with alternative solutions: paper documents with digital files, cement and steel with wood and chemicals with nature-based solutions as well as air travel with other alternatives. All the assumptions and expectations related to energy transition are perceived to be strongly dependent on policies and their implementation, to provide sufficient incentives to innovate and to invest for scaling up new solutions.

3.7. Results Cluster 6 Food, Bioeconomy, Natural Resources, Agriculture and Environment

Overview

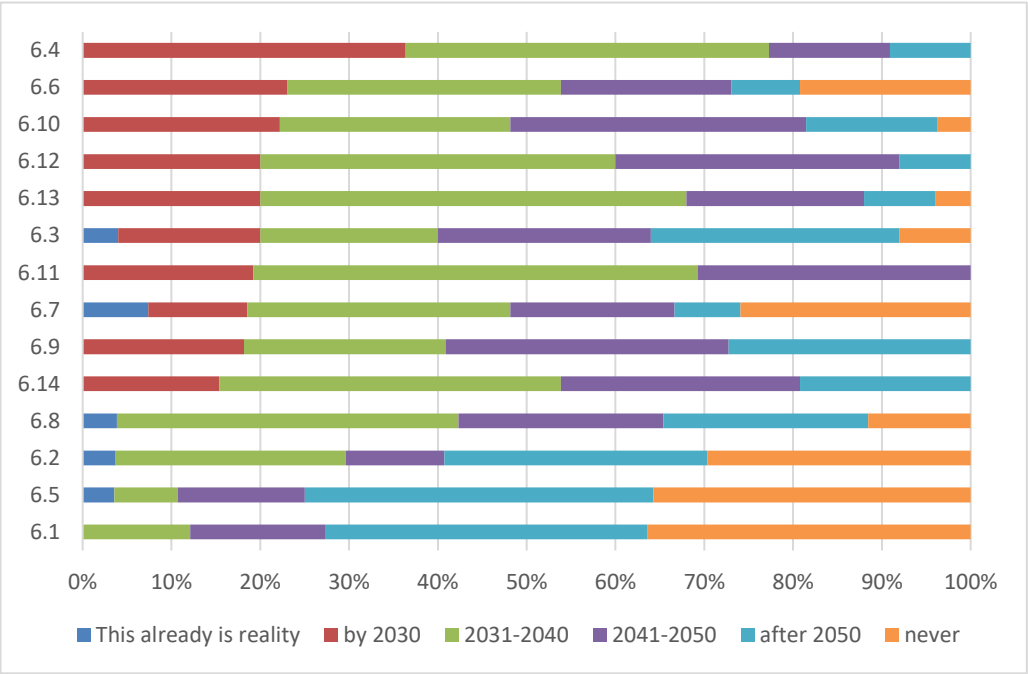


Figure 10: Assessment of time horizon for statements in cluster 6 (ordered by share of now - 2030)

C6: Food, Bioeconomy, Natural Resources		Time Horizon				Norma- tive Ori- entation	
Statements (*= Lessons further discussed in section 0)		Near term	Mid term	Long term/Never	Inconclusive	Agreed	Contested
6.1*	"In the EU agri-food production no longer places pressure on natural ecosystems."			X		X	
6.2*	"In the EU use of the seas and inland waters and marine resources no longer places pressure on natural ecosystems."			X		X	
6.3	"Animal welfare in fish reaches the same stand-				X	X	

	ards as animal welfare in mammals."						
6.4	"The share of low trophic species (e.g. algae and herbivores) in EU aquaculture systems has doubled compared to 2022."		X			X	
6.5*	"In the EU human activity has become biodiversity-neutral."			X		X	
6.6*	"Food supply chains in Europe are fully transparent."				X		X
6.7	"Nature based solutions and sustainable ecosystem management account for at least 20% of employment in the EU."				X	X	
6.8	"Tourism, recreational and leisure activity development in coastal areas across the EU respect long-term environmental carrying capacity."		X			X	
6.9	"Soil based carbon sequestration has increased twofold in the EU compared to 2022."		X			X	
6.10	"Average per capita meat consumption in the EU has fallen below 30Kg per year (around 54 Kg in 2021)."		X			X	
6.11	"In the EU more than 70% of bio-waste streams are separated from other waste streams for recycling and reuse (In 2022 the average is 50%)."		X			X	
6.12	"The yearly EU consumption of pulses for food (excluding soy beans) has increased to 3 million tons (up from 2 million tons in 2022)."		X			X	
6.13*	"More than half of European companies have integrated natural capital and biodiversity impacts and dependencies into their corporate decision making and risk assessment."		X				X
6.14*	"Advanced internet based digital applications such as remote sensors for crop and livestock monitoring, data analytics and advanced planning and optimisation (e.g. via Farm Management Information Systems), control and execution of production with help of automatic machines (e.g. for milking) or robots (e.g. for weeding and harvesting), are used in more than half of farms in the EU."		X				X

Interpretation:

As Figure 10 illustrates, within the cluster "Food, Bioeconomy, Natural Resources, Agriculture and Environment" for 8 out of 14 statements the most selected time horizon was 2031-2040. For two (9, 10) 2041-2050 and for another two (1, 5) "after 2050" were the most selected. At the same time, six statements (1, 2, 5, 6, 7, 8) received a share of "never" assessments above 10%. For statement 1 "never" is even the largest share together with "after 2050". Only four statements (2, 3, 5, 7) were assessed as being "already the case" albeit by only few respondents. This assessment gives the impression that challenges within this cluster are mostly to be addressed between 2030 and 2050, but some reach even further with some experts doubting that they can ever be tackled. This is especially the case for the hope that humans will be able to erase pressure on ecosystems from their activities.

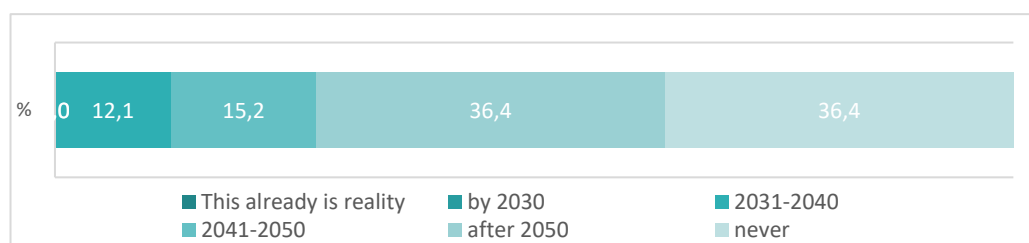
Individual Statements

Statement 6.1: In the EU agri-food production no longer places pressure on natural ecosystems.

Respondents

Expertise	n	%
Very high expertise	10	30,3
High expertise	8	24,2
Average expertise	10	30,3
Low expertise	4	12,1
Very low expertise	1	3,0
Σ	33	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	The crises get bigger and bigger	Average
2031-2040	Transition already in progress	High
2031-2040	All industrial systems have a huge inertia, including mentalities and stranded assets issues; changes in this field will be long to be achieved. EU could play a major model role for the rest of the world	High
2041-2050	Society will be forced to mobilize as it is imperative to do so, but the change will take some years.	Low
2041-2050	the inertia in the agri-food system is very high because of the financial constraints farmers face as well as the fact that both consumers and retail need to change their behaviour. transitioning a system that is to integrated in our economy and way of life will take at least twenty years.	Very high
2041-2050	Climate neutral food production will likely not be a reality before 2050	High
after 2050	The vested interest simply blocks all attempts. Who generates GDP? Chemical industry, others industries, businesses.	Very high
after 2050	Given the population we already have and the natural resources required to feed them I fear there will always be a residual impact of food production on our	Very high

	natural ecosystems.	
after 2050	A certain degree of pollution is not avoidable, for example with regard to nitrogen losses, so a certain pressure will be always there. My answer relates to pressure within thresholds, so acceptable pollution. Europe has a major nitrogen pollution problem, which is very difficult to mitigate. Therefore my expectation is, that even though improvements can be achieved on short time-scales, a full mitigation below thresholds will take very long.	Very high
after 2050	transformation only when it is too late, earlier populism and cheap meat will determine decisions	Very high
after 2050	Some international foresight studies predict a chemical pesticide free agriculture by 2050,	Average
after 2050	To completely remove all pressure on natural ecosystems will require substantial reductions of current impacts of agricultural production, as well as reductions in aggregate production. I could see this occurring in the long run, particularly as global populations peak and start to fall. But this isn't likely to happen in the short to medium term.	Average
after 2050	I think it is impossible that there will not be pressure on natural ecosystem anymore. The pressure can be diminished hopefully but not cancelled	Average
after 2050	I don't think that the measures adopted to date are significant enough to transform agri-food production by 2050. But there is significant enough work in niches that might eventually work to eliminate the pressure on natural ecosystems.	Very high
after 2050	The process to take research results for policy takes time	High
after 2050	Knowledge is continuously generated but at a low pace	Low
Never	given the present trend I am doubtful that demand will reduce up to a point not to place pressure	High
Never	There will always be pressure. The question is, if the system can regenerate or not. But we can do a lot to farm detached from ecosystems - using vertical farms and recirculating systems (RAS), etc.	Very high
Never	The statement sounds a bit strange, but there will always be pressures on the natural ecosystems, depending on what is meant with natural here.	High
Never	It is natural that human activity exercises pressure on the environment. It is more a question of how this pressure can be absorbed by the environment in a sustainable way.	Average
Never	The reality is that agri-food production will always place pressure on natural ecosystems. However, our goal should be to minimize the pressure as much as possible.	High
Never	I firmly believe that we will be able to reduce this pressure with current techniques such as aquaponics and new ones that are truly circular economy, integrated and multi-trophic within smart farms. Reduce the pressure a lot, yes, but never eliminate it.	Very high

Interpretation

On this statement we have received assessments and comments from respondents with very high and high expertise. The issue of agricultural ecological footprint is clearly assessed as a very long-term challenge. Not one respondent thinks that this will be addressed by 2030 and only few believe in a solution by 2040. Rather, “After 2050” and “never” are the most selected time horizons. Comments reveal that the high share of never is due to the rather radical formulation of the statement. Many experts state that food production will always exercise pressure on the environment to some extent. Instead, experts modify the goal into minimizing the pressure to an acceptable level that allows ecosystems to regenerate.

Even for this more modest goal however respondents voice grave concerns and point to substantial barriers such as vested interest of polluting industries, inertia in the agri-food system, the fact that both consumers and retail need to change their behaviour, financial constraints faced by farmers, population growth, mentalities, populism, stranded assets and nitrogen losses. Many respondents expect that overcoming these barriers will take a long time beyond 2050 even though solutions are in principle available. Explicitly mentioned are: Multi-trophic smart farms, vertical farms, recirculating systems (RAS), pesticide free agriculture, aquaponics and new ones that are truly circular economy.

Some experts also highlight strong external driving factors that could accelerate change such as increasing crises, already ongoing transition and in the long term a peak in the global population. One respondent with very high expertise highlights that there is significant enough work in niches that might eventually work to eliminate the pressure on natural ecosystems. Another states that the EU could play a major model role for the rest of the world.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

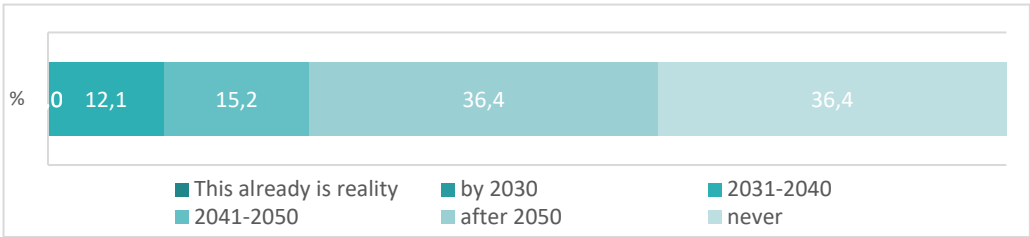
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.2: In the EU use of the seas and inland waters and marine resources no longer places pressure on natural ecosystems.

Respondents

Expertise	n	%
Very high expertise	4	14,8
High expertise	6	22,2
Average expertise	10	37,0
Low expertise	5	18,5
Very low expertise	2	7,4
Σ	27	100,0

Time Horizon:



Comments

Time Horizon	Comment	Expertise
2031-2040	It depends on the level of urbanization	Average
2031-2040	SAME COMMENT as for ground productions; May be, we could save time as the fishing vessels at sea could be more easily controlled (e.g. Red tuna in the Mediterranean Sea) easier; in addition, the synergies in wind parks for aquaculture, fishing, tourism, scientific monitoring, education... will help. A specific global programme for EU deserves to be widely developed	Very high
2031-2040	I would think this is easier to make a reality than the agri-food system. Nevertheless, a lot of hurdles still need to be overcome.	Low
2031-2040	My answer refers to fishery. In the near-term, I don't see the political economy. In an optimistic scenario, this can be achieved by 2030 as it is something that can be achieved by catch-quotas if there is a majority for it.	Low
2041-2050	Same as for the previous statement	High
after 2050	We have had a huge impact on our natural ecosystems to date and the demand for food pro-	High

	duced from inland waters and marine resources is still increasing so it will take a long time to stop the impact	
after 2050	only if we really decide to reduce	Average
after 2050	The mission about the regeneration of ocean and water foresees protecting 30% of the EUs sea area and restoring marine eco-systems and 25,000 km of free-flowing rivers. We will need more time to completely eliminate the pressure on nature ecosystems	Very low
after 2050	The situation for water resources is actually worse than for agri-food production. But in the case of these marine resources, bans on specific techniques (like trawling) seem to be efficient. Also, the development of land-based aquaculture could also reduce the pressure on natural ecosystems.	High
after 2050	Research Results take time to be adapted for policy actions.	Very high
after 2050	Please refer to my previous reply	Low
Never	Regarding freshwaters, the source, the flow (rivers), natural and artificial reservoirs are all far away from natural functioning. To avoid pressure (well, of course what is a pressure, humans used aquatic resources 1000 years ago - probably not causing pressure, only locally). But to expect free flowing rivers, and natural lake shores not in our civilization.	High
Never	political pressures will limit the capacity to regulate natural resources	Average
Never	There will always be pressure. The question is, if the system can regenerate or not. But we can do a lot manage activities (ecosystem based), fish less and to farm detached from ecosystems - e.g. in recirculating systems (RAS), and to develop NbS for other than climate change mitigation/adaptation	Very high
Never	It is natural that human activity exercises pressure on the environment. It is more a question of how this pressure can be absorbed by the environment in a sustainable way.	Average
Never	As in case of agri-food systems, the human activities will always place pressure on natural ecosystems. Again, the way to go is to minimize the pressure as much as possible.	Average
Never	We may increase aquaculture on land, but we will always harvest edible resources from the sea, lakes and rivers.	Very high

Interpretation

The answers of this statement mirror the ones of statement 1 human activities will always place pressure on natural ecosystems. Again, the way to go is to minimize the pressure as much as possible but even this faces severe hurdles

and will take longer than 2050 in many respondents' opinion. The assessment of time horizon is also very similar.

As a difference it is pointed out that on the one hand the depletion of ecosystems is even more severe on water than on land, on the other hand measures such as banning trawling and catch quota can be highly effective. One expert with very high expertise calls for a specific global programme for the EU.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

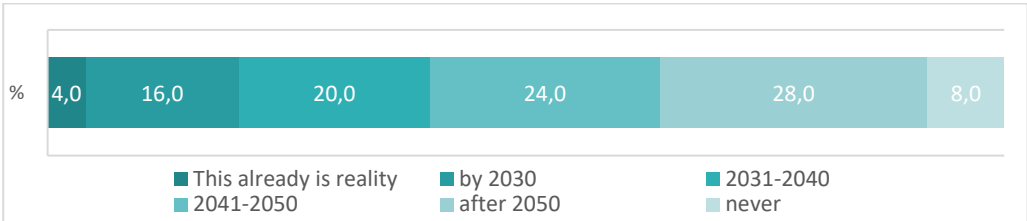
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.3: Animal welfare in fish reaches the same standards as animal welfare in mammals.

Respondents

Expertise	n	%
Very high expertise	1	4,2
High expertise	5	20,8
Average expertise	6	25,0
Low expertise	7	29,2
Very low expertise	5	20,8
Σ	24	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
This already is reality	probably better than for most animals at the moment, standards are not really comparable	Low
by 2030	This issue is very sensitive and the consumer feeling is crucial for the market. Labelling will have an important role to play.	Average
by 2030	I do not have expertise	Very low
2031-2040	a lot of work is ongoing to measure/understand behaviour, develop guidelines/indicators, and the upcoming CL6 partnership will also support research and innovation in aquatic animals	High
2031-2040	Production and consumption need to change for that statement to happen and the question is what level of animal welfare we want to have reached by then.	Low
2041-2050	the role of the consumer get more and more important	Average
2041-2050	this is dependent on culture and attitudes, and it will at least take a generation to change these dramatically. Currently and in near future (10 years) economics and profitability are the main drivers for changes, and these are not sufficient.	Very high
2041-2050	We like mammals, warm, hairy creature. Not wet, cold, no arm, no leg creatures.	Low

2041-2050	It is doable, if there is a will.	Low
after 2050	There is a bigger consumer pressure for reducing the impact of food production on the welfare of animals than the impact on the environment and I suspect that will spread to concern for fish	Low
after 2050	This will be a difficult goal to achieve as even achieving animal welfare for mammals will most likely not happen before 2050. Fish are not charismatic fauna - which means that there is much work to be done to convince humans of their need to be treated humanely. However, i do think that we could eventually make this a reality.	High
Never	It is just a guess	Very low

Interpretation

Assessments here range almost equally from this is already reality to never. Most respondents by a slight margin think after 2050 almost the same amount thinks 2041-2050. Arguments reveal uncertainty on the situation and definitions several respondents indicate low expertise. Still valid arguments are brought forward including from high expertise respondents. Empathy for “wet, cold, no arm, no leg creatures” is lower than for mammals but at the same time we do not even achieve such standards for farm animals currently. In fact, as one respondent points out the situation for fish may be better even already now.

The assessment of one respondent with very high expertise echoes many other voices: this is dependent on culture and attitudes, and it will at least take a generation to change these dramatically. Currently and in near future (10 years) economics and profitability are the main drivers for changes, and these are not sufficient.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

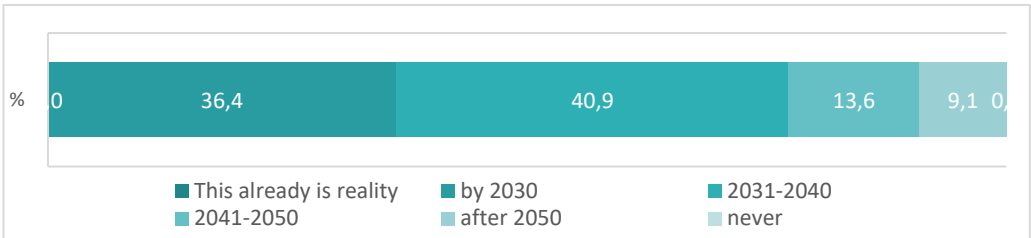
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.4: The share of low trophic species (e.g. algae and herbivores) in EU aquaculture systems has doubled compared to 2022.

