Study on long-term research and innovation agenda towards 2050 climate neutrality

Service Request 2022/02 (RTD/2022/SC/001) under framework contract CLIMA.A4/FRA/2019/0011

5 April 2022

Submitted to:

European Commission

Directorate-General Climate Action

By email: RTD-CALL-FOR-TENDER@ec.europa.eu / CLIMA-FWC-001@ec.europa.eu

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A proposal submitted by ICF S.A.
In association with Fraunhofer ISI, Perspectives, the Cleantech Group and Cambridge Econometrics

Date: 5 April 2022

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Date	5 April 2022

Executive summary

This offer has been prepared by ICF, in association with Fraunhofer Institute for Systems and Innovation Research (ISI), Perspectives, the Cleantech Group and Cambridge Econometrics, in response to the Service request *"Study on a long-term research and innovation agenda towards 2050 climate neutrality"*. This support to policy implementation and baseline assessment work is being commissioned by the Directorate-General for Research & Innovation (DG RTD) under the framework contract CLIMA.A4/FRA/2019/0011.

We are very pleased to respond to this Call for tenders as we believe our offer performs very strongly against DG RTD's contract award criteria. For this assignment, DG RTD and the different Commission services will benefit from:

- **…a well-structured, comprehensive and evidence-based methodology covering the six tasks presented in the Terms of Reference (ToR) and answering the four study questions to support ongoing decision-making processes (Award criterion 1 – Quality of the proposed methodology).** Our approach is specifically designed to meet the requirements of DG RTD and is the fruit of an intense cooperation among the partners over the last month. It combines traditional research methods, such as literature review and semi-structured interviews, with innovative approaches, including participatory foresight and horizon scanning based on machine-learning. Besides the state-of-the-art, this unique combination will allow us to go beyond the academic and grey literature to identify breakthrough technological and non-technological low-carbon solutions globally that have not benefited from large coverage yet. The requirement to assess the systematic interactions of mitigation approaches and specific solutions is fully integrated at different stages of our methodology. This will ensure this complex question is properly addressed and not just added as an extra layer to the analysis. We strongly believe that this approach is the right one to generate meaningful and original conclusions and to add value to the ongoing discussions on the design of the second strategic plan for Horizon Europe, the framing of the next EU Framework Programme for R&I and the design of major support programmes such as the Innovation Fund.
- **… an elaborated and balanced expert and stakeholder consultation approach allowing us to go beyond the 'usual suspects' and capture voices that are typically not included in these exercises (Award criterion 1 – Quality of the proposed methodology).** Building on the existing networks of our partnership, we have assembled a unique and diverse set of five external reviewers and 50+ external high-level experts. The external reviewers are fully integrated in the project team and were consulted during the design of this proposal to collect feedback on the ToR and our approach. Their role in the project will be to critically challenge our findings and act as peer reviewers of the project deliverables. They will also participate in the online expert conference. The 50+ external high-level experts we have gathered for this project are all highly experienced individuals with recognised leading expertise in their field. Collectively, they: (1) cover the breadth of technological and non-technological areas that will be addressed by the study; (2) represent various stakeholder groups and categories, ensuring that diverse perspectives can be captured; and, (3) provide extensive geographical coverage to allow for national / regional views on R&I priorities to be included. All these high-level experts are direct contacts of the core team and explicitly confirmed their willingness and availability to participate in the consultation process of the project.
- **…a highly experienced and specialised project team, with the requisite soft and hard skills, sectoral expertise and technical capability to meet all project requirements and ensure buy-in from stakeholders (Award criterion 2 – Organisation of the work).** ICF has joined forces with recognised experts from the

Fraunhofer ISI, Perspectives, the Cleantech Group, and Cambridge Econometrics, to deliver a cross-cutting study that will help inform the long-term strategic planning of R&I activities in the EU. Building on the long track record of delivering projects for the European Commission and extensive climate and energy expertise across all partners, we aim to provide a framework for prioritising innovation efforts across sectors and policy spaces, highlighting opportunities to accelerate and scale-up both technological and non-technological solutions based on an understanding of their systemic interdependencies. Our team is closely inter-connected with the ecosystems that DG RTD wishes to liaise with during this study: **Fraunhofer ISI**, **Perspectives** and **Cambridge Econometrics** operate at the border between academia and policy-making and bring rigour and excellence to the team; the **Cleantech Group** is uniquely positioned in the European cleantech ecosystem and benefits from direct contact with innovators, technology leaders, and investors; and, **ICF** brings unique expertise of engaging and working with governments across the globe to progress the fight against climate change, and will ensure all the findings stemming from the research are translated into actionable policy recommendations for DG RTD.

- **…a deep understanding of key project risks and a clear plan to mitigate them (Award criterion 3 – Quality control measures).** We have defined a strategy to mitigate risks based on a strong risk management plan. We will validate the approach with DG RTD to ensure we bring new insights to DG RTD and reduce the risk, for example, of generating findings focusing on incremental improvements only. We have also developed a robust approach for stakeholder engagement to maximise the quality of the inputs needed and overall buy-in. Finally, a key risk mitigation factor for the project is the fact that the team members selected to work on this project across the different partners have already worked together in the past and successfully delivered challenging projects for the European Commission. This is particularly the case of our proposed project manager, who has worked directly with **Fraunhofer ISI**, **Perspectives**, **Cambridge Econometrics**, and the **Cleantech Group** over the last two years for Commission services that include DG CLIMA, DG GROW and DG REFORM.
- **…a competitive package, with more than 448.5 team-days for the whole study at a total cost of €398,775 (below ToR budget threshold).** Our work allocation will ensure strong involvement of experts and senior experts in all project tasks.

Annex 3 provides CVs for the proposed project team, and Annex 1 presents details of relevant ongoing and previously completed projects. We await the selection decision with interest and can provide any further information during the selection process.

