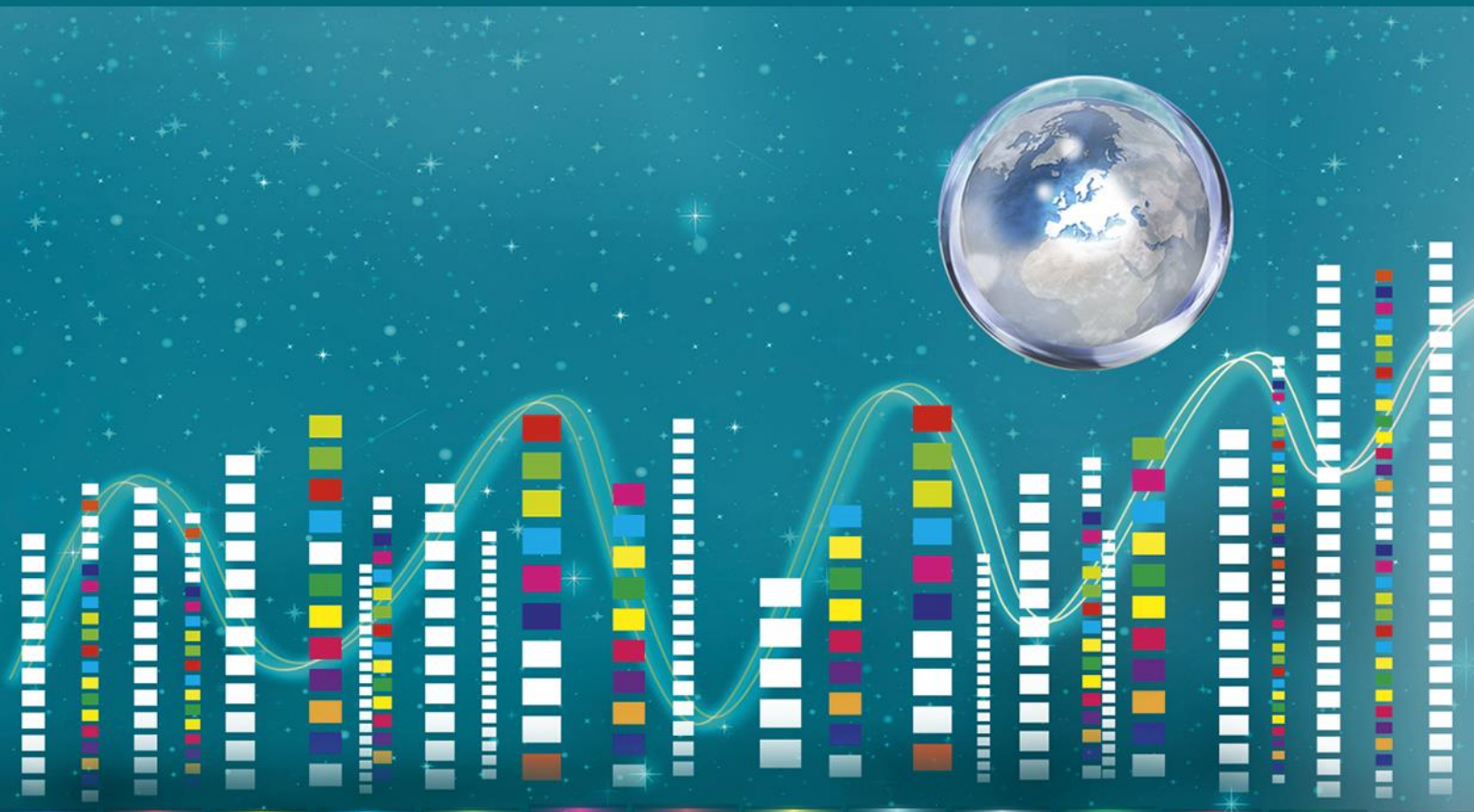
European Commission

Foresight

Low Carbon Economy

Targeted scenario N°10

Glimpses of the future from the BOHEMIA study



Research and Innovation

EN

***Low Carbon Economy* - Targeted scenario N°10**

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EUROPEAN COMMISSION

Low Carbon Economy
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from the BOHEMIA study

Directorate-General for Research and Innovation

2018

About BOHEMIA

BOHEMIA is a foresight study (contract N° Contract PP-03021-2015) designed specifically to support the preparation of the next framework programme.

The study put forward policy recommendations for the next framework programme, based on a foresight processes involving scenario development, a Delphi survey and an online consultation.

As part of its recommendations, the study identified 19 likely future scenarios with disruptive implications and associated priority directions for EU research and innovation.