Respondents

Expertise	n	%
Very high expertise	2	9,1
High expertise	3	13,6
Average expertise	8	36,4
Low expertise	4	18,2
Very low expertise	5	22,7
Σ	22	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	if we have not reached a doubling of LT organisms by 2030 we have failed (!) - there is a huge potential being explored at present - both in situ and on in systems on land for producing LT organisms, for food feed and extraction of biomolecules with high economic value.	High
by 2030	As there is not a big share today, this is not very ambitious.	Very low
by 2030	Doubling is easily possible given the low starting levels. The field is very active.	Low
by 2030	The share is very low, and it is not too challenging to double the share	Very high
by 2030	There is increasing research and market interest in this field and since the share is quite low in 2022, it will not take so long to double that share.	Average
by 2030	Several reasons for doing better in that trend: available technologies, huge potential markets, higher awareness of consumers, power of social networks, better image of aquaculture, progress	Average

	in carbone impact...	
2031-2040	especially algae as an alternative and efficient source of protein and fat.	Average
2031-2040	Hopefully a similar change can go through, as against red meat.	Very low
2031-2040	Just a guess	Very low
2031-2040	The pressure of social demand for 0-kilometre food and from the circular economy are creating new integrated, multi-trophic technologies, combining technologies in smart farms that are increasingly committed to the inclusion of species of a lower trophic scale, perfectly in cases such as aquaponics and RAS + aquatic plants or algae.	Very high
2041-2050	Aquaculture is a growth industry, if policy gets it right, then there should be enough investment in research to achieve this within this timescale	Average

Interpretation

This statement seems to be one of the few where the stated goal is not overly ambitious. Four experts including one with very high expertise argue that we can and should more than double this share even by 2030 as current levels are low and the field is very active. One respondent lists the drivers: available technologies, huge potential markets, higher awareness of consumers, power of social networks, better image of aquaculture, progress in carbon impact. In spite of these promising conditions most respondents expect that this will take until 2040 but only very few expect a longer time horizon. To sum up this seems to be a short to midterm challenge with high feasibility of being addressed.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

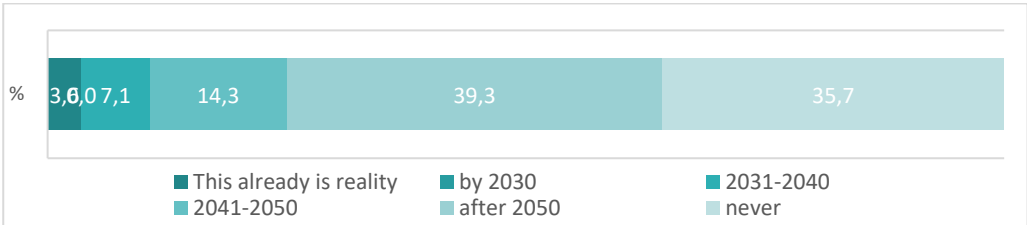
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.5: In the EU human activity has become biodiversity-neutral.

Respondents

Expertise	n	%
Very high expertise	2	7,1
High expertise	9	32,1
Average expertise	15	53,6
Low expertise	1	3,6
Very low expertise	1	3,6
Σ	28	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	It's a long way to reach this virtuous goal! In addition, proxies to estimate this neutrality are not simple to establish. The best could be to use the IPBES group and reputation to shape and secure the appropriate indicators	Average
2041-2050	For me, the definition of biodiversity-neutral is not clear enough to express an opinion. Option was taken in order to provide this explanation	Average
2041-2050	Biodiversity in the current state also depends on certain kind of land management applied today.	Average
2041-2050	Requires major changes to agri-food system, but is also high on the political agenda. Depends always on definition of biodiversity. But here I take one that allows for compensation.	Average
after 2050	this will vary per EU country. A fair assessment is that economies like France, Germany, the Netherlands will move faster than countries like Hungary, Poland and the like.	Average
after 2050	There are some efforts for rewilding and restore naturalness of habitats so there is some hope that it will offset negative developments.	Very high
after 2050	Long-term objective	Average
after 2050	neutral compared to what???? - present-day deteri-	Very high

	orated levels or 1800-level? We may have halted the further degradation of our own natural systems, however, we are importing a lot of degradation through the externalities of our imported goods. Biodiversity need SPACE, and if we do not stop expanding urban areas, we will not be biodiversity-neutral	
after 2050	I see the impact of human activity declining, but getting to neutrality seems like a much longer objective that is unlikely to be achieved by the middle of the century, even as I suspect progress will be made.	Average
after 2050	Need a lot of actions at several levels to establish the statement (not only the national governments)	High
after 2050	Depends on human created climate changes that will not vanish before 2050	High
Never	Given human population in the EU I don't think this is feasible	High
Never	This is a very noble goal and we should work towards it. However, as human population density is growing, i am afraid that it will not be possible. But we should try as much as we can.	High
Never	It will be difficult, unfortunately, that the anthropogenic activities became neutral to the biodiversity and environment. I suppose the this aim is very far	Average
Never	same arguments as before	Average
Never	Humans are never neutral, in agriculture, they create new species (breeding, gene engineering....), they drive plants and animals out of their traditional areas and rather shape the bio-landscape according to their own needs and desires. For example, they do not want to have wolves back.	Average
Never	I don't think that human activity will ever become biodiversity-neutral. Human-driven agri-food systems have always selected for varieties and species that we prefer to eat and this means that we can increase biodiversity (thus reverse biodiversity loss), but we will most likely continue to select for preferred varieties and species, which means that neutrality is impossible.	Average

Interpretation

Assessments and arguments mirror statement 1 & 2 respondents doubt that human activity will ever become biodiversity-neutral with the result that a large share has voted "never". At the same time, there is wide agreement that reducing impacts as much as possible is an important goal, which faces steep barriers resulting in a majority assessment that significant progress will be achieved only after 2050. Positive signs mentioned are efforts for rewilding and restore naturalness of habitats and the fact that biodiversity is high on the political agenda. Some respondents point to the need for good indicators for measuring this impact and a definition of baseline levels.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	X
Inconclusive	

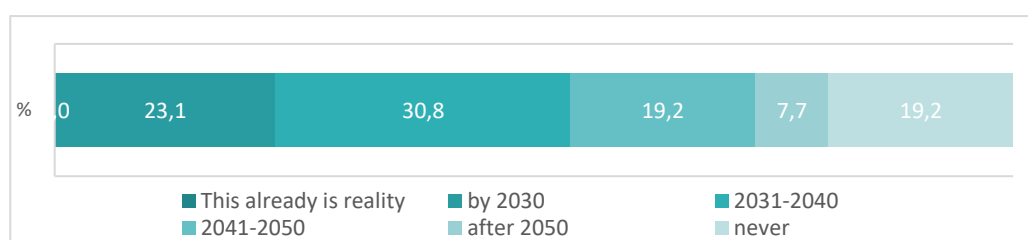
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.6: Food supply chains in Europe are fully transparent.

Respondents

Expertise	n	%
Very high expertise	2	7,7
High expertise	7	26,9
Average expertise	12	46,2
Low expertise	3	11,5
Very low expertise	2	7,7
Σ	26	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	In this case technology will be key as it will allow the citizen / consumer to access the information required directly.	Average
by 2030	this is already possible, so the rate limiting factor is implementation.	High
by 2030	I think at this moment the food supply chains are increasingly transparent but the focus on food traceability will be reinforced.	Average
2031-2040	Remember inertia forces; in addition, supply chain are related to profitability, which means that there is inevitably concurrence and secret. But micro-sensors should help a lot in this follow-up.	Low
2031-2040	This is not necessary a prime target. If you have sufficient regulation at any place of the supply chain, supply chains don't need to be transparent. Only in case of unregulated pollution, you need transparent supply chains so consumers can include this information into their decision making. I still think they will become transparent because of digitalisation.	Average
2031-2040	technology already exists	High
2031-2040	This could be done in the selected time-frame but we need to hurry and convince the people	Average
2031-2040	A lot of effort has been invested and this goal can soon be achieved	Low
2041-2050	For some supply chains that might become true earlier, as they become more regional, but for others not.	Average

	It depends on the kind of food.	
2041-2050	Technically, it should be possible now. However, due to monopoly and high lobbying in the industry it may not likely happen in near future...	Average
2041-2050	low industry interest in transparency, they will fight and hold back on this	High
after 2050	There is strong resistance in the business sector, for technical barriers and marketing reasons	High
Never	It is simply, and based on human feature, there will always be members in a chain with many participants, who will try to avoid visibility and accountability. So it is not for food, but a general phenomenon.	Average
Never	This is not in industry's interest	High
Never	too many different interests behind, food industry does not support full transparency	Average
Never	Full transparency is a fallacy - particularly if we are talking about capitalist supply chains. We can increase the traceability of some food products and increase the ability to know more about origin and safety issues, but full transparency may not even be desirable.	Very high

Interpretation

On these statement opinions are divided. The most frequently selected time horizon is 2031-2040. But also by 2030, 2041 to 2050 and "never" received relevant shares. Experts who expect this by 2040 and earlier stress that the technology (e.g. micro sensors) already exists, a lot of effort has been invested and only implementation is lacking. More sceptical respondents highlight inertia forces such as too many different interests and resistance from food industry as well as the multitude of participants where always some will avoid visibility. One expert with very high expertise raises the interesting question whether full transparency is even desirable. In a similar vein, another respondent argues that this is not necessary an appropriate target because "If you have sufficient regulation at any place of the supply chain, supply chains don't need to be transparent". This indicates that the focus could be on trustworthiness rather than full traceability.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

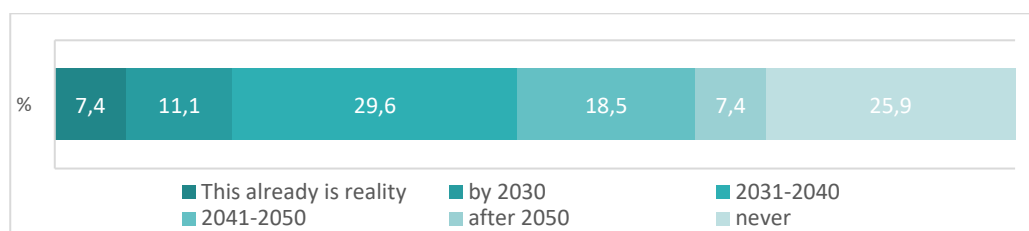
Normative Orientation	Assessment
Agreed	
Contested	X

Statement 6.7: Nature based solutions and sustainable ecosystem management account for at least 20% of employment in the EU.

Respondents

Expertise	n	%
Very high expertise	1	3,7
High expertise	5	18,5
Average expertise	15	55,6
Low expertise	5	18,5
Very low expertise	1	3,7
Σ	27	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	The practical feasibility is already here; the key is the political will and the support of the EU. More publicity, notably through young people (such as Greta Thunberg) could help a lot. The vision is always the same: In a turbulent world, EU has to show the right way to secure food supply for all without necessarily destroying the environment.	Average
by 2030	it probably already exists	High
by 2030	As this is key to the food transition, this should be aggressively supported in the coming years.	Average
2031-2040	I think the Green Deal will help on that statement	Average
2031-2040	Should be possible, if political frame would favour the change.	Low
2031-2040	Recent developments, e.g. the Natura Restoration Law, if will survive Member States, and other initiatives can have the potential to substantially increase direct links of jobs to ecosystems.	Average
2031-2040	optimistic answer - but is one possibility	Average
2031-2040	Green Employment is one of the fastest growing forms of gross added value to the EU economy. If investments continue, then the 20% target should be reached within 10 years, if not before.	Average
2041-2050	Although there is currently an increase in social awareness, much more trained personnel are required to be able to manage, in a truly sustainable way, each	Average

	type of ecosystem (coastal, high mountain, high seas, natural forests, river, etc.)	
2041-2050	To be really sustainable we have to work together with nature and there will be a certain kind of idealistic involvement.	Low
2041-2050	It will never happen if you mean employment in ecosystem management itself. But if you mean working in managed systems, then I believe it will be possible, as long as the EU keeps putting pressure on MS to develop ecosystem-based management of space and resources, and if EU support the development of NbS into other areas than climate mitigation/adaptation but to improve other societal challenges	Very high
2041-2050	we will have to as disasters will force us	Average
2041-2050	I refer to the bioeconomy sector only	High
Never	Agriculture is down to 1% of employment. At least the primary sector will not grow by 2000%; if it grows at all. Maybe if you include the full supply-chain, but even then...	Average
Never	I think this % is too high to be feasible if you take all service industries into account	Average

Interpretation

Most respondents expect this between 2031-2040 or else 2041-2050. Still there is also a substantial group thinking that this will never be the case. Comments reveal some of the issues. As one expert with very high expertise puts it: "It will never happen if you mean employment in ecosystem management itself. But if you mean working in managed systems, then I believe it will be possible. Also others suggest broadening this to "green employment and bioeconomy.

As drivers of such 2NbS based employment" respondents mainly mention policy initiatives such as the Green Deal, the Natura Restoration Law, EU support the development of NbS, EU putting pressure on MS to develop ecosystem-based management of space and resources, and EU support of the development of NbS into other areas than climate mitigation/adaptation to improve other societal challenges. Other external drivers mentioned are the pressure from young people and the mounting number of crises and the pressing need for food security.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	
Long-term challenges 2050-never	
Inconclusive	X

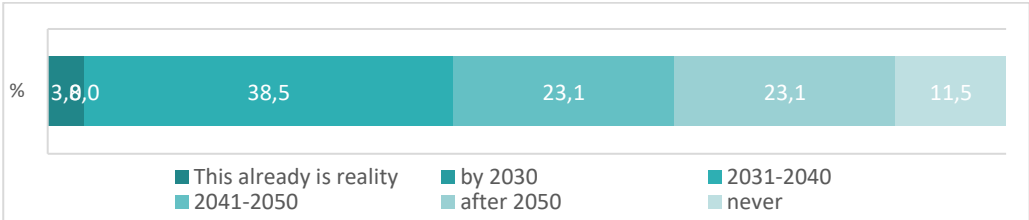
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.8: Tourism, recreational and leisure activity development in coastal areas across the EU respect long-term environmental carrying capacity.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	3	11,5
Average expertise	13	50,0
Low expertise	6	23,1
Very low expertise	4	15,4
Σ	26	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
2031-2040	If regulative framework will be in place and political/economical support is guaranteed, should be possible to achieve in relatively near future.	Low
2031-2040	If this is really wanted, it could be possible. One possibility discussed is a kind of ticket system for tourism. Personally, I cannot believe that this comes true.	Average
2031-2040	do you mean carrying capacity of the present-day deteriorated system? that could probably happen within 15-20 yrs. If you mean coastal areas with restored/improved biodiversity and ecosystem services it may take longer.	High
2031-2040	It is not a target, but a necessity. How can decisions makers speak about education to sustainability without starting by their own behaviour? Modelling is one of the key-tool to demonstrate that sustainable tourism can entail in more jobs and develop a new relationship between Man and Nature (this famous change of Paradigm)	Average
2031-2040	it depends on governments/politicians	Low
2041-2050	it's important for the attractiveness of the coastal areas	Average
2041-2050	I think that this can be achieved with stricter rules about tourism and recreational boat usage - there are examples of areas that already control the number of people allowed into certain habitats - but I am not sure what the environmental carrying capacity is for the coastal	Very low

	areas in the long term.	
2041-2050	Takes time to convince the actors. Many areas would have to be rebuilt.	Low
2041-2050	As tourism is an important asset to countries economically, finding a true balance between environment and income from tourism will be a struggle and take time.	Low
2041-2050	As sea level rises have an impact there will be an obvious imperative to take action	Low
after 2050	I guess this would require a removal of large parts of the already built-up buildings and infrastructure.	Very low
Never	Majority of people would avoid nice natural marshes at seashore, and prefer sun umbrellas, and laying on the hot sand, without annoying biodiversity.	Average
Never	too high economic pressure and lack of political will	Average

Interpretation

In principle, the goal seems to be widely shared. Respondents mention diverse reasons why this is important: sea level rise, attractiveness of the coastal areas and forming a sustainable relationship between humans and nature. Opinions on the feasibility and time horizon diverge. Most respondents expect the rise of sustainable tourism in coastal areas between 2031 and 2040. Another quarter of respondents thinks it will take even until 2050. Another group expects it only after 2050 and three respondents even don't expect this to happen at all.

Notwithstanding the diverse assessment of the time horizon barriers and enabler mentioned are similar: The key driver is the will to make it happen. Instruments are regulatory frameworks, economic support, access restrictions, modelling, removal of buildings and leading by role model. The barriers however mentioned are high economic pressure and lack of political will as well as human preferences. One respondent with high expertise points to an important specification she argues that carrying capacity of the present-day deteriorated systems could probably happen within 15-20 yrs. while coastal areas with restored/improved biodiversity and ecosystem services it may take longer.

Categorisation

Time Categories	Assessment
Near term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long term challenges 2050-never	
Inconclusive	

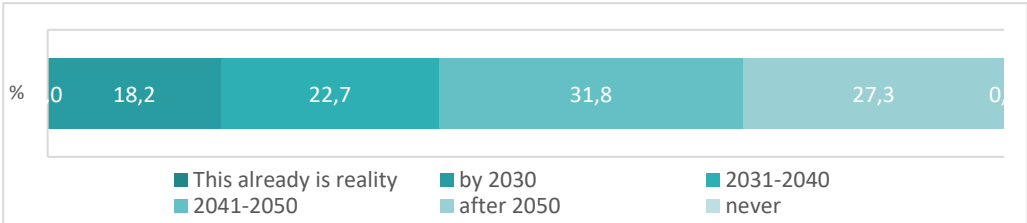
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.9: Soil based carbon sequestration has increased twofold in the EU compared to 2022.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	3	14,3
Average expertise	13	61,9
Low expertise	2	9,5
Very low expertise	3	14,3
Σ	21	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	Once again, when there is a will, there is a way. But the global vision is still missing as the Ukraine war showed it. Looking at coal, oil and gas as security sources of energy is not the right way to react. The key is not to capture Carbon; it is to reduce the GHG emissions and the use of fossil fuels; EU should act as a team!	Average
by 2030	We know how to do it, so let's do it.	Average
by 2030	Soil-based carbon sequestration currently is negative, so we are losing carbon. Increasing this twofold should be not a target. In interpret this this way, whether we are able to increase SOC sequestration strongly. Given the low current levels, this is easily possible. As soon as it is included in a carbon-pricing scheme, a lot will happen there, and as this would favour farmers, I see a large likelihood that this will be implemented in the political economy.	High
2031-2040	depends on new technologies, but it is possible. There are new attempts of CRISPR to bind carbon in plants (and thus in soil), if that is also included.	Average
2031-2040	already on-going	Average
2031-2040	The capacities to store carbon are limited. Now it	Average

	is very popular and will be used intensively.	
2041-2050	This is tied to the forms of agriculture adopted and it is unlikely that soil based carbon sequestration will occur without large-scale adoption of organic, low-till practices.	Average
2041-2050	The momentum behind recognition of soil carbon sequestration is rising	Average
2041-2050	I hope....	Very low
after 2050	when we really have to, it is easy....	High
after 2050	if the agroecological transition is successful	Average

Interpretation

While nobody thinks that this will never happen, opinions on the time horizon are almost equally spread across the categories. There seems to be agreement that current levels are low, technologies are available and momentum is rising. On the other hand, large-scale adoption would imply a significant paradigm change in agricultural practices.