Yours sincerely,

Mark Allington
Vice President

1 Introduction and objectives

"We do not have all the answers yet. But this is Europe's man on the moon moment."

Ursula von der Leyen, President of the European Commission, announcing the European Green Deal, December 2019

Transforming Europe into a climate neutral economy and society by 2050 requires extraordinary efforts and the mobilisation of all sectors, economic actors, coupled with all the creative and brain power one can think of. Each sector will have to fundamentally rethink the way it operates to ensure it can transition towards this new net-zero paradigm, without jeopardising other environmental and social objectives. While the EU has seen the emergence of a vibrant ecosystem of cleantech innovators and investors over the last decade supported, among other, by ambitious policy frameworks and research and innovation (R&I) agendas at national and EU level, this is only the beginning. To seize its "man on the moon moment", the EU must intensify its efforts and design the right enabling conditions for the emergence of the next wave of breakthrough innovations. This will not only allow the EU to achieve its climate neutral objectives; it will also keep the EU at the forefront of the global fight against climate breakdown, while at the same time maintaining its competitiveness.

Achieving climate neutrality is an unprecedented challenge that will require significant acceleration of the pace of innovation to quickly bring forward solutions

Both technical and non-technical solutions currently in the early stages of development require significant public and private support to accelerate their market entry and widen deployment. While modelling scenarios are helpful tools to explore possible decarbonisation pathways, they silently assume the emergence of solutions, which often do not yet exist – particularly, carbon dioxide removal (CDR) technologies. Reliance on such emergence – without taking commensurate action or correcting for inadequate assumptions – is a risky approach. Delayed action increases the risk of failing to deliver on the greenhouse gas (GHG) emission reductions and the removals needed by 2050, and shifts the burden to future generations.

However, even when recognising the importance of pursuing innovative mitigation approaches, it is unclear which might prove most effective and how their emergence can be enabled or accelerated (and how to spot those cases where expectations need to be dampened). This is because the successful scaling of new solutions often feeds from multiple nurturing factors – some of them techno-economical and (natural-)resource driven, others shaped by social preferences and the regulatory and policy landscape. The central role of systemic interlinkages is particularly evident within the mitigation sub-category of CDR, where resource constraints, business-case synergies, and societal acceptance may strongly determine their ultimate role.

ICF has joined forces with recognised experts from the Fraunhofer ISI, Perspectives, the Cleantech Group and Cambridge Econometrics

Together we will deliver for DG RTD a cross-cutting study that will help inform the long-term strategic planning of R&I activities in the EU. Building on the long track record of delivering projects successfully for the European Commission, and extensive climate and energy expertise across all partners, we will provide a framework for prioritising innovation efforts across sectors and policy spaces,

highlighting opportunities to accelerate and scale-up both technological and non-technological solutions based on an understanding of their systemic interdependencies.

Our team combines leading expertise in the design of low-carbon solutions and system- and foresight-thinking with a unique ability to sense the pulse of European and global innovators and financiers

It will provide the European Commission and DG RTD with out-of-the box thinking. To address the four research questions identified in the Terms of Reference (ToR, see Table 1.1), we have built on the network of our partnership to assemble an exceptional panel of external reviewers and a diverse pool of experts that will provide us with the critical thinking required to address the challenges set out above.

Our team's thorough and complementary understanding of the challenges of decarbonising the economy, combined with an innovative methodological approach and proven experience in managing large stakeholder consultations, will ensure the study addresses the four key study questions, by providing a comprehensive analysis of the state-of-the-art knowledge and capturing the latest developments and insights across all focus areas.

The methodology we have designed covers all the tasks as defined by DG RTD in the ToR and structures them in a logical workflow

As illustrated by Figure 1.1 and Table 1.1, our methodology carefully and logically integrates the various study objectives, study questions and task requirements into a robust approach. More specifically, these tasks include:

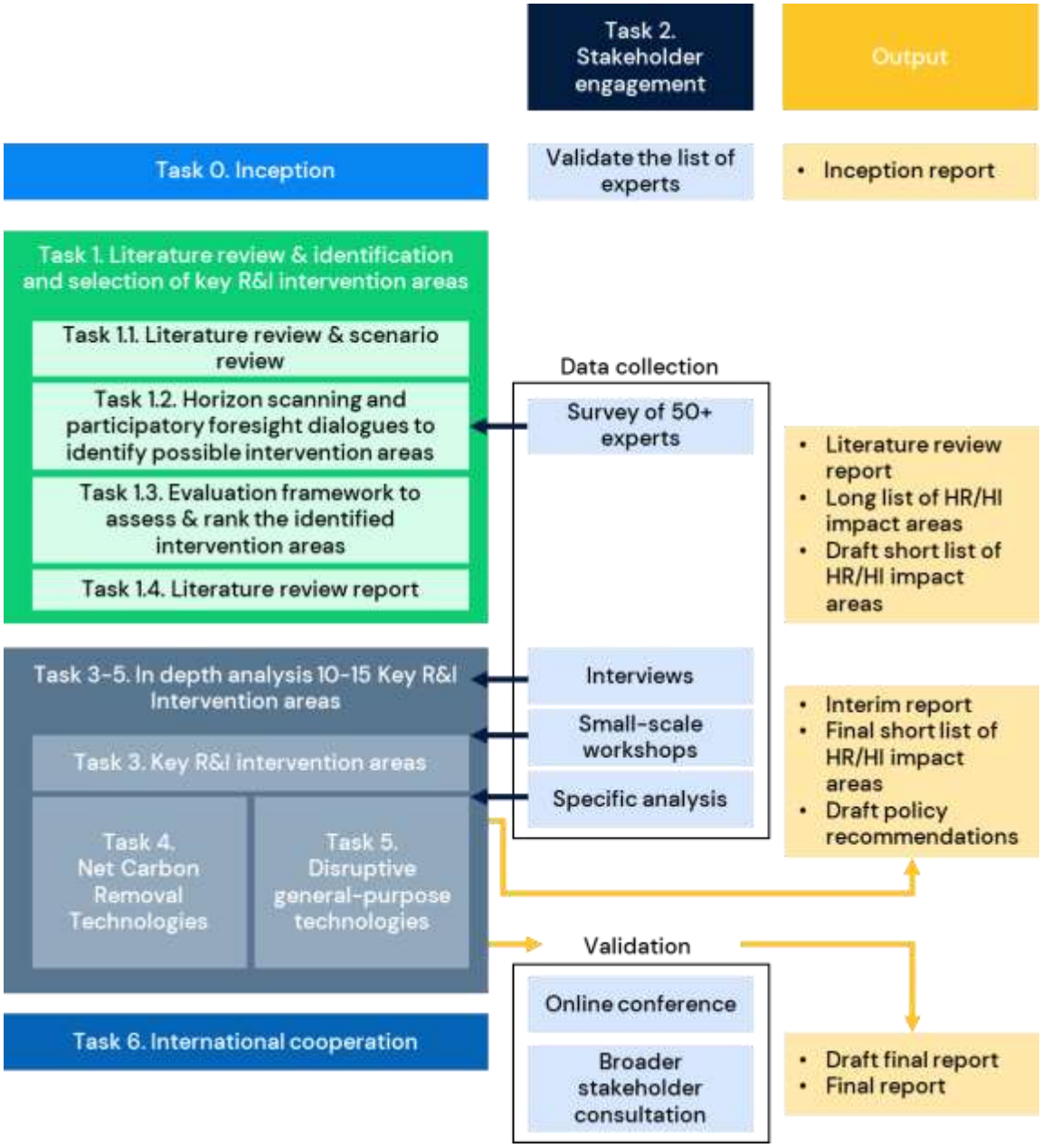
- **Task 0** - Organising an efficient inception phase to (1) mobilise our team; (2) build a strong working relationship with DG RTD and ensure we have access to the latest policy developments; and (3) validate our suggested methodology and stakeholder engagement approach;
- **Task 1** - Conducting a comprehensive and inclusive review of the existing body of knowledge, looking beyond the traditional sources of information, and also capturing the results of our horizon scanning, scoping survey, and participatory foresight dialogues to (1) produce an evidence-based, long-list of technological and non-technological breakthrough low-carbon innovations (also capturing disruptive general-purpose technologies); and (2) assessing this long-list against a robust evaluation framework to identify the solutions with the highest mitigation potential and the most need of policy support. This second aspect will also take into account the systemic impact of these solutions;
- **Task 2** – Essentially a functional task, aiming at engaging in extensive consultations with European and international experts on different focus areas. In a first stage, the aim will be to collect knowledge and insights on the key research questions via different consultation tools specifically designed for this project. In a second stage, we will validate the findings and recommendations drawn from the research through a final online expert conference. Lastly, we will also engage with a broader set of stakeholders to collect additional insights and feedback on our key findings and recommendations;
- **Tasks 3, 4 & 5** – Completing in-depth analysis of 10 to 15 R&I solutions and interventions areas, ranked as the most impactful and risky ones in view of existing market and societal conditions identified under Task 1. This in-depth analysis will be organised in three stages:

  - Stage 1 will consist of the systematic analysis of the identified solutions and their mitigation potential to answer the first, second and third study questions. This will be completed through the assessment of individual solutions against a set of established criteria. This analysis will be complemented by an analysis of the systemic interactions of the identified solutions, in order to better understand how to design integrated and inclusive policy solutions for their deployment (Task 3);
  - Stage 2 will consist of a focussed assessment of disruptive net carbon removal technologies and solutions, providing an overview on the opportunities and challenges related to their breakthrough as well as an analysis of their maturity levels, estimated mitigation potential, and R&D investment needs to support scale-up (Task 4);
  - Stage 3 will focus on the role of disruptive general-purpose technologies in the race to achieve climate neutrality by 2050. To this end, we will analyse the wider technological landscape to develop an understanding of the emerging opportunities and challenges related to climate-focused applications of general-purpose technologies such as artificial intelligence (AI), machine learning, etc. (Task 5).

- **Task 6** - Mapping and analysing the international landscape of R&I cooperation to provide an overview of current international collaboration mechanisms and their scope of action to help the European Commission identify where and how to engage to accelerate the rapid development and diffusion of breakthrough low-carbon solutions over the next 10-15 years in Europe and beyond.

Figure 1.1 presents the overall methodology we have developed to ensure that the requirements and objectives of the Service Request are successfully met.

Figure 1.1 Overview of the methodology in line with the Term of Reference



As illustrated in Table 1.1, the methodological approach summarised above will allow the study team to properly respond to the four study questions identified in the ToR.