The full range of the results of the study is available at https://ec.europa.eu/research/foresight

Targeted scenario N° 10

Low Carbon Economy

Summary

The EU has slashed the release of greenhouse gases in the atmosphere, invested heavily in carbon sinks and has become carbon neutral including for energy intensive industries like steelmaking. Energy and transport sectors have radically changed through low carbon electricity, cities' sustainable mobility and CO2 storage opportunities. Carbon capture technologies, together with renewed environmental actions, enlarge artificial and natural carbon sink, reversing carbon emission trends.

UN Sustainable Development Goals (SDGs) most relevant to this scenario:

The scenario

It is 2040 and the EU economy is carbon neutral. “Decarbonisation”, slashing the release of greenhouse gases in the atmosphere, and massive efforts for carbon absorption, expanding artificial and natural carbon sinks, makes it possible to reverse the trends of CO2-equivalent concentration in the atmosphere.

EU cities have low carbon mobility systems with extended, fast, cheap electric public transport. Compact and polycentric city designs favour walking and cycling in expanded green areas and paths, as well as shared transport among commuters. Most EU cities have large zones where fuel-combusting vehicles are forbidden. Some countries, such as Finland and Germany, have banned fuel combusting vehicles altogether. Long-distance travels and freight transports are limited thanks to revived attention to local socio-economic systems. Remaining long-distance transport relies on fast trains and hyper loops, and electric trucks. Bio-jet fuels are increasingly used for aviation.

The power sector plays a pivotal role. The share of low-carbon electricity supply in the EU is approaching 80%. Power and industrial sectors employ Carbon Capture and Storage (CCS), but the main novelty is widespread Carbon Capture and Usage (CCU). Almost all CO2 from European industrial production is re-used. Permanent CO2 capture from the air and mineralization processes are slowly taking off. Carbon neutrality is fostered through a massive reforestation programme, converting bogs to cranberry farming, and other novel options. Nature-Based solutions and re-greening cities ensure a large percentage of urban and peri-urban green areas, strongly increasing the potentiality of natural environment to absorb CO2.

Agriculture plays its part, being more sustainable, with less mechanised and intensive agricultural systems and a sharp reduction of livestock. As diets have changed, meat production and consumption are quite low, cutting agricultural emissions and environmental impact. The circular economy interconnects all the sectors, with more than 90% of materials and waste physically recycled or reused energetically. The economy has undergone a deep structural change. Consumers prefer buying services rather than goods, as reusing and recycling have permeated people’s daily life and habits. Across industries, the green economy boosts growth and employment, and new jobs have also emerged in the agricultural sector, which now focuses on sustainable production.

Relevance for Europe

Halting global warming is a global challenge that will generate economic opportunities for the innovation leaders. Accordingly, there is world competition in energy systems, as well as in dealing with the problem of greenhouse gases in the atmosphere. Seizing the economic opportunity of the low carbon transition now means that the EU would develop a competitive advantage in the next decades, and support economic growth and employment in emerging sectors.

Contribution towards the UN Sustainable Development Goals (SDGs)

The targets set during the 2015 Paris Climate Conference are now integrated in the SDG 13 that calls for urgent actions to combat climate change and its impacts. Not only emissions have to be slashed, also carbon in the atmosphere has to decrease, opening up a completely new research and policy field for carbon sequestration. By further pushing the low-carbon transition to more ambitious targets, the EU could significantly contribute to SDG 13, as well as drive the achievement of other related SDGs. For example, it could contribute to SDG 9 (Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation) especially for what concerns upgrading infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes. Similarly, it could bring forward changes to achieve SDG 11 on sustainable cities and communities and SDG 12 for responsible consumption and production.

Implications for EU policy

Environmental regulation, energy policy and agriculture policy are central to this transition. The current policy targets are not sufficiently ambitious to meet the goal of limiting the global mean surface temperature increase since pre-industrial times to less than 2 °C. Bolder targets should be set, accompanied by the identification of pathways for the transition that do not threaten but rather improve citizens' quality of life.

Future Directions for EU R&I policy recommended by the public consultation

- **Exploitation of new business models for circular economy and promotion of sustainable life-styles**
- **Research and Development of sustainable recycling technologies**
- **Research and development of carbon capture and storage and use**
- **Efficient monitoring and protection of biodiversity, promoting also the adoption of innovative tools and practices for soil protection.**
- **Regulation and implementation of emissions trading and carbon taxes together with incentive schemes for low carbon activities**
- **Regulation and implementation of emission monitoring**
- **Carbon harvesting from the atmosphere through photosynthesis**
- **Research on opportunities and solutions for zero carbon transport.**
- **Research on possible substitutes for meat proteins**