On the other hand, respondents emphasise that the capacities to store carbon are limited and the focus should be on reduction of GHG emissions.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

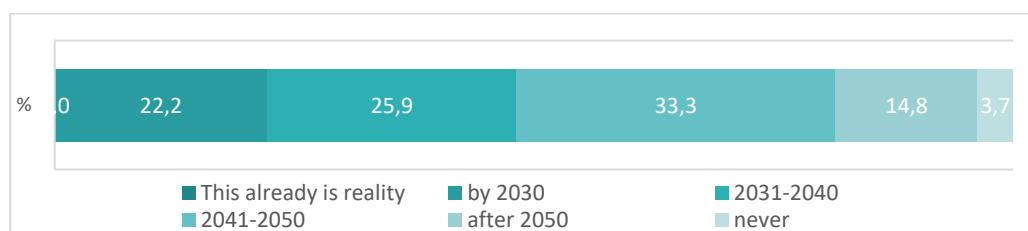
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.10: Average per capita meat consumption in the EU has fallen below 30Kg per year (around 54 Kg in 2021).

Respondents

Expertise	n	%
Very high expertise	1	3,8
High expertise	15	57,7
Average expertise	6	23,1
Low expertise	4	15,4
Very low expertise	0	0,0
Σ	26	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	optimistic answer but with the current prices, we are on this way.	High
by 2030	Already happening	Average
by 2030	There will be a change to alternative proteins where possible and the remaining meat will be produced more sustainable.	High
by 2030	Consumer / citizen behaviour in this direction is already changing very quickly and the food system as a whole is adapting and enabling this.	Average
by 2030	Things are evolving quite rapidly notably thanks to young generations. But EU must be careful not to put shame on meat consumption. The key could be the benefit for the health for the people but this should start at school notably where low income classes put their children.	Average
2031-2040	If you mean meat from livestock - It could potentially happen very soon. But EU consumers may still eat >30kg/year of artificially grown meat, fish, low-trophic organisms (shrimp, mussels, insects, etc.) in the future	High
2031-2040	It is already a trend in Western Europe, and also present in Central Europe. If prices increase like now, it soon will be not just trendy, but also the	High

	everyday for the poor.	
2031-2040	Behaviour change is difficult. Also, the relative share of meat replacers is growing rapidly, but still small. However, investing in hybrid meat products will enable a swift reduction in meat consumption. Sensorically these products are superior to 100 % plant based replacers. The current pressure on the animal production sector (Nitrogen related) will help in this respect.	High
2031-2040	Given the trends of technological development as well as social preferences, I expect a strong decline of meat consumption in the future.	Very high
2041-2050	If the waste of food will be minimized, then this would be possible. However, it should always be kept in mind that animal protein is an important part of human diet.	Low
2041-2050	There is much concern around meat consumption and the variety of alternative protein and nutrient sources is increasing.	High
2041-2050	the attitude of the consumer change more and more	Average
2041-2050	It is already on a downwards trajectory	High
2041-2050	This depends in part by what is defined as meat. If novel plant-based and cultured meats are not included in this amount, I could certainly see a reduction in the consumption of conventional meat productions to around 30KG by the middle of the century. If these products don't get adopted, or are included in the definition of meat consumption, then I don't think this target will be achieved in any time frame.	High
2041-2050	after disasters we will finally realize the need	High
after 2050	We will no longer be able to afford it by 2050	Low
after 2050	Per capita meat consumption was actually around 68 kg per capita in 2021 and is on an increasing trendline. This is because Western Europe is indeed reducing the quantity of some meat consumption, other countries and other forms of meat consumption continue to rise. I don't think that we will be able to get to below 30Kg before 2050.	High
after 2050	there is an already ongoing trend on reduction. With appropriate measures the target is feasible	High

Interpretation

This statement received many answers from respondents with high expertise. Opinions on the time horizon are equally spread across categories with a slight preference for 2041-2050 and only one person thinking this would never be the case. Experts seem to agree on the goal of shifting from livestock meat consumption to alternative forms of proteins such as novel plant-based and cultured meats as well as low-trophic organisms. There are four main drivers men-

tioned: Social preferences which already point this way, price increases, availability of alternatives and necessity due to disasters.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

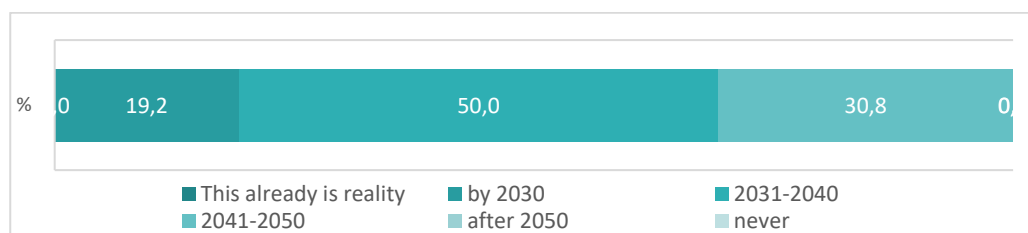
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.11: In the EU more than 70% of bio-waste streams are separated from other waste streams for recycling and reuse (In 2022 the average is 50%).

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	5	20,0
Average expertise	12	48,0
Low expertise	6	24,0
Very low expertise	2	8,0
Σ	25	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	this is a matter of investment in waste processing plants.	High
by 2030	It is easy to incentivise for waste separation, e.g. in CH the waste is very expensive and everything you can separate is highly appreciated.	High
by 2030	Sounds realistic if incentives, technologies and education are managed in a coherent way for a full decade	Low
2031-2040	the demand for biomaterial will increase, thus the incentive for recycling/reuse will be there to push the development of practical solutions	Average
2031-2040	I hope....	Very low
2031-2040	I think this is a valid policy-target by 2030, in particular if targeting countries that currently perform not so well. Above 70% will become much more challenging.	Average
2031-2040	Needs a good regulatory/political framework and an educational program.	Low
2031-2040	I think that this is achievable if we are already at 50%. We just started separating our waste only 10 years ago and if in 10 years we have arrived at 50%, we should be able to add another	Average

	er 20% in the next 10-15 years (assuming that the low-hanging fruits were the first to switch and that there are structural barriers to further change).	
2031-2040	Possible, but optimistic answer.	Average
2031-2040	As faster as possible, it will be a good option. This is a big challenge that will be solved quickly since the bio-waste can be valorised by different ways in different potential fields of applications	Average expertise
2041-2050	Social pressure will make law enforcement more severe and polluting industries will be increasingly punished by market demand.	Average
2041-2050	the attitude of the consumer change more and more	
2041-2050	There is an economic impetus for this as countries strengthen their bio-economy strategies	High
2041-2050	depending on policies put in place	Average
2041-2050	Already ongoing	Average

Interpretation

A majority of respondents expects separation of 70% of bio-waste streams to be achieved in the EU by 2031-2040 another large group expects this only until 2050. Five respondents among them two with high expertise think this achievable even before 2030. Drivers & enablers mentioned are consumer attitudes, economic incentives, regulatory/political framework and an educational program, increasing demand for biomaterials and advancements in waste processing technologies.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

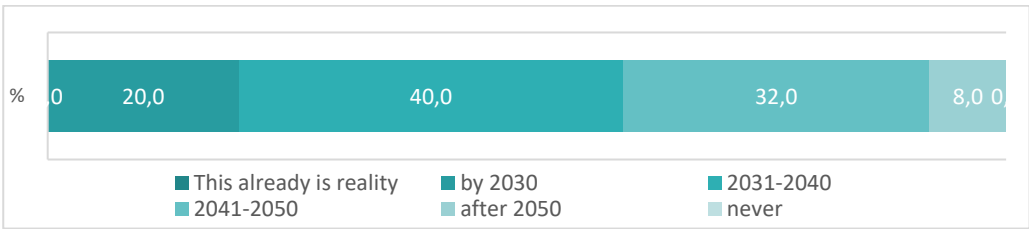
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.12: The yearly EU consumption of pulses for food (excluding soy beans) has increased to 3 million tons (up from 2 million tons in 2022).

Respondents

Expertise	n	%
Very high expertise	1	4,2
High expertise	7	29,2
Average expertise	11	45,8
Low expertise	3	12,5
Very low expertise	2	8,3
Σ	24	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	if novel meat replacements are counted in, i think this is possible by 2030 - maybe also 2031-3040 - also given the currently very low levels to start from.	Very high
by 2030	Pulses will be part of products from the category alternative proteins and will in general become more popular.	High
by 2030	This aim is related to EU and national policies. The usefulness of integrated policies at the scale of the EU makes senses. The treat could come from climate change and summer water shortages. Modelling and cooperation at the scale of the EU should help	Low
2031-2040	Consumption of processed foods may drive the demand in the shorter term. It might take longer for changing food habits/traditions ...	Average
2031-2040	Recent consumer surveys demonstrate that there is a growing interest in pulses, but at least a 15 year time lag is needed - particularly as we might see a drop in consumption in the meantime as the older generations that do eat pulses die off and the younger generations need to learn to include pulses in their diets.	High
2031-2040	only if the trend of reducing meat goes on	Average
2031-2040	It is not an easy prognosis. On the one hand, it is estimated that per capita meat consumption will decrease in the future, which would make me think that European citizens will consume more vegetable protein such as legumes. But on the other hand, it is estimated that the	Average

	EU population will only grow by +0.6 % by 2026, and then decrease until 2100. It seems that what is written in this statement could only be fulfilled if the consumption increases in that proportion to produce something exportable. Option was taken in order to provide this explanation.	
2031-2040	It is a generational change	Average
2031-2040	This should be possible within 10 years.	High
2041-2050	It is rather important also for soil quality.	Low
2041-2050	Pulses are an alternative to meat source of proteins. Nonetheless, efforts needs to be invested to educate consumers on how to prepare these dishes.	High
2041-2050	comes easy when meat consumption is reduced	High
2041-2050	every year: more Vegan and vegetarian	Average
2041-2050	There is a move in this direction already but it will be dependent on food processors using more pulses	Average
2041-2050	with appropriate policy measures this is possible	High
after 2050	Increased consumption of plant-based alternatives will likely spur some additional consumption of pulses in processed food products. The whole consumption of pulses is recommended as shifts towards healthier diets, and I could see this also contributing to a broader increase in pulses. Not sure if this would reach a 50% increase in aggregate, particularly with population growth in Europe likely to be fairly flat or declining over the next several decades.	Average

Interpretation

This statement received highly differentiated argumentations including from respondents with high expertise. The goal of increasing pulse consumption seems widely shared partly as part of the effort to reduce animal meat consumption but also for soil quality. Drivers are the rise of pulse based meat alternatives and processed food and impeding factor may be the lack of knowledge on preparing pulse-based dishes especially in younger generations as well as climate change and summer water shortages. In the long-term population decline in Europe will balance out the rise in the share of pulses so a rise in absolute consumption seems likely only if exports are included.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

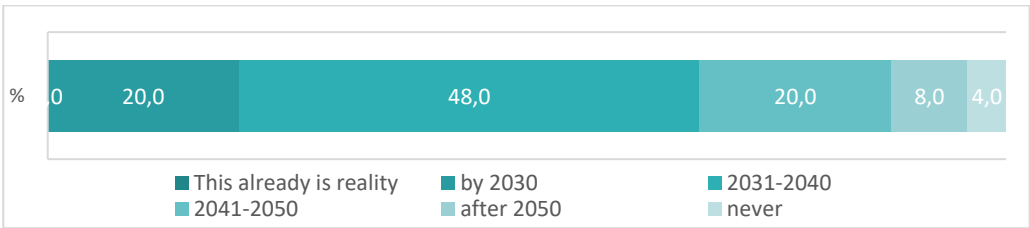
Normative Orientation	Assessment
Agreed	X
Contested	

Statement 6.13: More than half of European companies have integrated natural capital and biodiversity impacts and dependencies into their corporate decision making and risk assessment.

Respondents

Expertise	n	%
Very high expertise	1	4,0
High expertise	5	20,0
Average expertise	13	52,0
Low expertise	6	24,0
Very low expertise	0	0,0
Σ	25	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	Will perhaps differ for different countries but CSR related regulations are already making head way in industry. Essential to drive any transition.	Average
by 2030	The level of exposure and mechanisms available make changes in this area very rapid.	Low
2031-2040	The drive is already there to take natural capital and biodiversity into account. The big question is: to what extent will these efforts lead to real benefits for nature? - or just be an obligation - i.e. some paperwork to fill in.	High
2031-2040	The multi-nationals have already done this, but 95% of EU companies are SMEs - these companies are extremely difficult to influence, particularly in terms of integrating risk and impact assessments into their reporting.	Very high
2031-2040	in their reflections and risk assessment, yes, but in real decision-making later. There will be a lot of buzz wording and greenwashing here.	Average
2031-2040	I think it will go fast. But mostly greenwashing. Yes, it	Average

	will be included, highlighted on the website. But real decisions will stick to monetary benefits.	
2031-2040	...on paper, at least...	Average
2031-2040	depending on regulation	Average
2031-2040	it will happen formally. Minimum impact	High
2031-2040	once the digital infrastructure is there, this is easy to roll out at low costs.	Average
2031-2040	There is still little knowledge on the importance of biodiversity and natural capital and thus it will take some time to educate that many companies/people, even if regulated by the state.	High
2031-2040	Excellent goal, but green-washing is an Olympic sport! Steady efforts in incentives, social control, scientific studies, shaming of liars... will be needed to change mentalities and decisions in the major companies. The key is the fine tuning of reliable and world scale labelled indexes with an international office for studies and control. Another Commission for the UN? We could start by the UE scale.	Average
2041-2050	Perhaps I am a bit too optimistic here, but this should be done as soon as possible.	Low
2041-2050	It is a growing business	High
2041-2050	it's important for the image	Low
after 2050	There are a lot of small companies so if % is by number of companies it will take a long time. Different answer if by economic volume	Low

Interpretation

A clear majority of respondents sees this happening between 2031-2040. At the same time, many respondents point to the problem of "greenwashing" and doubt the benefits for nature. One respondent argues that: "Steady efforts in incentives, social control, scientific studies, shaming of liars... will be needed to change mentalities and decisions in the major companies". Another expert points to the specific challenge of influencing SMEs who make up a large share of European industry.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

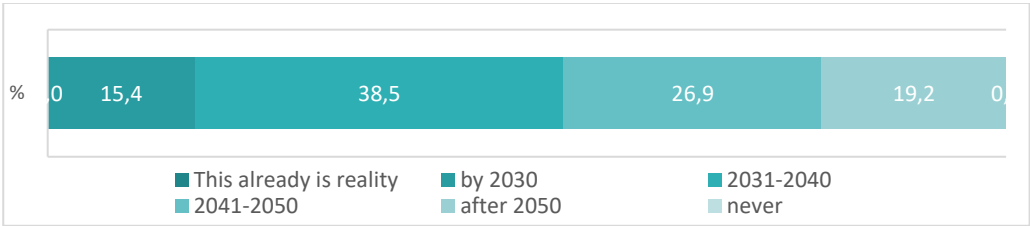
Normative Orientation	Assessment
Agreed	
Contested	X

Statement 6.14: Advanced internet based digital applications such as remote sensors for crop and livestock monitoring, data analytics and advanced planning and optimisation (e.g. via Farm Management Information Systems), control and execution of production with help of automatic machines (e.g. for milking) or robots (e.g. for weeding and harvesting), are used in more than half of farms in the EU.

Respondents

Expertise	n	%
Very high expertise	0	0,0
High expertise	9	34,6
Average expertise	14	53,8
Low expertise	2	7,7
Very low expertise	1	3,8
Σ	26	100,0

Time Horizon



Comments

Time Horizon	Comment	Expertise
by 2030	Looking out of my window, I see a drone flying past spreading pesticides.	High
by 2030	If this applies to formal commercial farms rather than borderline smallholdings that make up a lot of farming in certain cultures then this probably will be sooner.	Low
2031-2040	It will happen to some extent very soon. New services are developed at present. How much each farm is using the suite of possibilities is another question.	Average
2031-2040	If there are subsidies for the adoption of these technologies, many farmers will most likely adopt them because they are already on the market and don't require too much changes in how the farms (fields) are physically arranged/organized.	Average

2031-2040	in medium-sized and large farms this is already the normal	High
2031-2040	What I experienced, that some large farms already apply such techniques, like spraying from drones. But for family farms, the costs are c. double of what is manageable.	High
2031-2040	Besides several studies and prototypes were already developed I think that we need a decade to move on in this field	Average
2031-2040	It depends on the percentage they are used within one farm. To a certain extent a lot of farms will have digital help for one or the other task.	High
2031-2040	Technology has to remain a tool under the control of a person. Several activities must remain also done by human being in order to keep a link with nature. Boring and tiring activities can be secured by robots under the control of AI. But the noble part of these activities has to still be operated by human beings. Ethics of this evolution have to be developed and broadly explained. The EU should take care not to lose its soul in the relationship with Nature. How can you celebrate Gaia and replace peasants by robots? We still need shepherds, in the mountains, in the plains, on the coast, and at sea!	Average
2031-2040	Key to transition to sustainable and economically viable farming. EU should invest heavily in this.	Average
2041-2050	Smart farms are becoming a reality because they are more sustainable, have less impact on the environment, are more profitable and produce higher quality products, using less space and fewer resources. It is credible that in 10 to 15 years we will be at the levels established in this statement.	Average
2041-2050	it gets more and more important for farms	Average
after 2050	depends on the definition of a farm. I doubt that small farms will ever adopt these technologies. It will be different if we consider agricultural area. In this case I could say that more than 80% will adopt some of these technologies by 2040	High
after 2050	Average European farms are too small	High
after 2050	There are a lot of small farms in the EU I am not sure this is a sensible metric - should be by value	High

Interpretation

Most respondents expect the rise of such systems by 2031-2040 or at least by 2050, some argue that this could happen even before 2030. It is pointed out that medium-sized and large farms are already using these systems and technologies are available. At the same time, several respondents argue that small family farms that make up a large share in the EU are less likely to adopt these technologies partly due to the high costs.

There are also opposing views on the desirability of this goal. One respondent points to the danger of “losing soul in the relationship with Nature”. Another respondent argues “Smart farms are more sustainable, have less impact on the environment, are more profitable and produce higher quality products, using less space and fewer resources”.