Table 1.1 Our method will allow us to answer all the study questions

The study questions…	… will be informed through different channels…	… and answered in the study reports
1. Which technologies or non-technological solutions can be identified as both high-risk and high-impact and requiring particular public intervention and significant investments upstream of the innovation cycle in order to reach market maturity in the next 10-15 years?	■ **Task 1** will provide initial findings to all the study questions ■ The stakeholder consultation structured under **Task 2** will inform all the study questions ■ **Task 3** will focus on the in-depth analysis of the 10-15 R&I intervention areas prioritised under Task 1	■ The **Literature review** report will be structured around the four study questions and present initial findings stemming from Task 1. ■ The I**nterim report** will be structured around the four study questions and complement the results of the literature review report with the first insights gathered through the expert consultation (Task 2) ■ The **Final report** will be structured around the four study questions and present our final answers to the study questions. It will also be accompanied the outcome of the consultation of experts and stakeholders.
2.1. Which are the opportunities and challenges of breakthrough and disruptive technologies in net carbon removals?	■ **Task 1** will provide initial findings to all the study questions ■ The stakeholder consultation structured under **Task 2** will inform all the study questions ■ **Task 4** will focus on the assessment of net carbon removal technologies	
2.2. Which are the opportunities and challenges of breakthrough and disruptive technologies in disruptive general-purpose technologies?	■ **Task 1** will provide initial findings to all the study questions. ■ The stakeholder consultation structured under **Task 2** will inform all the study questions ■ **Task 5** will focus on the role of disruptive general-purpose technologies in the race to achieve climate neutrality by 2050	
3. How can systemic interactions of mitigation approaches be taken into account in the development of the R&I agenda towards long-term carbon neutrality?	■ **Task 1** will provide initial findings to all the study questions ■ The stakeholder consultation structured under **Task 2** will inform all the study questions ■ **Task 3** will integrate an analysis of the systemic interactions of the identified mitigation solutions and approaches to better understand how to design integrated and inclusive policy solutions for their deployment	
4. **How can EU engagement in international fora be strengthened to facilitate rapid development and diffusion of breakthrough solutions in the next 10-15 years at European level, and worldwide?**	■ **Task 1** will provide initial findings to all the study questions ■ The stakeholder consultation structured under **Task 2** will inform all the study questions ■ **Task 6** will specifically focus on answering study question 4.	

2 Methodology

2.1 Task 0. Inception

***Lead**: Jerome Kisielewicz, ICF.*

2.1.1 Objective(s) and scope

The objective of this Task 0 is to organise an efficient inception phase to (1) mobilise our team; (2) build a strong working relationship with DG RTD and ensure we have access to the latest policy developments; and, (3) validate our suggested methodology and stakeholder engagement approach.

2.1.2 Task 0.1 Mobilisation of the team

After receiving the great news of winning this contract, ICF will immediately mobilise the team to ensure everyone is available to work on the project and begin scheduling staff time. We will arrange a preparatory call with DG RTD's project officer in the days following project award to agree on the specifics for the project launch. This includes the scheduling of the kick-off meeting and planning via a virtual Microsoft Teams platform, which ICF has been running successfully since the start of the COVID-19 pandemic.

To ensure a smooth start to the project, we will organise an internal meeting to bring the whole project team up to speed with the latest policy developments. This internal briefing will notably be informed by an update from the Cleantech Group and their ongoing work on Cleantech for Europe[1], which implies close and continuous cooperation with all the stakeholders of relevance for this project. Any issues raised at this meeting which we feel are pertinent to the project approach will be passed on to DG RTD. Section 3 of this proposal presents the detailed approach we have developed for the organisation of work for this project.

2.1.3 Task 0.2. Kick-off meeting

The kick-off meeting with DG RTD will be conducted within ten working days of contract signature and delivered via MS Teams, our current platform to exchange with European Commission services and other project stakeholders.

It is important to flag that Jerome Kisielewicz, our suggested Project Manager, and key researchers within the ICF team are based in Brussels, a few steps away from DG RTD, and could therefore easily meet with DG RTD staff in person either for the kick-off meeting or for any other meetings related to the project.

The kick-off meeting will involve all key people required for the successful delivery of this project, namely: the project management team, task leads, the DG RTD project officer and other unit colleagues, as well as relevant Steering Group representatives from the JRC, DG CLIMA and the European Environment Agency (EEA).

The purpose of the kick-off meeting will be to:

- Introduce project team members on each side and build the basis for a strong working relationship;

[1] https://www.cleantechforeurope.com/

- Provide an opportunity for DG RTD to comment on the ICF proposal and update the project team on the latest policy developments to be considered in the Inception Report and the roll-out of the project;
- Review the ToR to ensure complete alignment between the project team and DG RTD;
- Review and adjust the methodology and criteria for prioritising high-risk/high-impact areas of support;
- Review and decide on the final list of experts (high-level and external alike);
- Agree on the table of contents for the Inception Report and draft outline of the Draft Final Report;
- Review the structure of surveys and interview questions presented in this proposal and provide initial feedback;
- Confirm the approach and outputs for each task, including the contents of all key deliverables;
- Agree on the best way to share documents between the team and DG RTD;
- Review the suggested workplan and agree on study objectives, timeframe, and deliverable dates; and,
- Agree on the form and scheduling of the weekly/regular teleconferences.

The above points will be confirmed in the agenda that we will design for the meeting and share with DG RTD for confirmation. Following the kick-off meeting, we will draft detailed minutes and share these with all the participants for validation within five working days. These minutes will be included as an Annex to the Inception Report.

2.1.4 Task 0.3. Validate the list of experts

A key success factor for the delivery of this project will be to engage with the most appropriate set of experts and stakeholders at the right moment in the project to collect the right type of information. Indeed, the objective of this project is not to identify so-called innovative solutions that have already been discussed over and over - or to limit ourselves to identifying incremental improvements.

DG RTD's bold objectives are very clear: identify and analyse those solutions that currently lie still hidden in laboratories or research centres, or that have not yet reached the level of attention they deserve for whatever reason (e.g., cost, risk-perception, social acceptance, etc.). There are multiple ways to identify such solutions and consulting innovators, researchers, financiers, and technology leaders is a key method to achieve this objective.

While section 2.3 of this proposal, focusing on Task 2, sets out our detailed consultation approach for the project, the objective in Task 0.3 will be to agree early on with DG RTD the composition of our different expert groups – and beyond that to validate our consultation approach. Based on the ToR, we have made a distinction between two categories of experts and stakeholders, as presented in Table 2.1. Each of these groups, and our proposed composition for them, are presented in the remainder of this section.