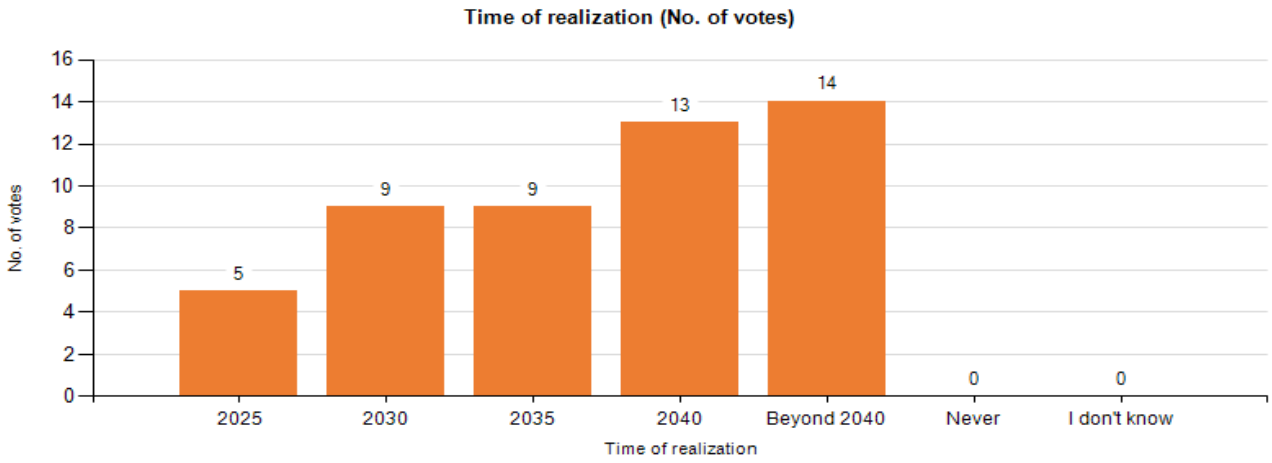
Annex: Relevant Data from the Delphi Survey

The Delphi survey of the BOHEMIA study asked experts about the time of realization of 143 statements about the future, and about the relevance of Research and Innovation for that realization, or about the relevance of the realization for Research and Innovation policy. The experts were asked to justify their judgements with arguments. The whole data set has been published and can be found at: https://ec.europa.eu/research/foresight

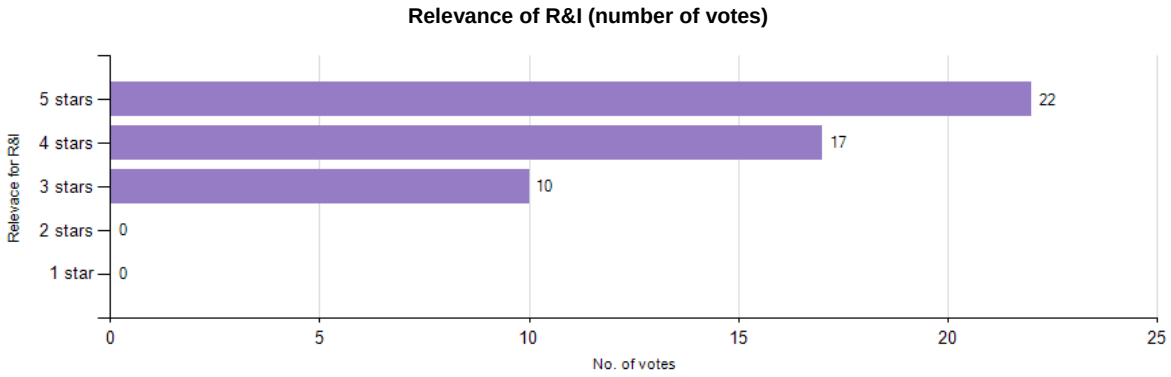
This annex includes the parts of the data set that are relevant to this scenario.

The share of low-carbon electricity supply in the EU increased from 30% in 2016 to more than 80%