Categorisation

Time Categories	Assessment
Near-term challenges (now and by 2030)	
Mid-term challenges (2030-2050)	X
Long-term challenges 2050-never	
Inconclusive	

Normative Orientation	Assessment
Agreed	
Contested	X

Conclusions

Several statements in this cluster evolve around the impact of human activities especially food production but also tourism on ecosystems on land and water. Respondents emphasised that while there will always be an impact we need to strive to minimise it to levels that allow ecosystem regeneration. The challenges involved are massive and several respondents are doubtful whether they can be addressed even in the long term, partly due to the lack of sufficient will from powerful actors.

On the other hand, some of the approaches such as shifting towards more sustainable diets, uptake of sustainable farming practices and tourism seem to be more realistic in the mid-term mainly driven by changing social attitudes.

To sum up the goals of this cluster were largely seen as mid to long-term challenges with substantial need for action especially for policy. Research and innovation with attention not only to technologies but also to cultural and social practices can make important contributions.

3.8. Crosscutting Observations

Table 4: Distribution of statements across time categories

Time Categories	Assigned Statements	#Total ²
Near term challenges (now and by 2030)	2.3, 2.7, 3.6	3
Mid-term challenges (2030-2050)	All other statements	27
Long term challenges 2050-never	1.6, 2.2, 2.5, 2.8, 4.1, 4.2, 4.7, 4.11, 5.1, 5.8, 5.11, 6.1; 6.2, 6.5	14
Inconclusive (strongly diverging or unclear assessments)	1.3, 2.1, 2.4, 2.6, 3.1, 3.3, 4.4, 4.5, 4.6, 6.3, 6.6	11

Table 4 summarises the classification of statements according to our timing categories. Most statements are within the expected range of 2030-2050. Fourteen statements however have been assessed with a longer time horizon or even as never to be realised while only three statements were assigned to the category of near term challenge.

Table 5: Distribution of statements across normative orientation categories

Categories	Statements	#Total
Agreed	All other statements	45
Contested	1.1, 1.3, 1.4, 4.5, 4.11, 5.4, 5.10, 6.6, 6.13, 6.14	10

Table 5 shows the categorization of statements according to the normative orientation. It can be seen that for most statements there is general agreement on the normative orientation indicated in the workprogramme. Only for ten statements, opinions of commenting experts on the normative orientations are diverging.

3.9. Lessons for future-orientation of the workprogramme

As shown by the assessment above, roughly half of the statements fall in categories that are well in line with the targets of the EU research framework programmes and the underlying strategic plan. This comprises the mid-term challenges as well as the statements with broad agreement on the normative orientation. In order to draw lessons for the workprogramme development we will therefore focus on the statements with “extreme assessments” that may hint at useful learnings for further WP development. This comprises 27 statements falling into the groups indicated in Table 6 below.

² Statement 4.9 was not allocated due to its ambiguous formulation, which is why the total number of Statements sums up to only 55

Table 6: Groups of statements to be analysed further

Group	Statements	#Total
Near term challenges (now and by 2030)	2.3, 2.7, 3.6	3
Long term challenges 2050-never	1.6, 2.2, 2.5, 2.8, 4.1, 4.2, 4.7, 4.11, 5.1, 5.8, 5.11, 6.1, 6.2, 6.5	14
Contested Normative Orientation	1.1, 1.3, 1.4, 4.5, 4.11, 5.4, 5.10, 6.6, 6.13, 6.14	10

For these 27 statements, we will look into the original formulation in the work-programme and discuss implications arising from the Delphi assessments and comments. In doing so we will no longer analyse the results alongside the clusters but rather look at groups of statements with a similar kind of assessment together.

3.1 Lessons from near-term Challenges

For three Delphi statements a majority of participants argued that “this is already reality” or „will be achieved by 2030“. In this section we discuss these “near term challenges” in the order of total share of both these categories combined.

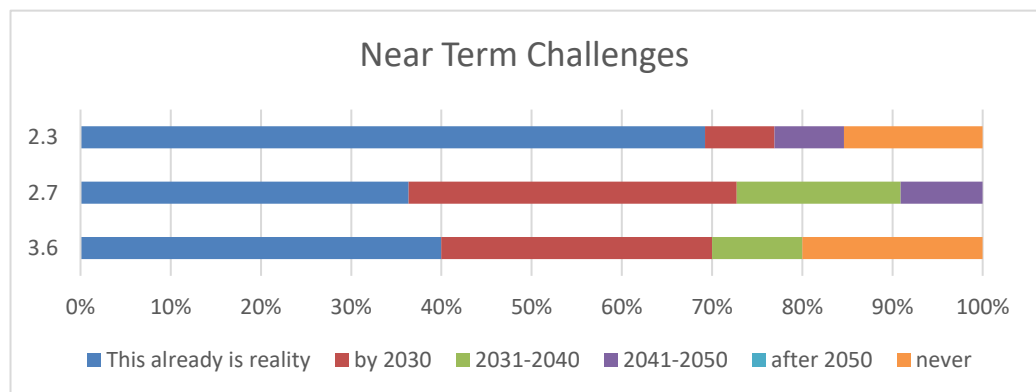


Figure 11: Overview assessment of near term challenges

Statement 2.3 Europe is a world leader in cultural heritage research and innovation.

Expert assessment:

This statement received the highest rate of “this is already the case” of all statements. Respondents judge Europe as one of the key actors in cultural heritage research. Still as was pointed out by one of the respondents “there is always room for improvement”.

In particular, as another expert emphasises, the excellence could be spread more across EU countries to better reflect its rich diversity of cultural heritage. Even though Europe is seen as already excellent, striving further in this area is seen as a worthy goal.

Original function in the workprogramme

The original quote from the workprogramme “Culture, creativity and inclusive society” is “Because it possesses a vast, varied and outstanding cultural heritage and can count on the high quality and numerous skills of its citizens, Europe is in the right position to become a world leader in cultural heritage research and innovation.” p.104

This was part of an argumentation for the grant for organising the Presidency event - Conference 'Cultural Heritage, a chance for Europe' which addressed the following four topics:

- A reflective heritage for a resilient society
- Sustainable management of cultural heritage
- Cultural heritage in a changing context
- Cultural heritage facing climate and environmental change.

Conclusion

The fact that experts see European leadership as already achieved does not compromise the value of organising such a reflective event in any way. Still, as emphasised by one of the respondents, excellence drives the quest for even more insights and perspectives.

Therefore, one could venture to ask, what is the deeper motivation of world leadership in cultural heritage research, who is competing against Europe in cultural heritage research and why is Europe better off by beating this competition? If the underlying motivation is primarily better conservation efforts, then leadership may not be the most important aspect to pursue.

Statement 2.7 The EU establishes minimum standards for the protection of cultural heritage in its territory.

Expert assessment

This statement ranks among the most “realistic” as none of the respondents thinks that it will never become reality. The comments show that the assessment depends highly on the definition of “minimum standards”. One person with high expertise maintains that such minimal standards are already in place while another points to major efforts required and expects realisation only within the 2040s.

Original function in the workprogramme

The original text from the workprogramme “Culture, creativity and inclusive society” is: “Through all these activities, research and innovation will underpin the European Union’s leading role in protecting, preserving and enhancing Europe’s cultural heritage and scale-up the competitiveness of its cultural and creative industries.” p.38

The sentence was part of the introduction for the destination: “Innovative research on the European cultural heritage and the cultural and creative industries”. In order to make this statement more tangible for assessment of time Horizon we had selected minimum standards as one concrete manifestation of such a leading role.

Conclusion

The fact that experts think that such standards are already in place shows that we did not succeed in developing an adequate indicator for the success of this expectation. In addition, the notion of “minimum standards” is probably too vague. Experts’ comments seem to indicate that the goal as such is an adequate one to be addressed with a mid- to long-term perspective. At the same time, the comments in statement 2.7 (all from high experts) questioned the leadership of the EU as well as the notion that EU R&I will underpin this leadership. It could be argued that the importance of the EU in this area in relation to other actors such as Member States or other International Organizations like UNESCO is perhaps overestimated.

Statement 3.6: Criminal use of end-to-end encryption in social media is posing a major challenge for law enforcers trying to prevent cybercrime.

Expert assessment

The assessments of this statement are rather diverse. Four people think that this is already reality and three expect it within the next ten years. One person with high expertise confirms the issues and states that there may be solutions. On the other hand, two people have indicated “never” as a time horizon. The comment of one of them indicates a possible reason: Even though one can expect the use of encrypted media by criminals, this may not be seen as posing

“major challenges” as much more severe threats are emerging from other types of cybercriminals that do not use social media to communicate.

To sum up, this is most likely a near and mid-term issue but its importance needs to be assessed in the context of the full spectrum of cybercrime. Also it is important to note that ethical considerations are relevant here that require societal deliberations so if this is to be addressed by STI social sciences and humanities would have an important role to play.

Original function in the workprogramme

The statement was derived from the workprogramme “Civil Security for Society”. The original quote is: “Software-based communication technologies such as 5G and beyond will bring many benefits but also pose a number of new challenges for the police and the judiciary. In particular, lawful interception systems will have to adapt to the increased use of encryption including end-to-end encryption, to edge computing that might limit the availability and accessibility to relevant data and to slicing technology that will multiply the number of virtual operators. In addition, high bandwidth access networks pose the challenge for police and the judiciary to be able to cope with tremendous amount of data and will accelerate the switch to application level communication that are commonly used by criminals.” p. 22. This was part of the scope for the call “HORIZON-CL3-2021-FCT-01-02: Lawful interception using new and emerging technologies (5G & beyond, quantum computing and encryption)”

Conclusion for workprogramme development

The fact that many experts think that this problem is already virulent does not diminish the relevance of the call. Rather it confirms the urgency. The hint of the expert that social media may not be the most important means of communication to be investigated here is indeed addressed by the call which does not focus on social media alone. A key question here is whether the programme can make a meaningful contribution to solving the problem – with the budget and procedures available to it. Interestingly the high expertise comment is that law enforcement is not well equipped. It is not that there are no technologies for solving this problem.

3.2 Lessons from long-term Challenges

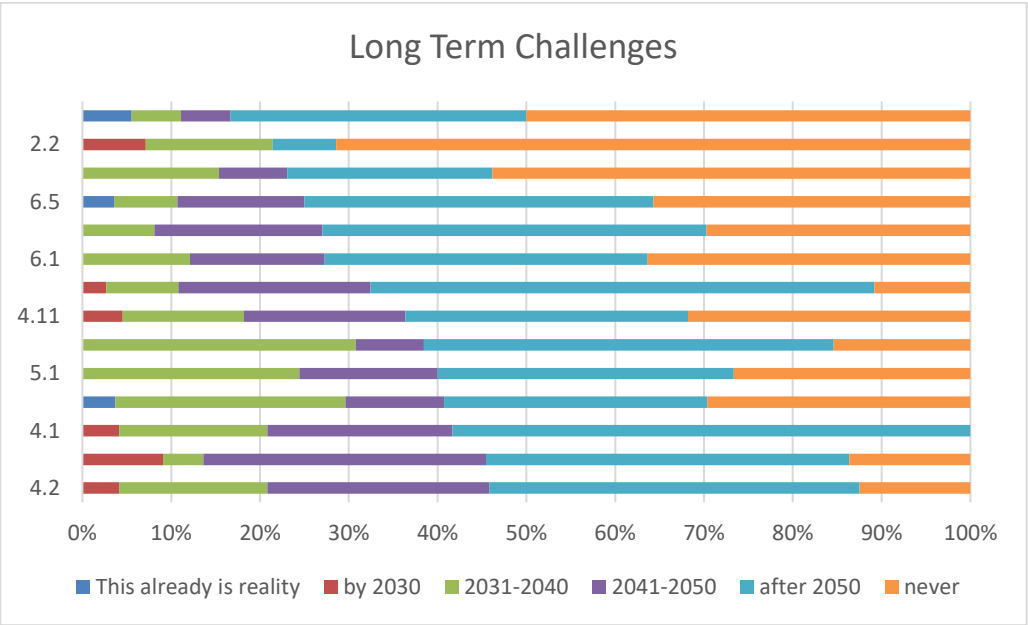


Figure 12: Overview assessment of long-term challenges

For fourteen Delphi statements a majority of participants expect this to become reality only after 2050 or even never. We discuss these “long term challenges” in the order of total share of both these categories combined as visualised in Figure 12.

Statement 1.6: Antibiotic resistant bacteria are no longer a major health threat in Europe."

Expert assessment

The great majority of respondents consider antibiotic resistant bacteria to be a major health threat in Europe at least until 2050 and even for good. The pipeline for new antibiotics is expected to be too small to outrun AMR evolution. Those who responded never, seem to consider bacteria will always change and thereby create new threats worldwide. At the same time, devising effective prevention and control measures and improving the surveillance of antibiotic-resistant infections will prevent antibiotics to become less effective. Some respondents call for more political commitment for investment in R&D, cross-sectional regulations for One Health and cross-border actions to reduce AMR.

Original function in the workprogramme

The workprogramme “Health” states that “The increasing levels of AMR present a major threat to human health with serious consequences also to animal and environmental health.” on page 78. This is the first sentence for the scope of the call “HORIZON-HLTH-2021-DISEASE-04-05: A roadmap towards the crea-

tion of the European partnership on One Health antimicrobial resistance". p.78. While this is clearly an expectation about the future, it is very general and certainly uncontroversial. For this reason, for the Delphi study we turned it around to see if experts expect a solution for this threat within reasonable time horizon.

Conclusion for workprogramme development

The fact that experts assess this threat as long term does not diminish the value of addressing this issue in a framework programme call. To the contrary, the type of "One health" approach promoted by the call is exactly along the lines requested by the experts. At the same time, the open nature of this challenge could be more acknowledged in the workprogramme.

Calls of this type should acknowledge the evolving nature of this threat rather than attempting to "solve" it. It could make sense to integrate an element of Foresight into the One Health perspective to continuously revise anticipatory assumptions and expectations in a reflexive manner.

Statement 2.2: European societies are so inclusive that no group in society considers itself unfairly excluded.

Expert assessment

As it was to expected, this "idealistic" statement received a high rate of "never" assessments and nobody thinks that this is already the case. Several challenges are mentioned, among them most prominently immigration which was singled out as a remaining challenge by three respondents. As underlying impediments respondents point to lack of participatory governance, the dominant economic paradigm and the digital divide between generations. Still none of the respondents questions the goal in principle and some even see it as achievable albeit in a long time horizon. Overall, one could say that the issue of inclusion was confirmed as valid long-term goal, that may however well be never fully achieved. This could be seen as a problematic tension especially if the open character of this goal is not acknowledged.

Original function in the workprogramme

"Access to experience with cultural heritage contributes to social cohesion and inclusion, by strengthening resilience and the sense of belonging, bringing people together and improving well-being." p 37

This is a sentence in the introductory text of the destination: innovative research on the European cultural heritage and the cultural and creative industries.

Conclusion

The experts' assessment confirms social cohesion as a key long-term goal, but points to the major challenges which are however located in politics and NOT in cultural heritage which has possibly been given too much importance here.

Nevertheless, comments suggest that the emphasis on participatory governance and inequality could be strengthened in future workprogrammes.

Statement 2.5: Migration no longer figures among the top issues on political agendas in Europe.

Expert assessment

The majority of respondents believes that this assertion will never become reality while nobody thinks that this is already the case or will become true in the next ten years. Influencing factors mentioned are climate change, environmental factors, worldwide population growth, socio-economic imbalance and current framings of the issue in politics. Still, respondents who have commented on their answer seem to confirm this as an important goal.

Original function in the workprogramme

"Migration has been a critical component of the makeup of European societies, one that is likely to dominate policy and political agendas for many years to come." p.71

It was part of the introductory text for the destination: "innovative research on social and economic transformations". The respective call in this destination is setting up a stakeholder network in order to provide "estimates of irregular migrants in Europe".

Conclusion

The assumption stated in the workprogramme is actually the opposite of our Delphi statement.

Therefore, the critical experts' assessment confirms the assumption made in the workprogramme that migration is likely to dominate policy and political agendas for many years to come and also the need to address this issue. There are however few indications about the role R&I could play.

One expert comment implies that the framing of migration could be an important aspect to tackle: "This will only start materialising when migration will be positively re-framed and channelled for economic growth, so that HR induced migration and labour migration and be more clearly differentiated and steered".

To sum up we conclude that the survey confirms the importance of this topic. In future programmes it may be useful to address the framing of migration in the policy discourse.

Statement 6.5 In the EU human activity has become biodiversity-neutral.

Expert assessment

Assessments and arguments mirror statement 1 & 2 respondents doubt that human activity will ever become biodiversity-neutral with the result that a large share has voted "never". At the same time, there is wide agreement that reducing impacts as much as possible is an important goal, which faces steep barriers resulting in a majority assessment that significant progress will be achieved only after 2050. Positive signs mentioned are efforts for rewilding and restore naturalness of habitats and the fact that biodiversity is high on the political agenda. Some respondents point to the need for good indicators for measuring this impact and a definition of baseline levels.

Original function in the workprogramme

The original text from the workprogramme "Food, Bioeconomy, Natural Resources, Agriculture and Environment" is as follows: "Research and innovation can enable these transformative changes to happen and initiate processes, behaviour changes and actions which are transforming the way we impact biodiversity" p. 24. It is part of the introductory text under the Destination – Biodiversity and ecosystem services under the headline of "Enabling transformative change in biodiversity".

Conclusion for workprogramme development

There is a clear tension between experts' scepticism and the assumption of the workprogramme's that transformative changes can be achieved by R&I. A number of comments provide useful hints that could inform future WP development in going deeper into the challenges involved in changing the way we impact biodiversity:

- Need to think in more depth about the desired state of ecosystem and the role of biodiversity: Experts question the definition of biodiversity. They ask is it about "halting the further degradation of our own natural systems" or are we aiming to go back to previous states or else to an entirely new state. As another expert emphasises there is a need to "shape and secure the appropriate indicators".
- Need to address land management practices: Experts stress that this goal "also depends on certain kind of land management applied today". One expert specifies that "Biodiversity needs SPACE, and if we do not stop expanding urban areas, we will not be biodiversity-neutral".
- Need to think beyond EU as "we are importing a lot of degradation through the externalities of our imported goods"

Statement 5.11: Aviation has become climate neutral (without using carbon offsets for compensation).

Expert assessment

The clear majority consider aviation to become climate neutral (without using carbon offsets for compensation) only after 2050 or never. Some anticipate continuing growth of air travel, while others question its future competitiveness, especially within Europe, and anticipate a possible reduction of flights. Views disperse on the technological maturity of alternative fuel solutions like hydrogen. Some perceive that regulations will be needed at a global scale in order to avoid unfair competition due to air travel emissions mitigation measures.