Table 2.1 We will engage with three categories of stakeholders for different purposes in the project

Category	Who they are?	How will they be involved?
External reviewers	■ 5 high-level experts with at least 10 years of professional experience. ■ Full members of the project team, directly subcontracted to ICF. ■ Mix of academics, innovators, technology leaders, and corporate leaders.	■ Provision of critical review of the key deliverables of the project (i.e. inception report, interim report, final report). ■ Participation in the expert online conference (Task 2.3).
High-level experts	■ 50 High-level experts with at least 10 years of professional experience. ■ Mix of academics, innovators, technology leaders, corporate leaders and financiers. ■ Coverage of all the sectors and areas of innovation relevant for the study. ■ Not part of the project team but all the experts on our list have explicitly confirmed their commitment to the project.	■ Expert input through: (1) Survey to inform the participatory foresight dialogue; (2) semi-structured in-depth interviews; and, (3) dedicated small-scale workshops. ■ Expert validation through the participation in the expert online conference (Task 2.3).
Additional stakeholders	■ 20-30 representatives from civil society, research institutes, industries and businesses, national funding agencies and international organisations that were not previously consulted.	■ Gather additional opinions, views and insights on the draft recommendations and the broader role, direction and investment needs of R&I to achieve climate neutrality through, amongst others, a bespoke questionnaire. ■ Participation in a 1-day online workshop.

As detailed in the Box below we will if course comply with all the GDPR requirements when engaging with stakeholders.

Box 1 GDPR

As we have compiled and will continue to compile a database of experts and their contact information, we have developed a strict and robust Data Security Plan. The plan sets out the measures and tools that will be put in place to collect, share and protect the data to be collected under this project. In the course of preparing this proposal, we have already informed all contact experts of how we will treat their data and for how long we will hold it.

Annex 2 presents ICF's draft Data Security Plan which has been designed to fully meet this project's requirements and builds on ICF Information Security Policy. We will agree any modifications required by the Commission to the Data Security Plan and proposed system architecture.

A key component of our Data Security Plan is a secure SharePoint Online location, hosted by ICF and with the server in Belgium, with a Microsoft Teams channel associated with it, that will be set-up for this project and that will serve as a Collaboration Hub for the project team. It will provide the online environment needed for efficient delivery of this contract.

2.1.4.2 External reviewers

The panel of five external reviewers will be tasked with critically challenging the study's methodology and findings, from its very inception to the final presentation. Their most important role will be to bring systemic thinking to the study, finding the connections and contradictions between the R&I intervention areas and specific technologies. The five external reviewers will also participate in the online expert conference.

The five external reviewers we have carefully chosen are a mix of academics, technology leaders, corporate leaders, and innovators. All five reviewers bring leading expertise in their professional field, and they have also been involved in formulating and steering policy recommendations.

Dr. Johan Schot is Professor of Global History and Sustainability Transitions at the Utrecht University Centre for Global Challenges. He is Academic Director of the Transformative Innovation Policy Consortium (TIPC) and the Deep Transitions research project coordinated from the Science Policy Research Unit at the University of Sussex Business School. Johan Schot is an academic entrepreneur who builds bridges between science and practice by applying a transdisciplinary research approach. He works jointly with actors from different academic disciplines, policymakers, governments, civil society, NGOs, the media and the business world to address the biggest challenges of our times such as climate change and social inequality. He is the author of influential publications including *Transitions Towards Sustainable Development. New Directions in The Study of Long Term Transformative Change*[2] (Grin, Rotmans & Schot, 2010) and *Three frames for innovation policy: R&D, systems of innovation and transformative change*[3] (Schot & Steinmueller, 2018).

Dr. Marlene Arens is Senior Manager within the Department of Environmental Social Governance at HeidelbergCement AG. In this role she represents HeidelbergCement in associations where the strategy to, and the policy needs for, a decarbonization of the cement industry are agreed on. Before joining HeidelbergCement, she gained extensive knowledge on industry transition working as a researcher for Fraunhofer ISI, as well as a Post-doctoral Fellow at Lund University, Sweden. Marlene holds a Master's Degree Mechanical Engineering from the Technical University of Dresden, Germany, and a PhD from Utrecht University, the Netherlands, in the field of Resources, Innovation and Technological change.

Jan Cornillie is Head of Strategy & Policy at 3E, a renewable energy technology firm, and Research Associate at the School of Transnational Governance at the European University Institute. He specialises in the synergies between technology, finance and policy to realise the transition to a net zero carbon economy. Jan is currently assessing the integration of digital and renewable energy technologies, in order to realise the smart energy systems required for a net zero world. He advises companies and governments on the implementation of the Paris Agreement, including the adoption of cleantech, the innovation in renewable-powered technologies and attractivity for sustainable finance.

Dr. Elena López Gunn is Director of ICATALIST, a consultancy applying scientific knowledge to climate change adaptation and sustainability, and Visiting Fellow at the University of Leeds. Her work focuses on the strategic development of projects,

[2] https://www.routledge.com/Transitions-to-Sustainable-Development-New-Directions-in-the-Study-of-Long/Grin-Rotmans-Schot/p/book/9780415898041

[3] https://www.sciencedirect.com/science/article/pii/S0048733318301987

vision of the future and innovation. She is currently working on climate change adaptation and the role of green infrastructure management. Elena is a member of the newly appointed European Scientific Advisory Board on Climate Change.

Dennis Pamlin is an entrepreneur and founder of 21st Century Frontiers, Senior Advisor at RISE Research Institutes of Sweden, and Senior Associate at the Chinese Academy of Social Sciences. His main skill is working with companies, governments and other organisations as a strategic economic, technology and innovation advisor in the area of sustainability. His background is in engineering, industrial economy and marketing. Dennis' current work includes work to establish a framework that can identify winners in a sustainable future, build a platform for global trend assessment, promote clusters capable of delivering transformative solutions, exploring the impact of our "digital twins" and develop tools that allow public procurement to support sustainable solutions.