Number of respondents : 48



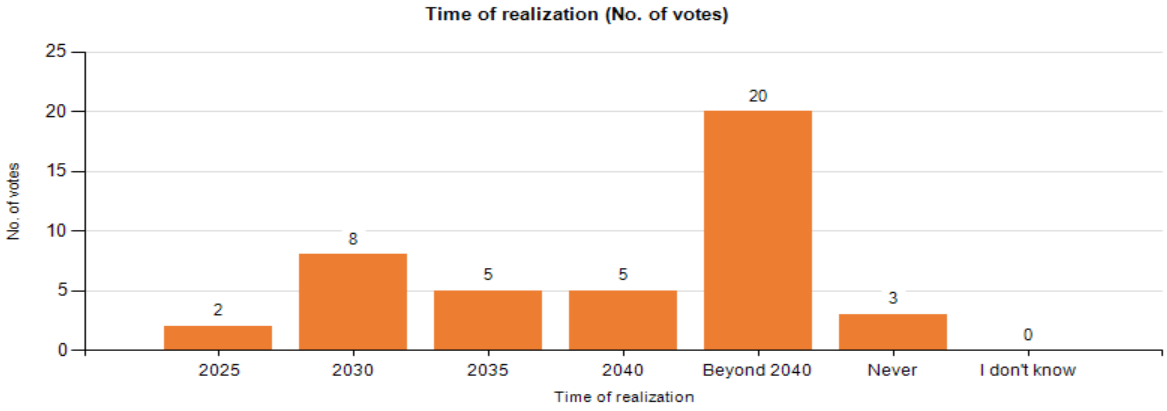
Arguments regarding the time of realization	No. of votes
Solar, tide and wave energy sources are still underexploited in most European countries and contributions and developments from these sources could contribute to achieving this figure.	46
Energy saving plays a role here, as will smart networks and energy storage.	33
The volatile financial market for energy is hampering the realisation of these technologies.	16
This is more about the collapse of the current socio-economic paradigm than simply about an increase in renewables. The actual amount of renewables within the timeframe will barely double.	10
If all wind energy facilities are really used and switched on, we can achieve 80% very soon.	8
Solar energy has a different implementation model as it can be installed by building owners and small land owners and costs are decreasing, so the percentage from solar will increase quickly.	6
The timing for achieving 80% will depend on the rate of electric vehicles uptake, as they will contribute to increasing consumption very fast.	5
Low cost, widely distributed energy storage is necessary to high electrical reliability needed to meet the goal.	5
Supply of raw materials (Li, Co, REE etc) may limit the uptake of renewable energy sources.	3
They are still heavily subsidised.	3
Timing will depend also on implementation of policies.	2
H2 derived from locally produced biomass can be an important contributor with distributed H2 production and improved H2 storage.	1



Average: 4.24 **Dispersion:** 0.63

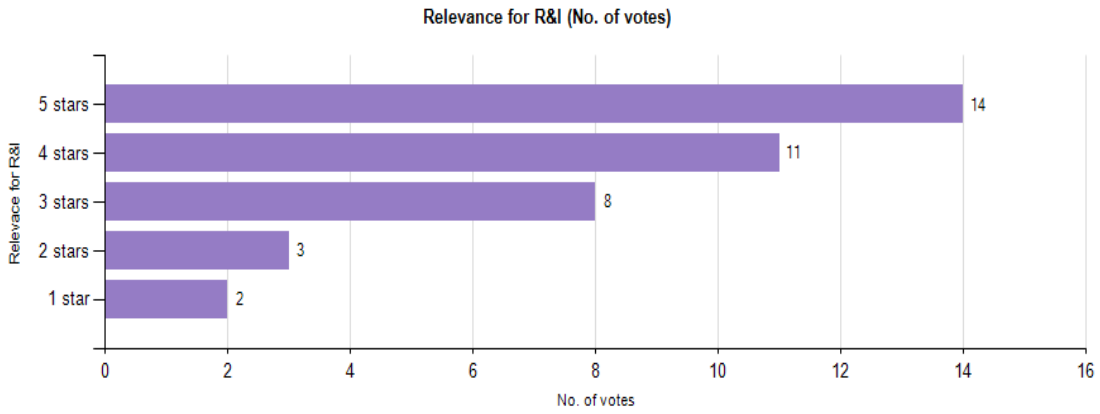
Arguments regarding the relevance of R&I	**No. of votes**
The supply itself is not the problem - the infrastructure for "transport" and energy storage are the problems that have to be solved.	43
We need behavioral studies on why people, on the one hand, demand more energy-saving and efficiency; but, on the other, behave contrary to that and use more energy for superficial machines.	23
Renewable energy needs a lot of critical materials. Proper recycling systems should be set up and substitutions developed	21
We need to develop smart-net technologies and storage. Unfortunately, the privatisation of electricity infrastructure makes addressing these public challenges politically very complex.	12
We need a lot of research on the "acceptance" of the different technologies and how to convince citizens that the infrastructure can only be supplied if there are visible facilities - even if they are not nice.	9
It depends on the definition: if you define nuclear power as low-carbon, then one should invest in the new small nuclear power plants, too. If not, the mass and efficiency of solar cells have to contribute more and require additional research.	9
We need research about the questions concerning how much citizens are willing and able to pay for energy.	5
Research is needed on low cost H2 generation from local biomass with improved H2 storage and deployment of fuel cell powered vehicles.	5
metals are needed; recycling and substitution are important but primary sources will still be needed	2
the growing importance of solar increases dependence on China: research is needed on next generation of solar panels	2
Power-to-gas systems need to be developed, optimized and established, in order to convert electrical energy to stable chemical energy	2
Breakthrough research on batteries is required.	2
Research is needed into social innovations - energy pricing arrangements which drive energy saving, in industry, transport and buildings, in ways which are politically acceptable.	1