Original function in the workprogramme

The original quote from the workprogramme is as follows: "Aviation's global economic impact, before COVID-19, was more than €2.4 trillion per year, while the European one was more than EUR 700 billion per year. However, the environmental impact, although in absolute terms small, it is projected to increase towards 2050 to a level that is not compatible with the Paris Agreement, if action is not taken now." p. 299

The quote is part of the introductory text of the Destination "Clean and competitive solutions for all transport modes" under the section aviation. As the destination targets a significant reduction of aviation's climate impact we had turned this around into a positive statement for the Delphi survey.

Conclusion for workprogramme development

The fact that a substantial share of experts does not believe in the possibility of the aviation sector becoming carbon neutral without offset within the timeframe needed to comply with the Paris climate goals should be taken into account within the next workprogramme development.

Some of the comments suggest to focus on the need to drastically reduce the number of flights e.g. through a shift towards train transport for shorter distances, as is already being discussed at the EU level but also through moving away from place holder flights and private aircraft used by the super wealthy. An important consideration must be the very long investment cycle of airlines. This cycle is affected by potential regulation much more than by potential technological advances in fuels, batteries and propulsion techniques

Statement 6.1 In the EU agri-food production no longer places pressure on natural ecosystems.

Expert assessment

On this statement, we have received assessments and comments from respondents with very high and high expertise. The issue of agricultural ecological footprint is clearly assessed as a very long-term challenge. Not one respondent thinks that this will be addressed by 2030 and only few believe in a solution by 2040.

Many experts state that food production will always exercise pressure on the environment to some extent. Instead, experts modify the goal into minimizing the pressure to an acceptable level that allows ecosystems to regenerate.

Even for this more modest goal however respondents voice grave concerns and point to substantial barriers such as vested interest of polluting industries, inertia in the agri-food system, the fact that both consumers and retail need to change their behaviour, financial constraints faced by farmers, population growth, mentalities, populism, stranded assets and nitrogen losses. Many respondents expect that overcoming these barriers will take a long time beyond 2050 even though solutions are in principle available. Explicitly mentioned are: Multi-trophic smart farms, vertical farms, recirculating systems (RAS), pesticide free agriculture, aquaponics and new ones that are truly circular economy.

Some experts also highlight strong external driving factors that could accelerate change such as increasing crises, already ongoing transition and in the long term a peak in the global population. One respondent with very high expertise highlights that there is significant enough work in niches that might eventually work to eliminate the pressure on natural ecosystems. Another expert states that the EU could play a major model role for the rest of the world.

Original function in the workprogramme

"The implementation of agro-ecological approaches will alleviate the pressure that agri-food production places on natural ecosystems, contributing to resilience of agri-food systems and facilitating nature-based responses to current and future agri-food risks and threats." p. 221

This is part of the scope for the call HORIZON-CL6-2022-FARM2FORK-01-12: Agro-ecological approaches in African agriculture systems.

Conclusion

The actual workprogramme statement does not expect elimination but rather alleviation of the pressure agri-food production places on ecosystems. Several of the aspects mentioned by the experts such as behavioural change across the value chain are addressed by the call. One should be aware however that a number of aspects that are not addressed by the call and are in fact beyond the reach of R&I are relevant to achieve this goal so the impact of R&I may be limited. This means that in spite of the possible alleviation through agro-ecological

approaches it remains uncertain whether pressures will ever reach an acceptable level.

Statement 5.8: The global waterborne transport sector has eliminated all its greenhouse gas emissions.

Expert assessment

The majority of respondents consider the global waterborne transport sector to have eliminated all its greenhouse gas emissions only after 2050 or never. Some consider batteries are not relevant for long distance, biofuels production will be limited for sustainability reasons and electro fuels are expensive and their effectiveness for as a large mitigation option remain highly uncertain.

Others note hydrogen and its use through fuel cells as promising having already been standardised, and perhaps for short journeys the energy stored in batteries will work.

One respondent considers that foreign fleets (e.g. Chinese) may be slow to convert and ship ownership/registration mitigates rapid change. Another respondent notes that the mitigation is only effective when targeted globally.

Original function in the workprogramme

The original formulation in the workprogramme Climate, Energy and Mobility is stating:

"Other than for short distances, waterborne transport is expected to become climate neutral mainly by the introduction of alternative, sustainable, and carbon-neutral fuels, by massive efficiency improvements and through related technologies for the fuel's use in propulsion and power generation on-board."
Page 325

This is part of the scope for the call HORIZON-CL5-2021-D5-01-09: CSA identifying waterborne sustainable fuel deployment scenarios (zero-emission waterborne transport ZEWT Partnership).

Conclusion

The analysis implies that the goal that is set in the call is extremely hard to achieve. On the one hand, this confirms the high importance of the call's approach of developing different clean fuel scenarios for specific waterborne segments and geographical areas and involving stakeholders to identify critical barriers. One key aspect to consider here would be a global effort towards standardisation and regulation in this sector.

At the same time, it indicates that in order to achieve the climate goals, reduction of waterborne transport needs to be considered as well.

Statement 4.11: EU`s industrial base has diversified its supply chains so widely that it has no critical material and technology dependencies anymore.

Expert assessment

Respondents are largely sceptical of getting rid of all critical dependencies. In line with this, a large majority expects this never or after 2050. Three respondents with very/high expertise give good reasons for their “never” assessment by stating that no country and especially not European ones with their lack of many resources will be able to become fully independent as important products depend on imports. At the same time, there are well-founded arguments that strategic autonomy will be reached in the sense that critical dependencies on single actors can be avoided. Some respondents are confident that this can be achieved within the next twenty years. Enabling factors mentioned are leadership and policies but also the collaborative capacity and creativity of European innovators in particular SMEs. Finally, it seems that in spite of the negation of full autonomy the issue of risk diversification is seen as highly critical up to the point that without it “there will [be] no Europe”. Still, some respondents emphasise that this is “more hope than founded expectation”. To sum up, there seems agreement that strategic autonomy is a goal worthy to pursue but that will never be fully attained. It seems important to focus this debate on diversification rather than on full elimination of critical dependencies. Interpreted in this sense, it is clearly seen as a key issue requiring political attention and creativity from all actors including RTI ones.

Original function in the work programme

“Research and innovation will be fundamental to spur industrial leadership and enhanced resilience. It will support the modernisation of traditional industrial models while developing novel technologies, business models and processes. This can enhance the flexibility of the EU’s industrial base, and increase its resilience by reducing EU dependencies on third countries for critical raw materials and technologies.” p. 90

This was part of the introductory text from DESTINATION – INCREASED AUTONOMY IN KEY STRATEGIC VALUE CHAINS FOR RESILIENT INDUSTRY in the work programme Digital, Industry and Space.

Conclusion

The expert assessment largely confirms the importance of reducing critical resource dependence on single actors. It does however suggest to focus less on securing access but more on diversification of options in line with risk management strategies commonly adopted in business. Diversification is mentioned in the workprogramme mainly in connection with Building EU-Africa partnerships. A learning for the workprogramme may therefore be to continue and even strengthen calls of the type of EU-Africa collaboration in further workprogrammes along with other measures focussing on diversification both of raw material use and sources. The assumption from the destination text that R&I

will substantially contribute to reducing EU dependencies remains untested by this survey.

Statement 2.8³: The spread of urban sprawl has been halted, giving way to settlements in line with the principles of environmental, social, cultural and economic sustainability.

Expert assessment

In this statement, there is a striking agreement among respondents with high and very high expertise. They all think that establishing sustainable models of human settlement will take decades and remain a continuous challenge beyond 2050. Two answers mention house prices and wealth generation in the housing sector as important drivers. None of the respondents thinks that this is reality or will be solved in the near future. Some respondents however see a realisation already before 2050.

Original function in the workprogramme

This statement originated from the cluster 6 workprogramme and was placed in this section in order to get social science expertise on this assumption. The original text was:

“Land use and management has a key role to play in Europe in terms of boosting carbon storage, producing biomass for the bioeconomy, reducing urban sprawl and attaining the objective of climate neutrality by 2050 while ensuring food and nutrition security, biodiversity commitments and well-being in general.” p. 471

The paragraph is part of the scope of the call “HORIZON-CL6-2021-GOVERNANCE-01-13: Modelling land use and land management in the context of climate change”. The call requests research to *„work on land use dynamics and explore the effects of policy measures that can influence such dynamics”*. The emphasis is on agricultural land use.

Conclusion

The experts’ assessment confirms the need to better understand the dynamics of change in land use as a highly relevant long-term challenge. While the workprogramme is focussing on agricultural land use, the expert assessment indicates that within future workprogrammes it may be worthwhile to look more specifically also into the dynamics of (sub)-urban sprawl as this phenomenon may be there to stay for a long time. In any case, it seems advisable to recognise the dynamics of slow change as well as the high uncertainty in this domain and design activities accordingly.

³ Statement originated from cluster 6

Statement 5.1: Final Energy consumption (i.e. the total energy consumed by end users, such as households, industry and agriculture) in Europe has fallen by 40% compared to 2022.

Expert assessment

The clear majority considers that final energy consumption in Europe will not fall by 40% compared to 2022, or if it did it would have to be after 2050. Respondents tend to note that technological solutions are not enough for curbing energy demand and there are no major signs of needed behavioural changes and international companies may try to block such developments.

Technological opportunities to curb energy demand mentioned include, for instance digitalization in the consumption of goods and services and the conversion to electricity in heating (heat pumps) and mobility (electric vehicles and e-micro-mobility). The need for strategies connecting the policy and practice is perceived by some respondents.

Original function in the workprogramme

"The transition of the energy system will rely on reducing the overall energy demand and making the energy supply side climate neutral. R&I actions will help to make the energy supply side cleaner, more secure, and competitive by boosting cost performance and reliability of a broad portfolio of renewable energy solutions, in line with societal needs and preferences." p. 129

This text was part of the introduction of the Destination– Sustainable, secure and competitive energy supply.

Conclusion

On the face of it the point here is that if the transition of the energy system relies on a reduction of energy demand as stated in the destination, the transition is not really feasible because the requisite reduction will simply not happen. Experts think that the energy transition needs a great deal more effort than they expect governments, industry and society at large to put into the project EU R&I is not going to make much difference unless it is very well plugged into necessary market reform efforts and work on standards and demonstrators.

Statement 6.2: In the EU use of the seas and inland waters and marine resources no longer places pressure on natural ecosystems.

Expert assessment

A majority of the respondents stresses that human activities will always place pressure on natural ecosystems so this statement may never be realised. Still, the way to go is to minimize the pressure and allow regeneration, as much as possible but even this faces severe hurdles and will take longer than 2050 in many respondents opinion. It is pointed out, that on the one hand the depletion of ecosystems is even more severe on water than on land, on the other hand

measures such as banning trawling and catch quota can be highly effective. One expert with very high expertise calls for a specific global programme for the EU.

Original function in the workprogramme

"The potential of marine resources and biotechnology will contribute to the coming "blue economy", accelerating the transition towards a circular and climate-neutral economy that is sustainable and inclusive. The concepts of the circular economy, bioeconomy and blue economy converge and altogether provide an opportunity to balance environmental, social and economic goals, with their sustainability ensured by the life cycle assessment approaches." p242

This is part of the introductory text for the destination "Circular economy and bioeconomy sectors".

Conclusion

The workprogramme does not talk about absolutely relinquishing human pressure on marine ecosystems, rather it aims at circularity, climate neutrality and sustainability. This is in line with the more moderate ambitions put forward by respondents. These R&I activities will need to be complemented by policy measures such as banning trawling and reducing catch quota. Also, it seems important to reflect on the underlying notion of ecosystem and define what is actually meant by "Sustainable ecosystems". The incorporation of the natural world into the human economy seems to create pressures that are not easily alleviated by policies even if they are aiming for circular or even regenerative economy designs. Accordingly, a much more fundamental rethinking of human ecosystem interaction may be required.

Statement 4.1: More than 80% of products in the market are made from recycled resources.

Expert assessment

This statement is unique in that not one respondent completely dismissed the possibility that this will happen but a large majority expects this only after 2050. The comments provide convincing reasons why 80% of recycled products is a very ambitious goal including from three respondents with high and very high expertise. They emphasise the complexity of products and subsequent supply chains and the lack of adequate infrastructure as reasons for long time to change production and consumption patterns. Also two respondents highlight people's mind-sets as an important factor impeding change. Interestingly two respondents mention that by 2050 scarcity situations may enforce the realisation of this statement.

Original function in the workprogramme

"Research and innovation will be fundamental to create the new products, services and business models needed to sustain or enable EU industrial leadership

and competitiveness, and to create new markets for climate neutral and circular products.” p 19.

This was a sentence from the introduction for destination CLIMATE NEUTRAL, CIRCULAR AND DIGITISED PRODUCTION. The notion of “circular products” is prominent also in other parts of the workprogramme.

Conclusion

Experts assessments confirm that the establishment of truly circular products is a very long-term challenge that is however not altogether unrealistic. It seems therefore well placed within an ambitious R&I programme. Many of the barriers mentioned by the experts such as e.g. reconfiguration of supply chains is also addressed in the calls. Some aspects however such as the lack of supporting infrastructures and suitable mind-sets may be less addressed.

The survey suggests that challenges may be even broader than addressed by the call. In particular, infrastructures and mind-sets for circularity could be worthwhile to look into.

Statement 4.7: After successful decarbonisation of the European energy system, energy in Europe is abundant and supply is stable.

Expert assessment

This statement has received rather sceptical assessments from half of the respondents. Three respondents think that carbon free energy will never be abundant in Europe. After decarbonisation, experts expect that even stable supply will be a challenge and much more abundance. The decarbonisation itself however is seen as the biggest challenge. Most experts think that if it will happen at all, it will take a long time. A slightly smaller group of respondents is more optimistic. They stress the potential of cooperation among Member States and investment initiatives such as the EIB agreement to drive this forward. In any case, this is clearly seen as a policy challenge, demand for R&I is not explicitly mentioned in the comments.

Original function in the workprogramme

“Flexibility solutions are key to achieve a renewable energy share to deliver the EU Green Deal objectives and which goes significantly beyond the current target of 32%. In the coming years, EU industries will need to adapt to the increased fluctuations in energy supply caused by the higher penetration of variable energy sources.” p. 59

This paragraph opens the scope for the call “HORIZON-CL4-2021-TWIN-TRANSITION-01-21: Design and optimisation of energy flexible industrial processes (Processes4Planet Partnership)”. The call addresses flexibility of industrial processes rather than the energy system itself.

Conclusion

The sceptical assessment of sustainable energy abundance by our experts indicates that we should be cautious in assuming abundance of carbon free energy when designing future industrial processes. This call is exactly addressing this issue by pushing for greater flexibility of industrial processes to be better prepared for times of scarcity. For the workprogramme this implies that this line of research should be strengthened. At the same time results imply that decarbonisation of industrial processes cannot rely on availability of renewable energy e.g. clean electricity. Therefore, other decarbonisation pathways including reduction of energy consumption and switch to different processes need to be pushed in parallel.

Statement 4.2: European industry is fully decarbonised.

Expert assessment

The EU has the ambition to combat climate change and decarbonise its production and consumption patterns. A large share of respondents sees this happening only after 2050. Three respondents opted for "never". Comments indicate that the reason for this may be the vagueness of the term "decarbonisation". Two comments indicate that appropriate policy framework conditions could achieve this within 20 years. Two others doubt that policy focus on this is sufficient and point out that EU measures are too slow. Overall most experts stress the importance of policy measures such as legislation and financial incentives. To sum up, respondents agree on the urgency of this goal and on the enormity of the challenge. Assessment on whether and when the goal can and will be achieved differ. Only half of the respondents think that this will be achieved before 2050.

Original function in the workprogramme

The Delphi statement was based on the following paragraph which stemmed from the scope section of the call HORIZON-CL4-2022-TWIN-TRANSITION-01-17: Integration of hydrogen for replacing fossil fuels in industrial applications:

"The integration of hydrogen into new production routes, the direct use of hydrogen for heating and the use and production of GHG emission-free hydrogen instead of carbon-intensive hydrogen will be fundamental to decarbonise EU industry across a number of sectors." p. 88

Conclusion

The expert assessment confirms the decarbonisation of EU industry as a highly relevant long term goal. It points to the many severe challenges involved in realising this goal with policy measures to speed up deployment of technologies at the core. The survey indicates that the main challenge is to accelerate technology deployment while R&I may be a minor factor compared to policy measures creating adequate framework conditions.

3.3 *Lessons from contested Statements*

This section looks at the statements where experts questioned the normative orientation of the state of things described in the statement, i.e. critical assessment of stated goals or threats within the statements. As the assessment of the normative orientation of the statements has no direct relation to the assessment of their time categories, we discuss the statements in the order they are listed in the cluster index.

Statement 1.1: Using objective biomarkers has substantially improved mental health outcomes.

Expert assessment:

Most of the respondents perceive using objective biomarkers to have substantially improved mental health outcomes somewhere between 2030 and 2050. Focusing only on biomarkers in improving mental health may threaten more integrated approaches to mental health. Biomarkers are already known in depression and schizophrenia, and they could potentially improve the analysis. However, further development, clinical trials and commercialisation are needed, and this takes time. Nevertheless, 17% considered this is already the case, though no comments seem to support this. The development of biomarkers may help the analysis of mental health, but the correct treatment and improvement of mental health require also other advances including addressing the social issues. The goal on biomarkers is contested by some respondents, as being too fixated on technology, when there is a need for more holistic care.

Original function in the workprogramme

"A deeper molecular and neurobiological understanding of the interplay between genetic, epigenetic and environmental risk and resilience factors, including neural circuit alterations, is critical for the development of objective biomarkers and evidence-based interventions that will significantly improve mental health outcomes." p. 17

This paragraph is located in the scope section of the call HORIZON-HLTH-2021-STAYHLTH-01-02: Towards a molecular and neurobiological understanding of mental health and mental illness for the benefit of citizens and patients.

Conclusion

The critical assessment of this statement indicates that in order to improve mental health outcomes calls like this one need to be complemented by activities that pursue a more holistic integrated approach to mental health and care. The current workprogramme also pursues this e.g. through other calls like HORIZON-HLTH-2022-STAYHLTH-01-01-two-stage: Boosting mental health in Europe in times of change. Our results encourage more activities along this line and the need for a strong emphasis, such as in the current WP, on inclusion of stakeholders such as health care professionals and patients as well as interdisciplinary, integrated approaches.

Statement 1.3: Artificial Intelligence-based health data assessment allows for 90% accurate risk prediction for the majority of non-communicable diseases.

Expert assessment

The results of the responses are not conclusive as regards when Artificial Intelligence-based health data assessment will allow for 90% accurate risk prediction for the majority of non-communicable diseases. While 55% consider this to happen between today and 2040, 45% consider this would happen after 2050 or never. The diverging views beyond the interpretations on the assumption may relate to the limitations of data and algorithms and the diversity of diseases to be diagnosed. Current limitations, including discriminatory biases, privacy concerns, infrastructural demands and regulatory challenges may continue to difficult the development of AI-based predictions. The new forms of diagnosis and increasing the speed of data processing will speed up progress in the prediction of health risks. Respondents have different interpretations of the assumption as well as diverging views on the goal itself. All in all, the respondents both have different interpretations of the assumption as well as diverging views on the goal itself. In particular, one respondent remarks: "risk prediction is a percentage - what does it tell you if you have a predicted (and correct) risk of 45% for a certain disease (e.g. cancer)? It is relatively useless... and this information makes people very insecure."