2.1.4.3 High-level experts

The pool of 50+ high-level thematic experts that will be consulted as part of the study is composed of a diverse and highly experienced individuals with recognised leading expertise in their field. In line with the breadth of technological and non-technological areas that will be addressed by the study, we have put together a comprehensive list of experts that:

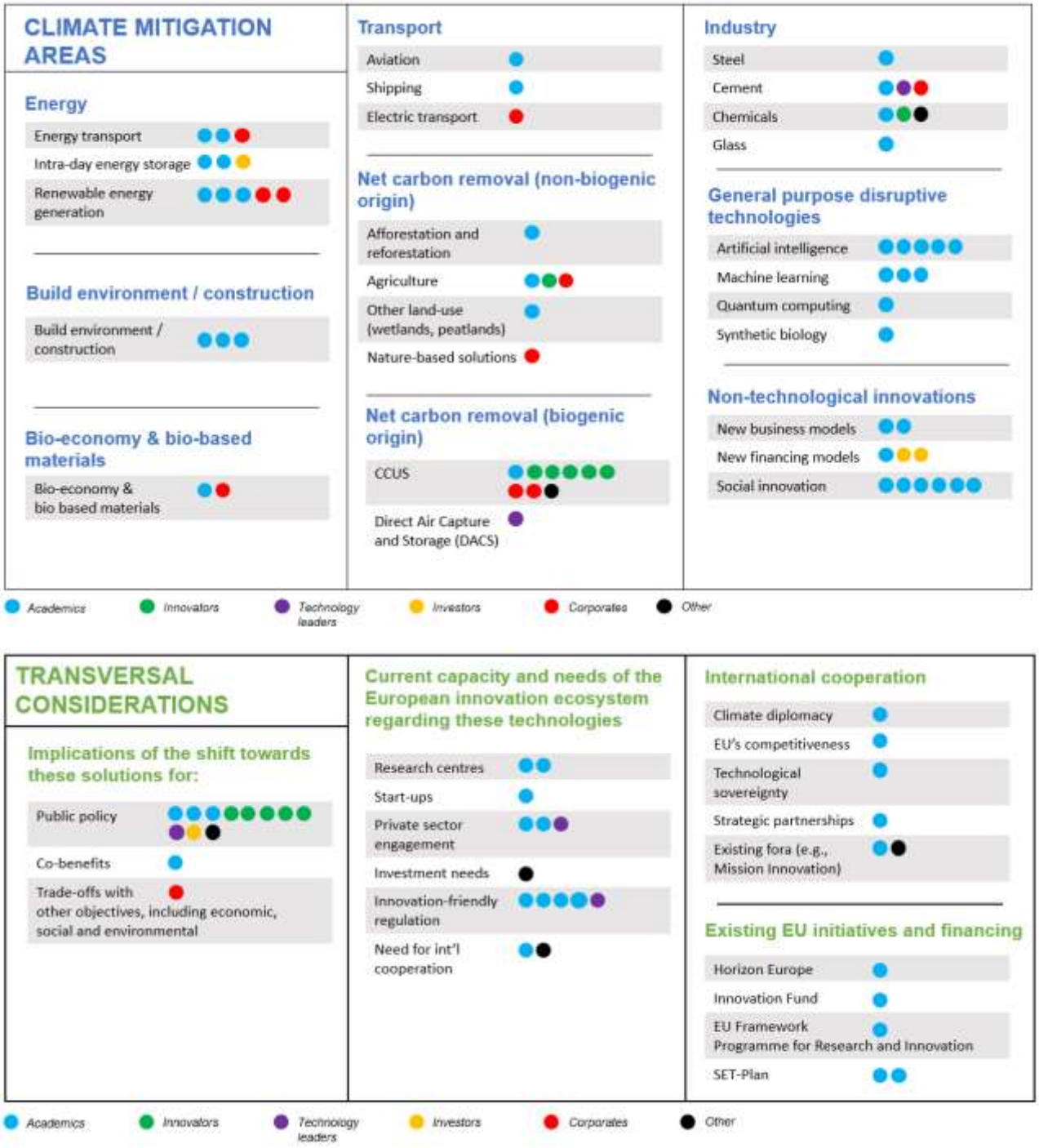
- covers a wide range of **thematic specialists** (including traditionally niche areas such as the role of quantum computing in the low-carbon transition);
- ensures **diverse perspectives** are captured, by including professionals with different backgrounds such as academics, innovators, investors, corporate representatives, etc.; and,
- provides extensive **geographical coverage** to allow for national / regional views on R&I priorities to be included.

Particular attention has also been given to achieving a good balance between:

- experts and leaders in purely **climate mitigation areas**, ranging from energy to bio-economy, industry, carbon removal technologies and business model innovation;
- professionals with **transversal expertise** that could provide a more holistic view of the other key issues that need to be tackled, if the EU is to massively accelerate climate innovations by 2050, including international partnerships, the wider innovation agenda and funding opportunities, and policy support to strengthen the innovation ecosystem.

Figure 2.1 below shows the wide coverage of thematic expertise that make up of our pool of experts. The full list of experts can be found in Annex 3.1.

Figure 2.1 Our pool of 50 high-level experts provides a comprehensive, diverse and complementary group across the majority of thematic areas and also brings extensive geographical coverage



To ensure the active engagement of these experts in the study, we have adopted the following strategy:

- We built an initial long list of 160+ experts during the proposal phase and shortlisted the most relevant ones for the study;
- All the shortlisted experts, that now compose our pool of 50+ high-level of experts, are direct contact from the project team, which will ensure a smooth communication with them;

- All the shortlisted experts were contacted during the proposal phase and explicitly confirmed their willingness and availability to participate in the consultation process of the project; and,
- We have included in the list of 50+ experts a number of highly specialised colleagues from ICF, Fraunhofer ISI and Perspectives and the Cleantech Group that will de facto participate to all the consultation exercises.