CO2 capture from the air is applied in all EU capitals, urban and industrial areas in the EU (including CO2 conversion to permanently storable substances, for example, mineralization)



Number of respondents : 41

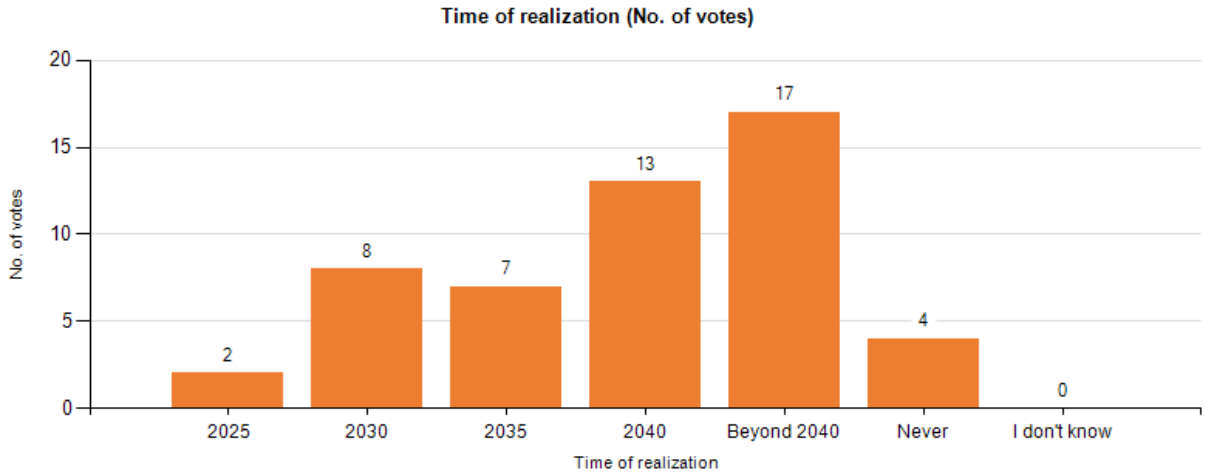
Arguments regarding the time of realization	**No. of votes**
The demand for carbon capture is huge.	27
Forests could be used to capture CO2 in wood products and substitute fossil energy.	12
Synthetic biology and ecological engineering can be a cheap and scalable solution for earth transformation.	10
Multiple alternatives to carbon sequestration are available including reduced CO2 generation, artificial photosynthesis, planting of forests, conversion of bogs to cranberry farming, and other options.	9
Petra Nova (produced by a Japanese company) collects 90% of the CO2 emitted by a factory, up to 5000 tonnes per year.	5
Carbon-clean technology (produced by an Indian company) is converting CO2 into baking soda – and could lock up 60,000 tonnes of CO2 a year.	5
Carbon capture from flue gas will be much more efficient than from the air (as in CCS).	4
Those technologies are far beyond what has been achieved for renewable-based electricity.	4
Using more wood in the construction industry would keep carbon captured.	3



Average: 3.84 **Dispersion:** 1.36

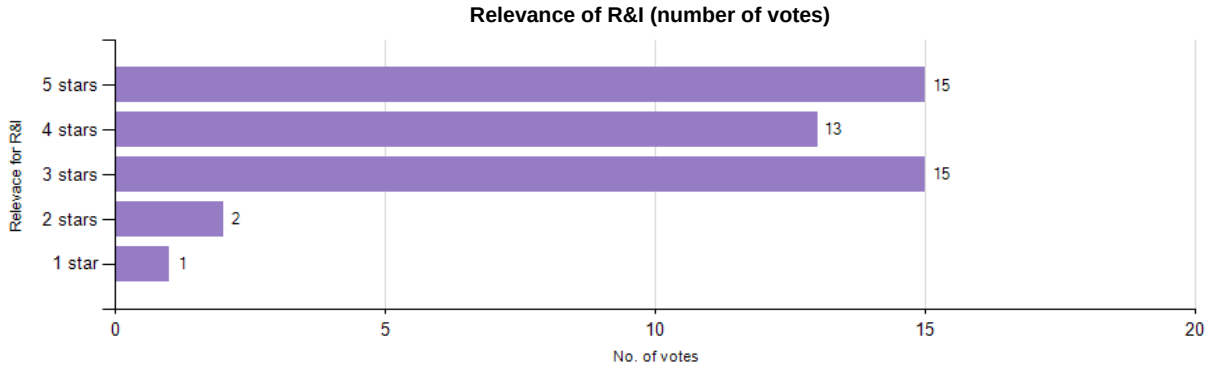
Arguments regarding the relevance of R&I	**No. of votes**
Europe is not at the forefront of these technologies, so it needs to scale up its relevant R&D.	28
Options that reduce energy use and reduce carbon production are more sustainable. Remaining carbon can be offset through planting trees or synthetic biology approaches that use the CO2.	14
Research on membrane technology for CO2 capture will bring together many researchers, stakeholders and private companies.	14
There is a promising line of research that needs to continue: US researchers have taken another step closer to developing a scalable option to capture and store carbon dioxide (CO2) using a new technique that involves injecting liquefied gas into ancient	6
artificial photosynthesis could be an option	6
Researchers found that commonly used industrial minerals called zeolites could significantly improve the energy efficiency of "carbon capture" technology. More research is needed to expand on this promise.	5
Research on new ecosystems combining synthetically modified and autochthonous organisms is needed.	4
easy-to-use and cheap materials and processes are required for this	3
no need to capture so much CO2 once renewable electricity is available	3
Research on carbon storage technologies need to focus on the robustness of storage	2