Original function in the workprogramme

"Artificial intelligence (AI) along with the increased availability of health data hold great potential to pave the way for personalised prevention and enable progress towards risk prediction and early detection of chronic non-communicable diseases." p. 30

This was part of the scope for the call HORIZON-HLTH-2022-STAYHLTH-01-04-two-stage: Trustworthy artificial intelligence (AI) tools to predict the risk of chronic non-communicable diseases and/or their progression.

The call strongly emphasises the inclusion of end users and patients as well as health humanities and ethics.

Conclusion

The key conclusion here is that there is contestation on whether the development of prediction will result in earlier and better detection of chronic non-communicable diseases. This implies that the advancement of the algorithm needs to be accompanied by broad public debate.

Statement 1.4: Comprehensive personalized disease prevention and health risk prediction is widely available as a service in the EU.

Expert assessment

Almost half of respondents consider comprehensive personalized disease prevention and health risk prediction to be widely available as a service in the EU between 2030 and 2050. The rest of the respondents are divided to those expecting this to happen before 2030 or after 2050/never, indicating strongly diverging views. While some respondents note the need for further development and technological advances, many refer here more to limited available resources and the need for more attention to prevention in general. Some respondents perceive currently a lack of investment in prevention via personalised medicine and digitalisation. This is especially the case in some EU MS and regions, as there are important differences in health services between MS.

Original function in the workprogramme

The sentence which is the basis for this Delphi statement is situated in the overall introduction of the health workprogramme: *"The digital transformation of health and care will help to increase the capacity of health care systems to deliver more personalised and effective health care with less resource wasting"* p.7

Conclusion

The experts' assessment largely confirms personalized health as a highly relevant long-term R&I direction. The doubts refer mainly to the affordability and the inequality of access. Both aspects are addressed in the work programme, especially inequality is explicitly targeted in destination 4 cost-effectiveness is often mentioned as a goal in the respective calls. At the same time, these are aspects that are partly beyond the scope of R&I & R&I policy and cannot be expected to be solved by a workprogramme. Future workprogrammes should continue tackling personalised health along the lines indicated in this WP. There may be a need for "reality check" and interaction with social and health policy actors in the member states, in order to better understand the issues "on the ground". Finally, due to the contested nature of the topic broad public debate should accompany the R&I activities.

Statement 4.5: Globally more than fifteen commercial deep-sea mining ventures are operating (at the moment only contracts have been issued).

Expert assessment:

This statement is characterised by a high uncertainty and several experts skipped it altogether. Respondents indicated low or even very low expertise. One respondent clearly states the reasons for the uncertainty: "lack of clear, unbiased information" with transparent ethical considerations. Other comments put forward the commercial promise of deep-sea mining and the rush for bat-

teries as a major driver. Also, assessments of timing vary from 10 to 20 years and longer it is notable that all respondents expect this to happen at some point in time - none opted for "never". To sum up results seem to indicate that due to high environmental risks deep-sea mining is restricted by ethical and legal boundaries. Research must therefore be carefully designed to respect these boundaries.

Original function in the workprogramme

The statement is based on the following sentence from the workprogramme:

"The expected increase of the global demand for metals needed for the energy transition might become a driver to initiate commercial deep sea mining, paved by the technological advancements." p.145

This sentence is from the scope section of the call HORIZON-CL4-2022-RESILIENCE-01-02: Monitoring and supervising system for exploration and future exploitation activities in the deep sea (RIA). The call requests that "the actions should design and develop a reliable and robust monitoring and inspection system for the exploration and future exploitation activities in the deep-sea". The call is thereby exactly addressing the uncertainty highlighted by the experts and is applying multidisciplinary approach.

Conclusion

The survey confirms the future expectation that the quest for deep-sea mining will rise due to the energy transition and thereby the high relevance of this call and further activities in this direction. The mixed assessment implies that ethical considerations and RRI aspects are bound to play a key role. Future WPs may want to strengthen this aspect e.g. by including social sciences and humanities or linking up with the respective activities in the OCEAN mission.

Statement 4.11: EU`s industrial base has diversified its supply chains so widely that it has no critical material and technology dependencies anymore.

This is not only contested but also long term (c.f. section 3.2 from long-term Challenges)

Lessons

Statement 5.4: The cement industry in the EU has successfully transitioned to climate neutrality.

Expert assessment

The slight majority of respondents consider the cement industry in the EU to successfully transition to climate neutrality between 2030 and 2050, and only one before 2030. Several mitigation options help the cement industry to decarbonise, such as CCS and reusing materials in cement production.

Low-carbon cement technologies are considered to have evolved over time and regulation may need to be updated to support diffusion of such options. Some

experts however suggest that substituting cement could be a better option. One expert warns: "As long as annual concrete demand stays as high as it is, it is difficult and associated with many other environmental problems (biodiversity losses)."

Original function in the workprogramme

The original statement within WP Climate, Energy and Mobility is:

"CCUS will play a crucial role in the EU Green Deal for the transition of energy-intensive industries and the power sector towards climate neutrality. Supporting R&I for CCUS will be particularly important in those industries where other alternatives do not yet exist like the cement industry. This will be highly relevant towards 2050, when most electricity will be coming from renewables, but the need to tackle the process emissions from industry will continue. If CCUS is combined with sustainable biomass, it could create negative emissions." p. 132.

The sentence is part of the introduction to the destination "Sustainable, secure and competitive energy supply" in the subsection "Carbon capture, utilisation and storage (CCUS)" By stating that cement industry could generate negative emissions this statement goes even beyond the one in our survey which only asked for climate neutrality.

Conclusion

The workprogramme here addresses the CCUS side of decarbonisation of the cement industry. This approach was not explicitly mentioned in the statement and is thereby not the subject of the experts' critical remarks. At the same time, it seems highly relevant to take the experts' warning seriously that decarbonising cement industry is extremely challenging and that reduction of demand and suitable standardisation and regulation is critical to achieve the carbon emission reduction goals.

To this end, it seems advisable that future workprogrammes in the energy field seeking to establish CCUS link up to the funding programmes addressing the industrial processes and to the demand areas such as in this case construction. This includes engaging with standardisation efforts ongoing in the sector to foster decarbonisation. Approaches towards low and zero carbon building driven by cutting-edge green building standards could become a key crosscutting R&I focus area. Also, biodiversity impacts should be considered here.

Statement 5.10: Biodiesel from algae is commercially viable.

Expert assessment

The clear majority of respondents considers biodiesel from algae to be commercially viable somewhere between 2030 and 2050, the rest of the responses disperse widely. Comments align that technologies are available, but the challenge is to scale it economically. Long-term challenges could arise if combustion engines get increasingly replaced by electric and other technologies reducing demand for biofuels.

Some respondents suggest that Europe may not to be the best for algae production and there are possibly better uses for algae like pharma, food and feed industries. Others question the sustainability of using algae based fuels. Comments indicate that if one wishes to get algae-based diesel into the markets, public funding and other incentives are needed.

Original function in the workprogramme

The original wording is as follows:

“Renewable fuels of the future will be also based on algae and non-biological feedstock for sectors that depend on and operate with dense fuels.” p. 247

This text is part of the expected outcome section of the call HORIZON-CL5-2022-D3-03-07: Development of algal and renewable fuels of non-biological origin. Several of the aspects mentioned by respondents are addressed in this call which requests: *“Implementing and improving circularity for energy and material use should be considered, also as means to enhance sustainability and economic feasibility of the proposed concepts. Proposals should also address systemic constraints and opportunities for scaling-up algal and non-biological renewable fuel technologies.”*

Conclusion

For future workprogrammes it seems useful to carefully consider whether the goals align with the expected developments in motor technology and especially electrification. Also, cooperation with other world regions could be explored that may have better conditions than Europe in this domain.

Statement 6.6: Food supply chains in Europe are fully transparent.

Expert assessment

On these statement opinions are divided. The most frequently selected time horizon is 2031-2040. But also by 2030, 2041 to 2050 and “never” received relevant shares. Experts who expect this by 2040 and earlier stress that the technology (e.g. micro sensors) already exists, a lot of effort has been invested in it and implementation is lacking. More sceptical respondents highlight inertia forces such as too many different interests and resistance from food industry as well as the multitude of participants where always some will avoid visibility. One expert with very high expertise raises the interesting question whether full transparency is even desirable. In a similar vein, another respondent argues that this is not necessary a prime target. If you have sufficient regulation at any place of the supply chain, supply chains do not need to be transparent. This indicates that the focus could be on trustworthiness rather than full traceability.

Original function in the workprogramme

The following sentence is behind this Delphi statement:

"Advances in R&I to upgrade transparency will provide multiple benefits relevant to improving food safety, fighting food fraud and addressing growing public concern in the EU as regards the climate, biodiversity and environmental impacts of food and diets in practice."

This sentence is part of the expected outcomes for call "HORIZON-CL6-2021-FARM2FORK-01-17: Increasing the transparency of EU food systems to boost health, sustainability and safety of products, processes and diets".

Conclusion

Delphi study results indicate that it may be useful in future workprogrammes to broaden the focus on trustworthiness. This can also be achieved by other means than full traceability such as broad public debate and suitable regulation.

Statement 6.13: More than half of European companies have integrated natural capital and biodiversity impacts and dependencies into their corporate decision making and risk assessment.

Expert assessment

A clear majority of respondents expect this to happen between 2031-2040. At the same time, many respondents point to the problem of "greenwashing" and doubt the benefits for nature. One respondent argues that: "Steady efforts in incentives, social control, scientific studies, shaming of liars... will be needed to change mentalities and decisions in the major companies". Another expert points to the specific challenge of influencing SMEs who make up a large share of European industry.

Original function in the workprogramme

"From the perspective of the private sector companies, integrating natural capital and biodiversity impacts and dependencies will enhance corporate decision making and business resilience as well as minimise investment risks. It will better inform, transform and improve their companies' sustainable decision-making processes, including by removing key blind spots in company risk assessments." p. 87

The text was an element in the expected outcome section of the call HORIZON-CL6-2021-BIODIV-01-21: Impact and dependence of business on biodiversity

Conclusion

Experts' assessments point to severe challenges in incentivising companies to pursue the preservation of ecosystems in earnest. Some hint that greenwashing can even have adverse effects on nature.

Future work-programmes could look into the mechanisms of marketing and investigate ways to counteract misinformation and in particular greenwashing. Also, research should be seen as one of several relevant factors, possibly not the most influential. The call recognizes this and includes social sciences and humanities and following a highly interdisciplinary approach, but interdisciplinary alone does not bring regulatory reform. Finally, the special conditions and importance of SMEs should be considered.

Statement 6.14: Advanced internet based digital applications such as remote sensors for crop and livestock monitoring, data analytics and advanced planning and optimisation (e.g. via Farm Management Information Systems), control and execution of production with help of automatic machines (e.g. for milking) or robots (e.g. for weeding and harvesting), are used in more than half of farms in the EU.

Expert assessment

Most respondents expect the rise of such systems by 2031-2040 or at least by 2050, some argue that this could happen even before 2030. It is pointed out that medium sized and large farms are already using these systems and technologies are available. At the same time, several respondents argue that small family farms that make up a large share in the EU are less likely to adopt these technologies partly due to the high costs.

There are also opposing views on the desirability of this goal. One respondent points to the danger of "losing soul in the relationship with Nature". Another respondent argues that: "Smart farms are more sustainable, have less impact on the environment, are more profitable and produce higher quality products, using less space and fewer resources".

Original function in the workprogramme

"The potential of digital technologies in the agricultural sector to enhance its sustainability and economic performance and to enhance working conditions has been acknowledged. The uptake of digital technologies in the agricultural sector and the development of supplementing data-technology-based solutions in the EU are increasing." p. 484.

This text opens the scope section of the call HORIZON-CL6-2021-GOVERNANCE-01-19: Development of the markets and use of digital technologies and infrastructure in agriculture – state of play and foresight: digital and data technologies for the agricultural sector in a fast changing regulatory, trade and technical environment.

Conclusion

Future workprogrammes tackling this topic may consider taking on board some of the concerns voiced by the experts such as the impact on small family farms and the consequences for human relationship with nature. The contested nature of this topic also indicates the need for participatory and transdisciplinary approaches that are already prominent in some parts of the workprogramme.

3.4 Overarching Lessons

In general, our results indicate that, while most expectations and assumptions about the future in the Horizon Europe work programme 2021-2022 are broadly shared, a significant proportion of them can be seen as controversial and risky, in, typically one of three ways:

- a) associated with goals that have a very long-term and therefore highly uncertain character – where the relevance to current practice needs special justification;
- b) associated with goals which have already been achieved or are close to being achieved – where the additional importance of Horizon Europe's pursuing the goal needs special justification; and
- c) where the goal in itself is controversial- where there is a need for consideration of the R&I needs of the different viewpoints.

The large majority of expectations assessed in our survey is situated in a mid- to long-term horizon that is perfectly suitable for an ambitious research programme such as Horizon Europe. Moreover, the normative orientation behind most of the expectations is largely shared by the respondents. The deep dive analysis of the twenty-seven statements resulted in additional useful lessons. The specific lessons were drawn on an individual statement level. On an overarching level we can point towards three types of challenges to be recognised in future workprogrammes:

1. Policy challenges

For some topics, our results indicate that the targeted goals are seen as worthy and highly relevant but not altogether realistic. Often in these cases, expert comments suggest that the potential of R&I for addressing the challenges is limited and point towards adverse political framework conditions and influence of powerful interests as barriers for achieving progress. In these cases for **future workprogrammes** different reactions are conceivable; One possibility would be to focus especially on areas where the framework conditions are in place so R&I can play a meaningful role. Another option would be to address these difficulties explicitly by integrating SSH research and setting up stakeholder dialogues that also include policy actors, an approach that is already spearheaded in several programmes. Another course of conduct could be to align R&I policy with other policy areas such as e.g. agricultural policy.

Examples for topics facing this type of policy challenge are sustainable agri-food systems, the decarbonisation in some parts of industry, decarbonisation of transport (especially aviation) and the realisation of personalised health.

2. Diversification challenges

This group is the most populated of the three. It includes topics where respondents disagree on the goal and others where they assess the goal as unsolvable. For all topics with “diversification challenges” respondents hint at possible alternative framings of the problem and subsequent approaches to tackling it. Some argue that with such re-framings, some seemingly intractable problems could turn into solvable ones.

When developing **future workprogrammes** it may be useful to check for these topics whether different perspectives on the very framing of the topic are well accommodated in the programme. Especially it seems worthwhile to explore whether diversification of trajectories may provide new inroads into “insolvable” issues. In some such cases, experts stress the need to integrate perspectives that view the problem as one of societal rather than only technological change and thereby focus on aspects like human behaviour, social fabric and social innovation. While we often saw that these aspects are indeed addressed in other parts of the programmes, it may be useful to integrate these aspects or at least connect the research teams in the respective programme lines to align their efforts.

Examples for topics “diversification challenge” are circular products, sustainable energy and digitalisation of agriculture.

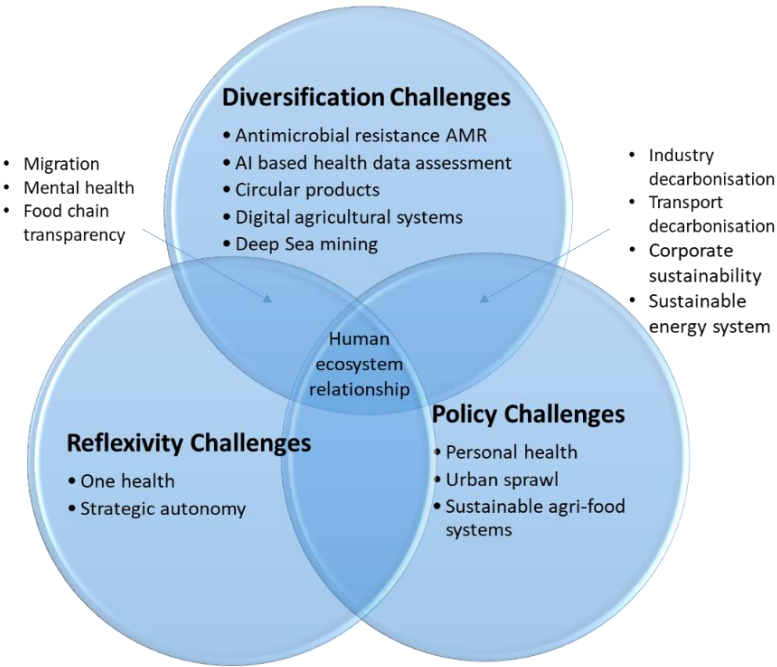


Figure 13: Venn Diagram of challenges for future workprogrammes

3. Reflexivity challenges

In a few cases, respondents stressed the need to continue sharpening key concepts. This may indicate that it may be useful to consider for **future workprogrammes** whether the generation of a shared understanding of key concepts could be integrated possibly with integrating key users such as e.g. patients or CSOs. **Examples** for such type of reflexivity challenges are “one health” and “strategic autonomy”. The Venn diagram in Figure 13 below illustrates how the topics are distributed across these groups. It can be seen that some topics are facing both types of challenges and the issue of human ecosystem relationship encounters all three of them.

3.10. Cluster Specific Findings

The overview of statements and challenge groups provided in **Error! Reference source not found.** below illustrates the slightly different situation between Horizon Europe clusters. Reflexivity challenges are mostly located in cluster 1 and 6 while clusters 4, 5 and 6 face an equal share of the diversification challenges. Policy challenges occur largely equally in clusters 2, 4, 5 and 6. Overall, cluster 6 (12 out of 14) and cluster 1 (5 of 6) show the largest share of statements assigned to a challenge group. Cluster 2 (3/8) and 3 (0/6) are least represented. In the following sections, we look at each cluster individually to extract possible cluster specific learnings from the analysis.

Table 7: Overview challenge groups and their topics

Policy challenges	Diversification challenges	Reflexivity challenges
Personal health (1.4) Migration (2.5) Urban sprawl (2.8) Industry decarbonisation (4.2, 4.7) Sustainable energy system (5.1) Transport decarbonisation/Waterborne (5.8) Transport decarbonisation/Aviation (5.11) Sustainable agri-food systems (6.1) Human ecosystem relationship (6.2, 6.5) Corporate sustainability (6.13)Text	Mental health (1.1) AI based health data assessment (1.3) Antimicrobial resistance AMR (1.6) Migration (2.5) Circular products (4.1) Industry decarbonisation (4.2, 4.7) Deep sea mining (4.5) Sustainable energy system (5.1) Industry decarbonisation (5.4) Transport decarbonisation/Waterborne (5.8) Transport decarbonisation/Aviation (5.11) Human ecosystem relationship (6.2, 6.5) Food chain transparency (6.6) Corporate sustainability (6.13) Digital agricultural systems (6.14)	Mental health (1.1) One health (1.6) Strategic autonomy (4.11) Human ecosystem relationship (6.2, 6.5) Food chain transparency (6.6)

Cluster 1 Health

As shown in Table 8 four topics in this cluster are of special interest in terms of assumptions and expectations. Personal health can be seen as a policy challenge, AMR as diversification challenge and one health as reflexivity challenge. Mental health faces both diversification and reflexivity challenges.