More than 90% of all materials and waste is physically recycled or re-used energetically in the circular economy



Number of respondents : 50

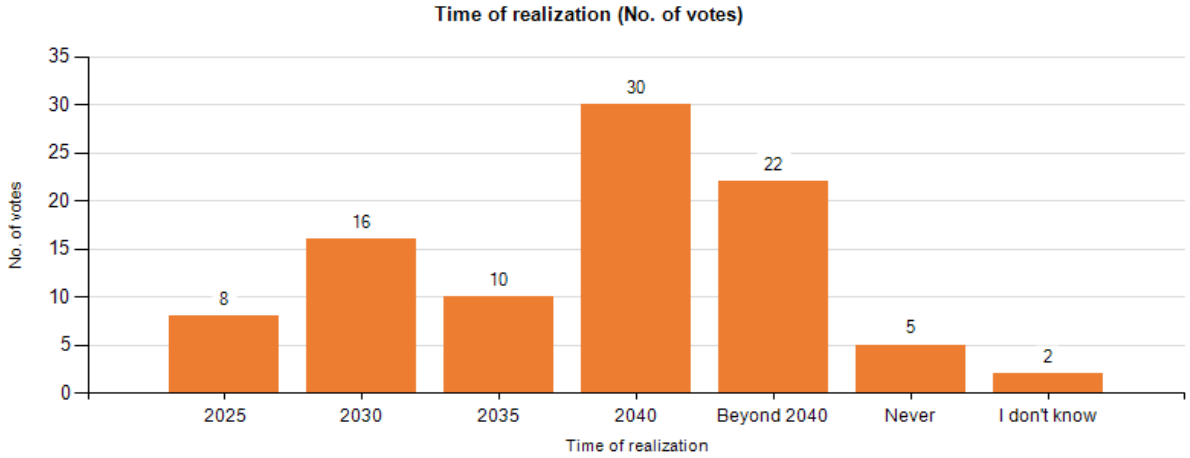
Arguments regarding the time of realization	**No. of votes**
Current recycling rates vary widely depending on the waste stream or country. A single figure of 90% may be inaccurate and too ambitious in some cases.	27
The European Commission adopted an ambitious Circular Economy Package, which includes a common EU target for recycling 65% of municipal waste by 2030.	26
A high level of recycling requires massive investment.	23
As consistent progress has been made in life-cycle assessment methodologies, there will be more public pressure to recycle and reuse.	20
This figure can only be achieved if it includes the reuse and service-life extension of goods, which is not subject to the second-law of thermodynamics and prevents waste rather than manage it.	16
Large scale utilisation of biowaste is a clear trend.	11
The main problem will be to curb the current inertia of the free market and the current consumption strategies.	7
Technically and politically, it is not a difficult target.	3
The re-use sector within the recycling sector has the potential of creating a huge amount of jobs for low-skilled people.	1