Table 8: Cluster 1 challenge groups

Policy challenges	Diversification challenges	Reflexivity challenges
Personal health (1.4)	Mental health (1.1) Antimicrobial resistance AMR (1.6)	Mental health (1.1) One health (1.6)

3.5.2 Cluster 2 Culture, Creativity and Inclusive Society

Our results confirm the assumption made in the workprogramme that migration is likely to dominate policy and political agendas for many years to come and also the need to address this issue. There are however restrictions on the role R&I could play. In future programmes it may be useful to address mechanisms of the framing of migration in the policy discourse. The aspect of migration can therefore be seen as a diversification challenge as indicated in Table 9.

Table 9: Cluster 2 challenge groups

Policy challenges	Diversification challenges	Reflexivity challenges
Migration (2.5)	Migration (2.5)	

Cluster 3 Civil Security for Society

No specific lessons beyond what is discussed within the statements

Cluster 4 Digital, Industry and Space

Table 10: Cluster 4 challenge groups

Policy challenges	Diversification challenges	Reflexivity challenges
Industry decarbonisation (4.2, 4.7).	Circular products (4.1) Deep sea mining (4.5) Industry decarbonisation (4.2, 4.7).	Strategic economy (4.11)

In cluster 4, five topics seem of special interest for review in future workprogrammes. For industry decarbonisation the survey confirms the WP approach but indicates that the main challenge is to accelerate technology deployment while R&I may be a minor factor compared to policy measures creating adequate framework conditions. It is therefore a clear policy challenge. At the same time insights from statement 4.7 on design and optimisation of energy flexible industrial processes imply that decarbonisation of industrial processes cannot rely on availability of renewable energy e.g. clean electricity. Therefore, other decarbonisation pathways including reduction of energy consumption and switch to different processes need to be pushed in parallel. This is to a large extent a policy challenge but also calls for opening of R&I approaches and is therefore positioned in both categories policy and diversification challenge.

For circular products, comments suggest that challenges may be even broader than addressed by the current workprogramme. In particular, infrastructures and mind-sets for circularity could be worthwhile to look into for future workprogrammes. It can therefore be seen as diversification challenge.

In a similar vein, deep-sea mining poses a diversification challenge as results imply that ethical considerations and RRI aspects are bound to play a key role. Therefore, future WPs may want to strengthen this aspect e.g. by including social sciences and humanities or linking up with the respective activities in the OCEAN mission.

Finally, strengthening autonomy in key strategic value chains can be seen as a reflexivity challenge as experts suggest to reconsider and sharpen the notion of independence and autonomy.

Cluster 5 Climate, Energy and Mobility

Table 11: Cluster 5 challenge groups

Policy challenges	Diversification challenges	Reflexivity challenges
Transport decarbonisation/Waterborne (5.8) Transport decarbonisation/Aviation (5.11)	Sustainable energy system (5.1) Industry decarbonisation cement (5.4) Transport decarbonisation/Waterborne (5.8) Transport decarbonisation/Aviation (5.11)	

For Sustainable, secure and competitive energy supply experts had expressed some scepticism about substantial reductions within reasonable time horizons with the consequence that efforts in the demand side of energy may need to be reinforced. For future workprogrammes it may be useful to review distribution of efforts for supply and demand side measures of the energy transition and to consider redoubling efforts to achieve substantial reduction of usage, in particular fossil fuels. We therefore see this as a diversification challenge.

The decarbonisation of the cement industry poses another diversification challenge in this cluster. It seems advisable that future workprogrammes in the energy field seeking to establish CCUS as a solution for decarbonising cement production, link up to the funding programmes addressing the industrial processes on the one hand and the demand areas such as construction and buildings. Approaches towards low and zero carbon building could become a key crosscutting R&I focus area. In addition, biodiversity impacts from cement production should be considered before factoring in negative emissions from cement production.

Finally, Transport Decarbonisation shows all characteristics of a policy challenge

- The analysis confirms the workprogramme approach to eliminate greenhouse gas emissions from the waterborne transport sector to a certain extent. It implies however that reaching the goal within the given range of means is almost impossible. In order to achieve the climate goals a broader approach may be required that also considers transport reduction.
- With respect to development of biodiesel from algae our results suggest that for future workprogrammes it seems useful to carefully consider whether the goals align with the expected developments in motor technology and especially electrification. Also, cooperation with other world regions could be explored that may have better conditions than Europe in this domain.

The fact that a substantial share of experts does not believe in the possibility of the aviation sector becoming carbon neutral without offset within the timeframe needed to comply with the Paris climate goals should be taken into account within the next workprogramme development. Some of the comments suggest to focus on the need to drastically reduce the number of flights e.g. through a shift towards train transport for shorter distances, as is already being discussed at the EU level but also through moving away from place holder flights and private aircraft used by the super wealthy.

Cluster 6 Food, Bioeconomy, Natural Resources, Agriculture and Environment

Table 12: Cluster 6 challenge groups

Policy challenges	Diversification challenges	Reflexivity challenges
Urban sprawl (2.8) Sustainable agri-food systems (6.1) Human ecosystem relationship (6.2) Corporate sustainability (6.13)	Human ecosystem relationship (6.5) Food chain transparency (6.6) Corporate sustainability (6.13) Digital agricultural systems (6.14)	Human ecosystem relationship (6.2, 6.5) Food chain transparency (6.6)

For Sustainable agri-food systems, our analysis confirms the workprogramme approach in particular the inclusion of social sciences and humanities and the

highly interdisciplinary approach. There are indications however that the role of R&I in addressing this may be limited as there is a major policy challenge involved. This applies also for urban sprawl where the survey indicates the need to recognize the importance of accompanying policy measures in particular land management practices. While the workprogramme is focussing on agricultural land-use the expert assessment our results indicate that it may be worthwhile to look more specifically also into the dynamics of (sub)-urban sprawl within future workprogrammes as this phenomenon may be there to stay for a long time.

Another instance is the attempt to impact corporate sustainability where there is a clear call for policy measures. In addition, it seems advisable to also diversify the R&I perspective by looking into the mechanisms of greenwashing and ways to counteract it and by considering the special role of SMEs. With respect to transparency of food systems, it may be useful to broaden the focus on trustworthiness, which can also be achieved by other means than full traceability.

With respect to digital technologies in the agricultural sector future workprogrammes may consider taking on board the impact on small family farms and the consequences for human relationship with nature. It seems sensible to consider strengthening the participatory and transdisciplinary approaches that are already prominent in some parts of the workprogramme as some aspects of this domains are contested.

Finally, the most fundamental challenge in this sector is posed by recalibrating human ecosystem relationships. In particular, experts' responses suggest to reflect on the deeper meaning of ecosystem sustainability and the desired state of biodiversity and to continue to think beyond EU as "we are importing a lot of degradation through the externalities of our imported goods". This domain entails major policy challenges, requires reflection on fundamental concepts and subsequently opening up R&I to a wider diversity of perspectives.

Annex 1: List of assumptions and expectations identified in the workprogramms

In order to ask for assessments of the time horizon in a Delphi survey, it is necessary to develop statements that describe a future development in the present tense and are formulated as distinctly and concretely as possible, which, not least, usually precluded the use of causalities. For this purpose, the assumptions and expectations about the future originally found in the work programmes had to be adjusted, in some cases significantly (cf. Deliverable 2). This process was carried out in several loops. In the following, all statements from the final questionnaire are listed together with the original extracts from the work programmes from which they originate.

Since the six clusters of the work programme differ in length and density of future expectations, some of the expectations found had to be combined or dropped out in order to achieve a relatively evenly distributed number of statements for the participants in the survey.

- In a handful of cases we developed statements for a cluster that were consistent with the topical focus of that cluster but originated from the work programme texts of other clusters (these cases are indicated by a deviating number in the column "cluster").
- If several source texts have directly been included (combined) in the same statement, this is indicated by the fact that two rows in the second column "Source extracts..." refer to only one row in the first column "Delphi Statements".
- Conversely, if several separate statements were formulated from the same source extract, this is indicated by a number in brackets at the end of the extracts (e.g. "(1/2)")
- Lastly, clusters 4, 5 and 6 contained a particularly high number of future expectations and therefore had to be truncated. Extracts that were already taken up in other statements ("Redundancies"), or those that had to be cut ("dropouts"), are listed separately under the statements of these three clusters.

Cluster 1

Delphi Statements	State-Source extracts from the work programme	Cluster
C1.1: Using objective biomarkers has substantially improved mental health outcomes.	A deeper molecular and neurobiological understanding of the interplay between genetic, epigenetic and environmental risk and resilience factors, including neural circuit alterations, is critical for the development of objective biomarkers and evidence-based interventions that will significantly improve mental health outcomes.	1
C1.2: Healthcare expenditure	Due to demographic changes in the EU with a population projected to continue ageing and higher expectations regarding provision of health care services, public health	1

across the EU reaches 15 % of GDP (from 10% in 2022).	threats with relevant repercussions for society and the introduction of innovative and digital solutions to improve health care systems' functioning, the demand for health care services as well as the budgetary pressures on health care systems are and will keep increasing.	
C1.3: Artificial Intelligence-based health data assessment allows for 90% accurate risk prediction for the majority of non-communicable diseases.	Artificial intelligence (AI) along with the increased availability of health data hold great potential to pave the way for personalised prevention and enable progress towards risk prediction and early detection of chronic non-communicable diseases.	1
C1.4: Comprehensive personalized disease prevention and health risk prediction is widely available as a service in the EU.	The digital transformation of health and care will help to increase the capacity of health care systems to deliver more personalised and effective health care with less resource wasting	1
C1.5: Multifunctional biomaterials that are capable of achieving several biological responses simultaneously are routinely used in advanced therapies and medical devices.	Multifunctional biomaterials play a major part in shaping the future of Advanced Therapies and Medical Devices.	4
C1.6: Antibiotic resistant bacteria are no longer a major health threat in Europe.	The increasing levels of AMR present a major threat to human health with serious consequences also to animal and environmental health.	

Cluster 2

Delphi Statements	Source extracts from the work programme	Cluster
C2.1: European governments have digitalised all their services and large-	The digitalisation of societies and their governments poses an opportunity to reinforce civic participation.	2

ly abandoned paper.		
C2.2: European societies are so inclusive that no group in society considers itself unfairly excluded.	Access to experience with cultural heritage contributes to social cohesion and inclusion, by strengthening resilience and the sense of belonging, bringing people together and improving well-being.	2
C2.3: Europe is a world leader in cultural heritage research and innovation.	Through all these activities, research and innovation will underpin the European Union's leading role in protecting, preserving and enhancing Europe's cultural heritage and scale-up the competitiveness of its cultural and creative industries.	2
C2.4: Europe is a world leader in film-making industries.	The lack of large and vertically integrated groups able to compete internationally, in combination with the nationally-based companies that were seriously affected by the COVID-19 crisis, will make it difficult for several EU companies to remain competitive in the international filmmaking industry.	2
C2.5: Migration no longer figures among the top issues on political agendas in Europe.	Migration has been a critical component of the makeup of European societies, one that is likely to dominate policy and political agendas for many years to come.	2
C2.6: Cultural heritage is accessible to all across the EU free of charge.	Because it possesses a vast, varied and outstanding cultural heritage and can count on the high quality and numerous skills of its citizens, Europe is in the right position to become a world leader in cultural heritage research and innovation. (1/2)	2
C2.7: The EU establishes minimum standards for the protection of cultural heritage in its territory.	Because it possesses a vast, varied and outstanding cultural heritage and can count on the high quality and numerous skills of its citizens, Europe is in the right position to become a world leader in cultural heritage research and innovation. (2/2)	2
C2.8: The spread of urban sprawl has been halted, giving way to settlements in line with the principles of environmental, social, cultural and economic sustainability.	Land use and management has a key role to play in Europe in terms of boosting carbon storage, producing biomass for the bioeconomy, reducing urban sprawl and attaining the objective of climate neutrality by 2050 while ensuring food and nutrition security, biodiversity commitments and well-being in general. (1/2)	6

Cluster 3

Delphi Statements	Source extracts from the work programme	Cluster
C3.1: Investment in natural hazard preparedness and	Europe is facing increasingly frequent and intense natural hazards, including epidemics, droughts, heat waves, storms, floods and wildfires, which trigger needs for constant innovation when it comes to the protection of people.	3

protection across Europe has doubled from 2022.	The risk landscape has changed significantly over the last decades. With new and emerging risks and risk magnifiers such as climate change, cyber threats, infectious diseases and terrorism, countries need to anticipate and prepare for the unexpected and difficult to predict	3
C3.2: Individual resilience training is established in school curricula in most European countries.	Finally, enhancing preparedness for and management of high impact low-probability events cannot happen without an increased resilience of individuals.	3
C3.3: Quantum technologies are compromising most non-quantum based cryptography.	Quantum technologies will pose a significant risk to the security of our society by compromising much of modern cryptography	3
C3.4: New and emerging risks and risk magnifiers such as climate change, cyber threats, infectious diseases and terrorism are twice as prevalent in Europe as they were in 2022.	new and emerging risks and risk magnifiers such as climate change, cyber threats, infectious diseases and terrorism will be more prevalent in the future	3
C3.5: More than 50% of EU cities have installed more than 15 CCTV cameras per 1000 inhabitants (in 2022 the highest number in the EU is 11 in Berlin. In London the number is 68).	significant expansion of public spaces that are monitored via CCTV systems risks to create negative effects for the right for privacy	3
C3.6: Criminal use of end-to-end encryption in social media is posing a major challenge for law enforcers trying to prevent cyber-crime.	Software-based communication technologies such as 5G and beyond will bring many benefits but also pose a number of new challenges for the police and the judiciary. In particular, lawful interception systems will have to adapt to the increased use of encryption including end-to-end encryption, to edge computing that might limit the availability and accessibility to relevant data and to slicing technology that will multiply the number of virtual operators. In addition, high bandwidth access networks pose the challenge for police and the judiciary to be able to cope with tremendous amount of data and will accelerate the switch to application level communication that are commonly used by criminals.	3

Cluster 4

Delphi Statements	Source extracts from the work programme	Cluster
C4.1: More than 80% of products in the market are made from recycled resources.	Research and innovation will be fundamental to create the new products, services and business models needed to sustain or enable EU industrial leadership and competitiveness, and to create new markets for climate neutral and circular products.	4
C4.2: European industry is fully decarbonised.	The integration of hydrogen into new production routes, the direct use of hydrogen for heating and the use and production of GHG emission-free hydrogen instead of carbon-intensive hydrogen will be fundamental to decarbonise EU industry across a number of sectors.	4
C4.3: 100% of fibre reinforced polymer composites is recycled in Europe (compared to a maximum of 20% for glass fibres in 2022).	In addition, the environmental legislation on recycling of end-of-life components and structures will mean that from 2025, for example, 80,000 tons of fibre reinforced polymer composites will have to be recycled every year in Europe.	4
C4.4: The EU is the world's most secure and trusted data hub.	The EU has the means to become the world's most secure and trustful data hub	4
	The diffusion of platforms for data sharing and the availability of interoperable datasets is one of the key success factors which may help to drive the European data economy and industrial transformation	4
	As data becomes the new fuel of the economy and a key asset to address our societal challenges, the EU cannot afford to have the data of its businesses, public sector and citizens stored and exploited largely outside its borders.	4
C4.5: Globally more than fifteen commercial deep sea mining ventures are operating (at the moment only contracts have been issued).	The expected increase of the global demand for metals needed for the energy transition might become a driver to initiate commercial deep sea mining, paved by the technological advancements.	4
C4.6: Europe is at the cutting edge of quantum capabilities.	Technologies Flagship conducts research and development activities in the key domains of quantum computing and simulation, quantum communication, and quantum sensing. The Flagship will contribute to world-leading quantum computers and simulators that will be acquired by the European High Performance Computing Joint Undertaking, and will be crucial to achieving its Digital Decade goal of having its first computer with quantum acceleration by 2025, with a view	4

	to being at the cutting edge of quantum capabilities by 2030. These machines will have a profound impact, with applications in medicine, manufacturing, or new material and new drugs design but also in cryptography, finance and many other sensitive domains.	
C4.7: After successful decarbonisation of the European energy system, energy in Europe is abundant and supply is stable.	Flexibility solutions are key to achieve a renewable energy share to deliver the EU Green Deal objectives and which goes significantly beyond the current target of 32%. In the coming years, EU industries will need to adapt to the increased fluctuations in energy supply caused by the higher penetration of variable energy sources.	4
C4.8: Europe has become a technology and industrial leader of the green and digital twin-transition.	The green transition and digital transformation are just at their beginning. Major opportunities lie ahead to position Europe as a technology and industrial leader of this transition.	4
	Europe will be a leader in the twin (green & digital) transition	4
	Climate Neutral and Circular Innovative Materials Technologies Open Innovation Test Beds (OITBs) will support companies, especially SMEs, to become world leaders in clean products and technologies.	4
	Research and innovation will be fundamental to spur industrial leadership and enhanced resilience. It will support the modernisation of traditional industrial models while developing novel technologies, business models and processes. This can enhance the flexibility of the EU's industrial base, and increase its resilience by reducing EU dependencies on third countries for critical raw materials and technologies. (1/2)	4
C4.9: Biological modes of production have become more important than digital ones.	Biological transformation of industry can harness innovative and more efficient modes of production which can satisfy the needs of future generations.	4
	The use of biological elements as key enabling technology for manufacturing is an emerging trend that perfectly concurs with the pressing requirements of sustainability.	4
C4.10: The majority of ICT based products involve quantum technologies (second generation).	Quantum technologies will transform industry and society and be of key global importance	4
C4.11: EU's industrial base has diversified its supply chains so widely that it has no critical material and technology dependencies anymore.	Research and innovation will be fundamental to spur industrial leadership and enhanced resilience. It will support the modernisation of traditional industrial models while developing novel technologies, business models and processes. This can enhance the flexibility of the EU's industrial base, and increase its resilience by reducing EU dependencies on third countries for critical raw materials and technologies. (2/2)	4
	In addition, activities will foster innovation to develop the circular economy and exploit the potential of biological resources for renewable products. This will reduce the EU's dependence on non-renewable resources, and help to reduce emissions/waste from industrial processes by using more sustainable bio-based systems. At the same time it	6

	will avoid trade- offs that could damage biodiversity and will promote synergistic measures to protect biodiversity.	
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Cluster 4: Redundancies and dropouts from the work programme extracts

that shapes competitive and trusted technologies for a European industry with global leadership in key areas by enabling production and consumption respecting the boundaries of our planet, and maximising the benefits for all parts of society in the variety of social, economic and territorial contexts in Europe

The shift towards a sustainable and inclusive economic model will be further enabled by the broader diffusion and uptake of digital and clean technologies across key sectors.

Green hydrogen will be available to decarbonise production processes

This will make an essential and significant contribution to achieving climate neutrality in the European Union by 2050, and to the achievement of a circular economy.

EU will be a climate-neutral, circular and competitive economy by 2050 (with no loss in product quality)

A successful transition to a climate-neutral, circular and digitised EU economy relies heavily on a secure supply of raw materials. In order to strengthen EU autonomy and reduce over-dependency, we must boost domestic sourcing, both for primary and secondary raw materials.

In addition, “extreme SWE” could have devastating societal and economic consequences with potential costs for disruptions and damages estimated in tens or even hundreds of billions of Euros.

While chemical and related materials production is expected to double globally by 2030, this will largely take place outside Europe

Digitalisation improves resilience, agility and competitiveness, and enables cost-efficient production in Europe. It will also support a radical reduction of the environmental footprint of the sector.

an integrated energy system, linking different energy carriers, infrastructures and consumption sectors in the EU, will be set to deliver climate neutrality by 2050 in a cost effective way

A climate neutral energy system will be in place by 2050.

Cluster 5

Delphi State-ments	Source extracts from the work programme	Cluster
C5.1: Final Energy consumption (i.e. the total energy consumed by end users, such as households, industry and agriculture) in Europe has fallen by 40% compared to 2022.	The transition of the energy system will rely on reducing the overall energy demand and making the energy supply side climate neutral. R&I actions will help to make the energy supply side cleaner, more secure, and competitive by boosting cost performance and reliability of a broad portfolio of renewable energy solutions, in line with societal needs and preferences.	5

C5.2: The steel industry in the EU has successfully transitioned to climate neutrality.	CCUS will play a crucial role in the EU Green Deal for the transition of energy-intensive industries and the power sector towards climate neutrality. Supporting R&I for CCUS will be particularly important in those industries where other alternatives do not yet exist like the cement industry. This will be highly relevant towards 2050, when most electricity will be coming from renewables, but the need to tackle the process emissions from industry will continue. If CCUS is combined with sustainable biomass, it could create negative emissions. (1/4)	5
C5.3: The chemical industry in the EU has successfully transitioned to climate neutrality.	CCUS will play a crucial role in the EU Green Deal for the transition of energy-intensive industries and the power sector towards climate neutrality. Supporting R&I for CCUS will be particularly important in those industries where other alternatives do not yet exist like the cement industry. This will be highly relevant towards 2050, when most electricity will be coming from renewables, but the need to tackle the process emissions from industry will continue. If CCUS is combined with sustainable biomass, it could create negative emissions. (2/4)	5
C5.4: The cement industry in the EU has successfully transitioned to climate neutrality.	CCUS will play a crucial role in the EU Green Deal for the transition of energy-intensive industries and the power sector towards climate neutrality. Supporting R&I for CCUS will be particularly important in those industries where other alternatives do not yet exist like the cement industry. This will be highly relevant towards 2050, when most electricity will be coming from renewables, but the need to tackle the process emissions from industry will continue. If CCUS is combined with sustainable biomass, it could create negative emissions. (3/4)	5
C5.5: The paper industry in the EU has successfully transitioned to climate neutrality.	CCUS will play a crucial role in the EU Green Deal for the transition of energy-intensive industries and the power sector towards climate neutrality. Supporting R&I for CCUS will be particularly important in those industries where other alternatives do not yet exist like the cement industry. This will be highly relevant towards 2050, when most electricity will be coming from renewables, but the need to tackle the process emissions from industry will continue. If CCUS is combined with sustainable biomass, it could create negative emissions. (4/4)	5
C5.6: Battery development time is reduced by half compared to 2022.	Digitalisation of battery testing will lead to an acceleration of the battery development time, a higher quality of the battery assessment, and an improvement of the battery design itself and a better estimation lifetime. Improvement in battery testing will result in major cost savings, in particular in the development phase.	5
C5.7: CCAM (Cooperative, connected and automated mobility)-services operate without major failures across the EU.	The Physical and Digital Infrastructure (PDI) is pivotal to improve CCAM services. [...]. PDI support will particularly help in more challenging geographical or weather conditions, and can mitigate failure situations or gaps in the Operational Design Domain (ODD).	5
C5.8: The global waterborne transport sec-	Other than for short distances, waterborne transport is expected to become climate neutral mainly by the introduction of alternative, sustainable, and carbon-neutral	5

tor has eliminated all its greenhouse gas emissions.	fuels, by massive efficiency improvements and through related technologies for the fuel's use in propulsion and power generation on-board	
C5.9: More than 50% of maritime and inland waterways feeder services in the EU are fully automated.	Automated maritime or inland waterways feeder services are seen as the most promising applications where the feasibility and commercialisation of automated shipping can be proven.	5
C5.10: Biodiesel from algae is commercially viable.	Renewable fuels of the future will be also based on algae and non-biological feedstock for sectors that depend on and operate with dense fuels.	5
C5.11: Aviation has become climate neutral (without using carbon offsets for compensation).	Aviation's global economic impact, before COVID-19, was more than €2.4 trillion per year, while the European one was more than EUR 700 billion per year. However, the environmental impact, although in absolute terms small, it is projected to increase towards 2050 to a level that is not compatible with the Paris Agreement, if action is not taken now.	5

Cluster 5: Redundancies and dropouts from the work programme extracts

To achieve the goals of climate-neutrality by 2050, renewable energy sources installations in particular wind will have an explosive growth and replace or substitute carbon from fossil origin in the power sector and in other economic sectors such as heating/cooling, transportation, agriculture and industry. Their large scale and decentralised deployment is expected to create more jobs than the fossil fuel equivalent they will be evermore present in the lives of European citizens.

The use of fuel cells (FC) for waterborne applications is becoming increasingly relevant as stack power increases and the problem of the storage of un-regulated alternative fuels is solved. Demonstrating and upscaling this technology will lead to initial and earlier applications in IWT and short sea shipping vessels, as well as to complementary power generation on-board ships with high power demand, whilst also setting foundations towards deployment within even larger scale long distance applications.

The transition to a decentralised and climate neutral energy system will greatly benefit from the use of digital technologies which will enable buildings and industrial facilities to become interactive elements in the energy system by optimising energy consumption, distributed generation and storage and vis-à-vis the energy system. They will also trigger new business opportunities and revenue streams for up-graded, innovative energy services which valorise energy savings and flexible consumption.

Cluster 6

Delphi ments	State- no	Source extracts from the work programme	Clus- ter
C6.1: In the EU agri-food production		The implementation of agro-ecological approaches will alleviate the pressure that agri-food production places on natural ecosystems, contributing to resilience of agri-food sys-	6

longer places pressure on natural ecosystems.	tems and facilitating nature-based responses to current and future agri-food risks and threats	
C6.2: In the EU use of the seas and inland waters and marine resources no longer places pressure on natural ecosystems.	The potential of marine resources and biotechnology will contribute to the coming “blue economy”, accelerating the transition towards a circular and climate-neutral economy that is sustainable and inclusive. The concepts of the circular economy, bioeconomy and blue economy converge and altogether provide an opportunity to balance environmental, social and economic goals, with their sustainability ensured by the life cycle assessment approaches.	6
	Cluster 6 will steer and accelerate the transition to sustainable, healthy and inclusive food systems to achieve effectively the objectives of the farm to fork strategy. It will empower farmers, fishermen and aquaculture producers to transform their production methods more quickly and efficiently and make the best use of nature-based, technological, digital and social innovations. This will deliver better climate mitigation and environmental results, increase climate resilience and reduce dependency on pesticides and antimicrobials. At the same time, it will also provide consumers with affordable, safe, nutritious, healthy and sustainable food.	6
C6.3: Animal welfare in fish reaches the same standards as animal welfare in mammals.	Sustainable and resilient aquaculture systems, including the use of low trophic species (e.g. algae and herbivores), high animal welfare standards and alternative sources of protein for food and feed, will increase seafood production and reduce its environmental impact while adding economic value to the chain. (1/2)	6
C6.4: The share of low trophic species (e.g. algae and herbivores) in EU aquaculture systems has doubled compared to 2022.	Sustainable and resilient aquaculture systems, including the use of low trophic species (e.g. algae and herbivores), high animal welfare standards and alternative sources of protein for food and feed, will increase seafood production and reduce its environmental impact while adding economic value to the chain. (2/2)	6
C6.5: In the EU human activity has become biodiversity-neutral.	Research and innovation can enable these transformative changes to happen and initiate processes, behaviour changes and actions which are transforming the way we impact biodiversity	6
C6.6: Food supply chains in Europe are fully transparent.	Advances in R&I to upgrade transparency will provide multiple benefits relevant to improving food safety, fighting food fraud and addressing growing public concern in the EU as regards the climate, biodiversity and environmental impacts of food and diets in practice.	6
C6.7: Nature based solutions and sustainable ecosystem management account for at least 20% of employment in	A successful proposal will contribute to the EU’s goal of leading just digital, economic and ecological transitions that will leave no one behind, supporting in particular European Green Deal priorities such as the biodiversity strategy for 2030. It will support the empowerment of rural, coastal and urban communities to act for change and to contribute to the Green Deal objectives through education and upgraded skills regarding the design, implementation and benefits of	6

the EU.	nature-based solutions (NBS). By doing so, communities will be better prepared to adapt to climate change through the deployment of NBS, and turn digital and ecological transitions into increased resilience and positive long-term prospects, including jobs for all, notably for young people.	
C6.8: Tourism, recreational and leisure activity development in coastal areas across the EU respect long-term environmental carrying capacity.	People are empowered to act for change through upgraded skills and innovative governance that favours an integrated and interlinked territorial development. Coastal communities are better prepared to achieve climate neutrality by 2050, adapt to climate change, and turn digital and ecological transitions into increased resilience to various types of shocks, good health and positive long-term prospects, including jobs, for all including women, young people and vulnerable groups. Tourism, recreational and leisure activity development in coastal areas respects long-term environmental carrying capacity, and social goals.	6
C6.9: Soil based carbon sequestration has increased twofold in the EU compared to 2022.	Land use and management has a key role to play in Europe in terms of boosting carbon storage, producing biomass for the bioeconomy, reducing urban sprawl and attaining the objective of climate neutrality by 2050 while ensuring food and nutrition security, biodiversity commitments and well-being in general. (2/2)	6
C6.10: Average per capita meat consumption in the EU has fallen below 30Kg per year (around 54 Kg in 2021).	Improved and informed governance and social innovation contribute to reducing resource consumption and result in an increased innovation capacity of all actors. Informed consumers may pursue the objectives of circular economy, asking for efficiency and inclusiveness of services provided through less resources and goods, changing consumption patterns (e.g. reducing meat consumption), preventing food waste and separating bio-waste from other waste streams so that it can be (partly) converted to bio-based materials.(1/2)	6
C6.11: In the EU more than 70% of bio-waste streams are separated from other waste streams for recycling and reuse (In 2022 the average is 50%).	Improved and informed governance and social innovation contribute to reducing resource consumption and result in an increased innovation capacity of all actors. Informed consumers may pursue the objectives of circular economy, asking for efficiency and inclusiveness of services provided through less resources and goods, changing consumption patterns (e.g. reducing meat consumption), preventing food waste and separating bio-waste from other waste streams so that it can be (partly) converted to bio-based materials. (2/2)	6
C6.12: The yearly EU consumption of pulses for food (excluding soy beans) has increased to 3 million tons (up from 2 million tons in 2022).	Legumes have an important role to play in the transition towards more sustainable farming systems that provide economic, environmental and social benefits and address relevant objectives of the EU biodiversity and farm to fork strategies.	6
C6.13: More than half of	From the perspective of the private sector companies, integrating natural capital and biodiversity impacts and depend-	6

European companies have integrated natural capital and biodiversity impacts and dependencies into their corporate decision making and risk assessment.	encies will enhance corporate decision making and business resilience as well as minimise investment risks. It will better inform, transform and improve their companies' sustainable decision-making processes, including by removing key blind spots in company risk assessments.	
C6.14: Advanced internet based digital applications such as remote sensors for crop and live-stock monitoring, data analytics and advanced planning and optimisation (e.g. via Farm Management Information Systems), control and execution of production with help of automatic machines (e.g. for milking) or robots (e.g. for weeding and harvesting), are used in more than half of farms in the EU.	The potential of digital technologies in the agricultural sector to enhance its sustainability and economic performance and to enhance working conditions has been acknowledged. The uptake of digital technologies in the agricultural sector and the development of supplementing data-technology-based solutions in the EU are increasing.	6

Cluster 6: Redundancies and dropouts from the work programme extracts

With increasing effects of climate change and a shift towards low(er) input production systems, there is the need for crops that are capable of capturing resources more efficiently and are resilient to abiotic stresses.

In support of this strategy, the EU and the African Union are implementing a ten-year roadmap (2016-2026) on research and innovation in food and nutrition security and sustainable agriculture to which the successful proposal will contribute. It will also contribute to the transformation of food systems to deliver co-benefits for climate (mitigation and adaptation), environmental sustainability and circularity, dietary shift, sustainable healthy nutrition and safe food, food poverty reduction and empowerment of communities, and thriving businesses.

R&I will accelerate the transition to sustainable, healthy and inclusive food systems by delivering in various areas: dietary shifts towards sustainable and healthy nutrition; supply of alternative and plant-based proteins; prevention and reduction of food loss and waste; microbiome applications; improving food safety and traceability; fighting food fraud; behavioural change; personalised nutrition; urban food systems; food systems governance and systems science; and digital and data-driven innovation

Land-based protein crops are a source of food, feed and environmental services and have an increasingly important role to play in the transition to more sustainable farming systems that provide economic, environmental and social benefits

Achieving a good environmental status of marine ecosystems, will be accomplished not only through protected areas and the restoration of important ecosystems but also by the ways we use the sea so that we no longer endanger food security, fishers' livelihoods, and the fisheries and seafood sectors.

Annex 2: Delphi Survey - Composition of respondents

Domain experts were identified mainly through bibliographic analysis within the database “Dimensions⁴”. We started the search in each cluster with a general cluster-specific search string. We then identified additional experts for some of the statements with rather specific orientation using a more targeted search string. We did not introduce geographical restrictions but due to the European nature of many of the statements the majority of identified experts were EU based. In cases where EC Officials were identified through the search they were excluded to avoid biasing the results. In addition, personal contacts were mobilised especially in domains where the response was weak in the beginning.

In addition to the domain-specific experts, that were invited for one, in some cases two specific clusters, depending on their background, we also invited experts with a cross-cutting Foresight perspective.

In total 727 experts were identified distributed among the clusters as shown in Table 13 (due to the possibility of multiple assignments, the sum of the cluster assignments [771] exceeds the total number of experts contacted [727]).

Table 13: No of experts approached per cluster

Total	C1	C2	C3	C4	C5	C6	Cross-cutting
727	59	64	111	76	237	214	10

Of the 727 experts contacted, 103 completed at least one statement of the questionnaire, which corresponds to a response rate of 7.1%. The majority of respondents chose to answer one cluster (75), 19 chose two clusters, 4 chose three and four clusters respectively, and one person chose to answer all six clusters (see Figure 14).

⁴ <https://www.dimensions.ai/>

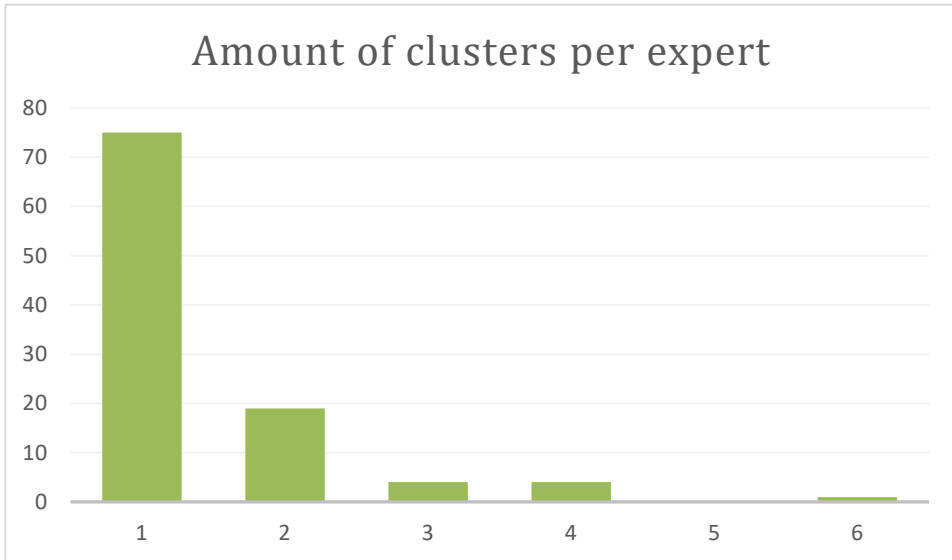


Figure 14: Amount of clusters per expert

To ensure anonymity, the questions on the personal background of the participants were limited to the most fundamental variables: Gender, age group and the country with which participants are most familiar.

Table 14 shows the distribution of male and female respondents across age groups. In total, 63 of the 103 respondents were male and 37 were female. Three respondents gave no answer and no one chose "other". The age group 31-50 was the most represented with 51 respondents, followed by 51-66 (37 respondents) and 66+ (14 respondents). One person gave no answer and no one chose "up to 30".

Table 14: Gender and Age group of respondents

Age group	female	male	n/a	Total
up to 30	0	0	0	0
31-50	19	32	0	51
51-65	15	21	1	37
66+	3	10	1	14
n/a	0	0	1	1
N	37	63	3	103

With regard to the question "which country are you most familiar with?" respondents named 29 different countries, 24 of which are in Europe. Germany was selected most often (13 times), followed by Italy and Austria (10 times each). Figure 15

Number of times selected

Country	Number of times selected
Germany	13
Italy	10
Austria	10
UK	8
Spain	6
France	6
Belgium	6
USA	4
Netherlands	4
Greece	4
Finland	4
Poland	3
Ireland	3
Sweden	2
Portugal	2
Norway	2
Czech Republic	2
Switzerland	1
Slovak Republic	1
Romania	1

"Which country are you most familiar with?"

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This report presents the results of a study on “Expectations and assumptions for the future in the Work Programme 2021-2022 of Horizon Europe”. The study scanned the HE Work Programme 2021-2022 for assumptions and expectations about the future and conducted a Delphi survey of experts on the likely time of realization of those expectations and assumptions. The analysis revealed three overlapping but distinct types of challenges associated with assumptions and expectations that should be recognised in future workprogrammes: policy challenges, diversification challenges and reflexivity challenges.

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