Average: 3.85 **Dispersion:** 0.98

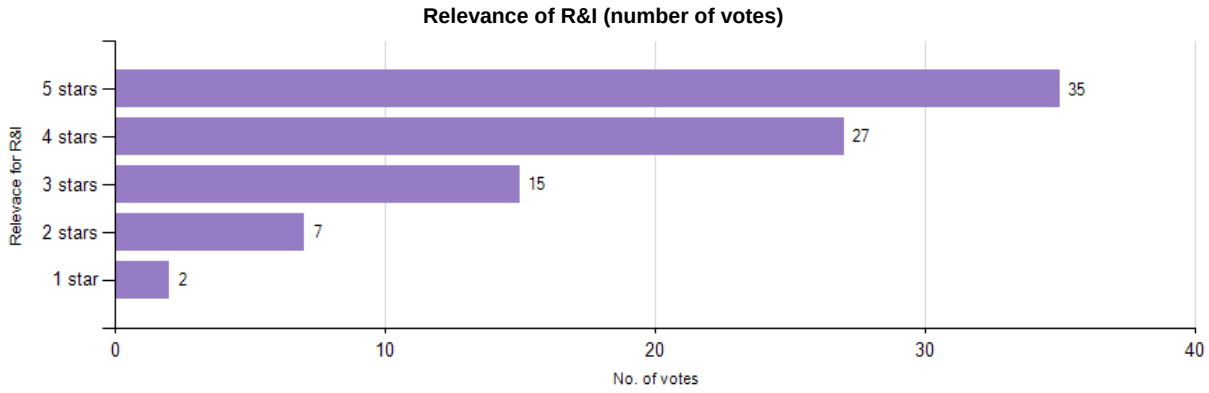
Arguments regarding the relevance of R&I	**No. of votes**
There is need for more efficient recycling technologies, among others because this is a promising market, which makes it an area that is therefore ripe for research.	33
Life Cyle Assessment for sustainable production needs a standardised approach in order to provide consistent results to policy makers.	26
There is a need for more efficient and non-destructive collection of end-of-life goods as well as new sorting techniques for material mixes to achieve a high purity of the materials to be recycled.	14
RI is needed to delink atoms instead of recycling waste, resulting in high purity resources instead of secondary materials, eg depolymerisation, delaminating, decoating, devolcanisation of tyres.	10
There is a need for research on how to push societies into a path of less waste production	9
products conception should involve this target	3

More than 80% of the CO2 from European industrial production is re-used



Number of respondents : 92

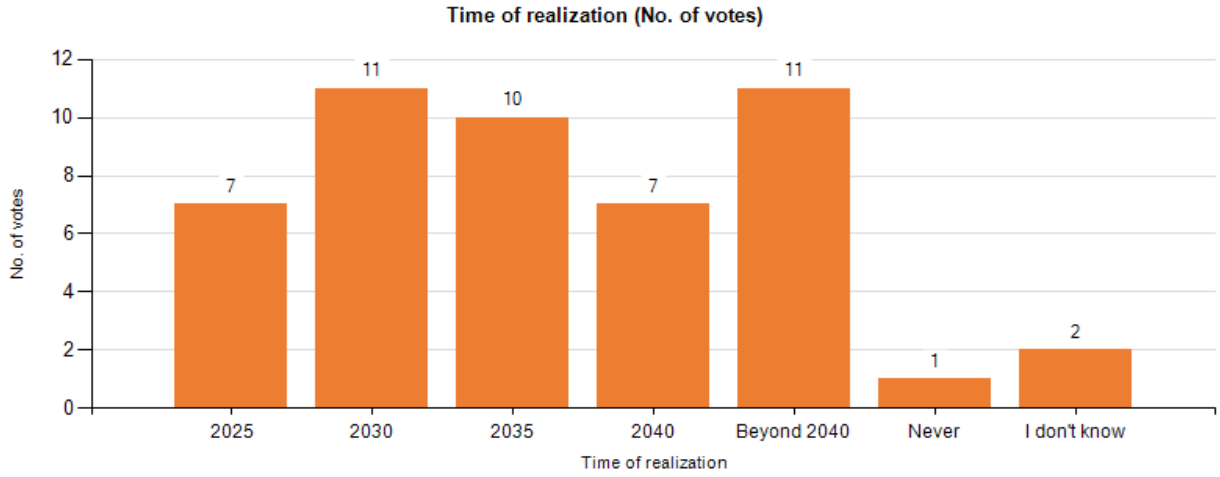
Arguments regarding the time of realization	**No. of votes**
As long as there is no CO2 capture on a large scale, this will take a lot of time.	64
There need to be significant additional incentives (economic and otherwise) for industry to implement carbon capture measures.	52
Circular economy and logistics are the key issues to reduce CO2.	28
Identify major sources for CO2 and start reduction from there.	18
An industrial plant in India has become the first in the world to generate almost zero emissions by capturing its own carbon dioxide (CO2) to produce valuable chemicals.	11
The decrease of CO2 production as industrial byproduct comes in favor of the re-use of the remaining CO2 captured.	10
It is impossible to reuse 80% of CO2 in the economy. The viable solution is to replace the CO2 source.	9
Many of the European companies operate in an global context. A global playing field is required for large scale implementation of CO2 re-use (=costly).	8
We are still missing a way to assess the true volumes of CO2 released in the atmosphere all along its life cycle, because it crosses a lot of industrial sectors and value chains.	4
If we only put a CO2 tax on the CO2 polluter, it will happen.	2
There is not large enough demand for CO2 itself and if brought back to carbon the energy expenditure is too large to be economically feasible.	2
The change to microbiological processes will support CCS and CCU since microbes will produce a CO2 stream not in need of purification and they can accept CO2 streams of less purity.	2
While benefits of CO2 reuse have been identified and some applications exist such as enhanced oil recovery, other than the H2020 prize the EU offers no incentives for R&D.	1



Average: 4 **Dispersion:** 1.12

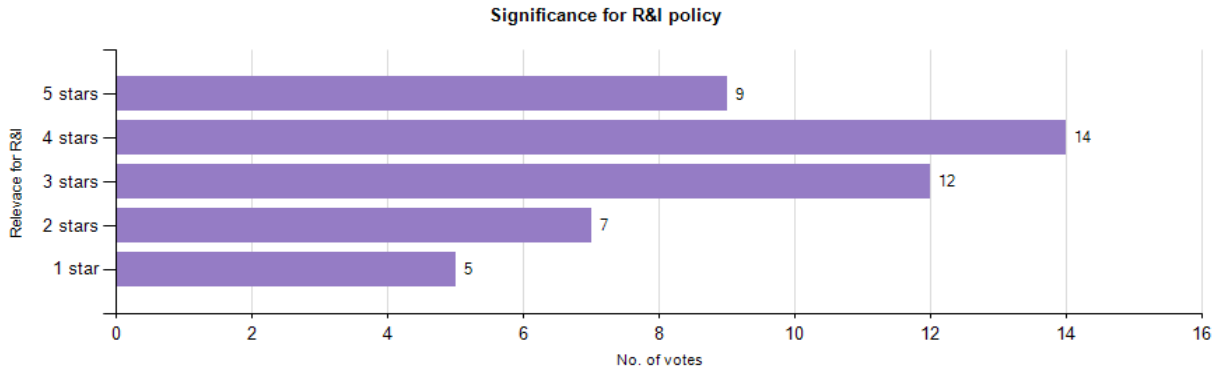
Arguments regarding the relevance of R&I	**No. of votes**
Research is needed for CO2 capture and transport. New applications have to be researched and tested.	68
Policy and enforcement remain critical in this area.	54
Even more R&D&I is needed for carbon re-use. CO2 is a very stable molecule and requires lots of energy to transform it into other products. That energy is not readily available yet.	22
CO2 Capture and Reuse will become highly attractive, when a low-energy, low-cost conversion method becomes industrially viable. Dedicated R&I actions must aim towards this goal.	16
Research money spent on non-fossil-fuel-based power generation generates better environmental return on investment, so carbon capture will be low-priority.	8
There has to come more positive arguments to have EU's citizens behind the idea	8
Integrated photonics will reduce the output of CO2 significantly as a Key Enabling Technology	5
The EU needs to direct R&D to address CO2 reuse in promising areas such as urea production, horticulture, water treatment, fire suppresion, refrigerant, etc.	3
CO2 reuse issue has to be dealed with on a global scale : reduction of generation, increase of recovery, R&D&I for process of conversion into valuable compounds, reforestation program, etc...	2
Synthetic biology may offer new approaches to CO2 reuse that need to be investigated.	2

All EU cities with more than 200 000 inhabitants have established large zones where gasoline-fuelled vehicles are forbidden



Number of respondents: 48

Arguments for time of realization	**No. of votes**
The current trend to ban diesel cars and the increasing awareness of health and lives saved will speed up this trend, if electrified (public) transportation gets adequate (climate) policy support.	39
The speed of introduction is highly dependent on the uptake of electric vehicles.	26
In some cities, there are already areas like this (Amsterdam, London).	14
Many European countries lack the political will to implement such reforms.	12
This trend is huge and will speed up in cities of high cultural value, as it will reduce the pollution in city centres (and related diseases) and facilitate tourism.	10
Accelerated development of hydrogen-powered vehicles is called for to assure energy security. Electric supply reliability cannot be assured under all scenarios e.g. solar coronal mass ejection.	4
Finland and Germany are discussing to ban gasoline-fuelled vehicles.	3



Average: 3.32 **Dispersion:** 1.53

Arguments regarding the significance for R&I policy	**No. of votes**
This is less a question of R&I and more an issue of political will (together with support from citizens and industry).	33
A ban could boost R&I policies to support alternative engines.	26
On the EU level, there can be some programmes for forerunners.	19
This is communal policy.	11
Hydrogen power addresses climate change like electric, but barriers to market entry are lack of infrastructure and inadequate technical solutions for H2 storage where RD&I is needed.	6
The only solution will be to go for 100% electric cars, with electricity 100% renewable and new clean batteries: a competition for clean and efficient batteries to be launched!	1

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Studies and reports

Publications Office