If despite the above mitigation measures, the response rate to our consultation remains below DG RTD's expectations, we will, conduct another selection of experts from the long list (i.e., over 160) developed at the proposal stage. The selection process will be the same as used for compiling the initial list of high-level experts which will involve getting the approval of DG RTD on the additions to the list and the CVs. The study team will also send an introductory email that will be accompanied by an accreditation letter signed by the Steering Group (DG RTD, JRC, DG CLIMA, and the European Environment Agency (EEA)) to support the needed buy-in.

2.1.4.4 Additional stakeholders

In addition to the input provided by our review panel and pool of 50+ thematic experts, the study will benefit from engagement with a wider network of stakeholders, that will bring important opinions and viewpoints that can help shape the EU's R&I agenda.

In particular, our team plans to bring perspectives from, among others, civil society, national/regional innovation funding agencies and international organisations. We believe it is crucial to engage these actors in a dialogue to ensure there is buy-in and strong support for the long-term vision for R&D in the EU and globally. This will help ensure all parts of the innovation ecosystem and beyond can work collaboratively towards the same objectives.

Some initial examples of the organisations we plan to consult with are provided in Table 2.2 below. This list will be discussed and agreed upon with DG RTD.

Table 2.2 Initial stakeholder mapping

Type of organisation	Example of organisation
Civil society	■ Negative Emissions Platform: https://www.negative-emissions.org/ European Regions Research and Innovation Network (ERRIN): https://errin.eu/ ■ Climate Action Network (CAN) Europe: https://caneurope.org/ ■ IUCN – International Union for Conservation of Nature: https://www.iucn.org/ ■
National funding agency	■ French National Research Agency (ANR): https://anr.fr/en/ ■ DFG - German Research Foundation: https://www.dfg.de/index.jsp ■ Research in Poland: https://researchinpoland.org/ ■ Danish Agency for Science, Technology and Innovation (DASTI): https://fundit.fr/en/institutions/danish-agency-science-technology-and-innovation-dasti ■ Spanish State Research Agency, AEI-Agencia Estatal de Investigación: https://www.aei.gob.es/
International organisation	■ Mission Innovation ■ OECD ■ WTO

Type of organisation	Example of organisation
	■ World Economic Forum ■ UNFCCC
Research institute	■ European Institute of Innovation & Technology (EIT): https://eit.europa.eu/ ■ Institute for Sustainable Development and International Relations (IDDRI): https://www.iddri.org/en ■ Centre for International Research on Environment and Development - UMR CIRED: https://www.cirad.fr/en/about-us/research-units/cired ■ Potsdam Institute for Climate Impact Research: https://www.pik-potsdam.de/en ■ Foundation for Research and Technology - Hellas (FORTH): https://www.forth.gr/en/home/ ■ Basque Centre for Climate Change: https://www.bc3research.org/
Industry and business	■ Global CCS Institute: https://www.globalccsinstitute.com/ ■ PsiQuantum[4]: https://psiquantum.com/ ■ Skeleton Technologies: https://www.skeletontech.com/?hsLang=en ■ Carbon Counts: https://www.carbon-counts.com/ ■ Bolt Energy: https://www.boltenergie.be/fr

2.1.5 Task 0.4. Inception report and meeting

The ICF team will prepare a draft Inception Report for approval. It will include all aspects outlined in the Service request, including the:

- list of external experts together with their CVs;
- structure of surveys, interviews and questionnaires;
- criteria and methodology to be employed in the screening and prioritisation process of technologies/solutions;
- themes to be covered during the workshops and expert conference; and,
- finetuned outline of the final report (as agreed upon at the kick-off meeting).

In addition, a revised workplan will be added, reflecting any changes in key milestones and deadlines.

We will incorporate any comments from DG RTD and will require the Inception Report to be signed off so that there is a shared understanding of all key aspects of the project from the outset. We expect approval by the Commission within four weeks from the kick-off meeting to align the team and ensure all outputs meet DG RTD's expectations and deadlines.

2.1.6 Output(s)

This task will result in the following outputs:

- Validated list of experts to be consulted;
- Draft Inception report; and,

[4] https://www.weforum.org/agenda/2019/12/quantum-computing-applications-climate-change/

- Final inception report.

2.2 Task 1. Literature review & identification and selection of key R&I intervention areas

***Lead**: Ralitsa Donkova, ICF.*

2.2.1 Objective(s) and scope

The objective of this task is to conduct a comprehensive and inclusive review of the existing body of knowledge, looking beyond the traditional sources of information to also capture the results of our horizon scanning and participatory foresight dialogues, with the aim to:

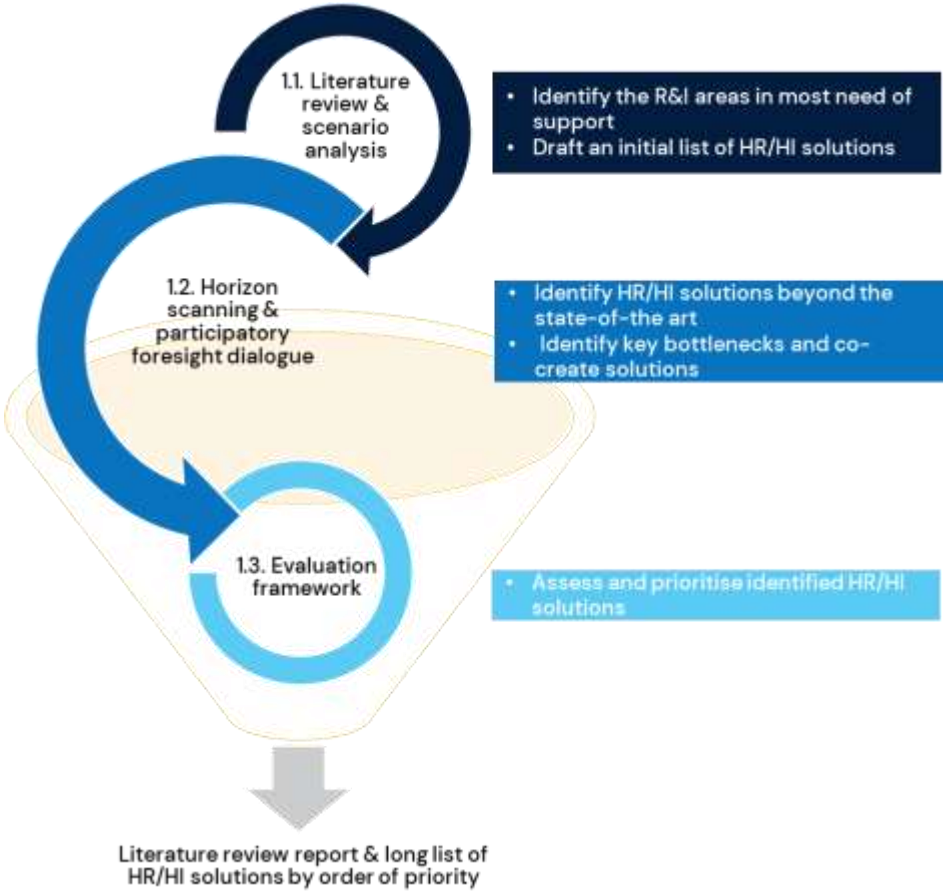
1. Produce an evidence-based, long-list of technological and non-technological breakthrough low-carbon innovations (also capturing disruptive general-purpose technologies); and,
   2.
3. Assess this long-list against a robust evaluation framework, to identify the solutions with the highest mitigation potential and the most need of policy support, also taking into account the systemic impact of these solutions.

Since the goal is to focus on breakthrough innovations at early stages of development, while at the same time also assess their feasibility and potential socio-economic and environmental impacts, we propose to **combine three methodological approaches.** This will help us to build a solid and comprehensive understanding of the state-of-the-art in each of the examined R&I areas, identify innovations at their earliest stages, and develop a reliable framework for the review and ranking of the selected R&I areas. The three approaches are:

- First, a **comprehensive literature review** to summarize the state-of-the-art. This includes also a **review of relevant scenarios for climate neutrality** which will help to identify the R&I intervention areas in most need of support, and to quantify and justify the selection of innovative solutions (Task 1.1);
- Second, **horizon scanning & participatory foresight dialogues** to (1) identify additional breakthrough innovations for climate neutrality which can make substantial contributions already to the time period 2030-2040; and, (2) collect insights to assess and prioritise possible solutions; and,
- Third, an **evaluation framework** to be able to assess and prioritise the identified solutions based on objective and transparent criteria.

As illustrated in Figure 2.2, the three approaches will work in a sequential, concentric manner and will build on each other.

Figure 2.2 Task 1 follows a clear structure to generate the desired results



We will begin with examining established sources to develop the core state-of-the-art, and then we will move to horizon scanning, which will examine sources and information that may have not yet made it into the peer-reviewed literature or conference proceedings. At the same time, however, we will also build in an iterative element to the research. The initial findings from the literature review will help us to refine the horizon scanning methodology, and the results of the horizon scanning will in turn help us enhance the state-of-the-art developed in the literature review task. This process will result in a comprehensive and inclusive long-list of innovative low-carbon technological and non-technological solutions.

The evaluation framework will build on the first two steps to define the criteria to be used for the assessment of the techno-economic feasibility, mitigation potential, as well as socio-economic, and environmental impacts of the identified solutions. The current level of support to the identified solutions will also be assessed. This evaluation framework will then be used to assess and score the long-list of identified solutions against transparent criteria to arrive at a ranking. The top 10-15 solutions in that ranking will then represent our draft short-list of high-impact, high-risk solutions.

2.2.2 Task 1.1. Literature review & scenario analysis

Our approach to the literature review will be based on the best practice procedures and approaches set out by the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre)[5]. This involves three main steps:

- Establish a systematic review protocol;
- Map and identify appropriate sources, using relevant search terms; and,
- Implement the review strategy according to a specifically designed review template.

On top of these three steps, we suggest adding a two more steps:

- Analysis focusing specifically on the review of key climate neutrality scenarios. These scenarios are key to gather insights on the importance of individual technologies in achieving climate neutrality, on their expected implementation time, on their techno-economic characteristics as well as on system aspects under which the technologies evolve. It is therefore a key source of information for the scope of this study, and it deserves particular attention.
- Initial findings and draft list of high-risk high-impact R&I areas.

We set out our 5-step approach to undertaking the review in the sections below.

Step 1. Establish a systematic review protocol

The initial task, immediately following the kick-off meeting, will be to build a more detailed understanding of the goals and scope of the literature review. This can be most effectively achieved by producing a review protocol. The protocol will address the following issues:

- **Specific review topics**: ensuring that all relevant aspects are covered and that there is sufficient focus to the analysis. The results of the literature review will inform the initial response to the four research questions set out in the ToR and the key hypotheses for each of these research questions that will then be explored and validated with stakeholders under Task 2. The objective of the literature review will also be to generate an initial long list of potential R&I areas to establish the state-of-the-art. It will also ultimately lead to the appraisal of these areas under Tasks 3-5, so these review topics will be jointly developed by all team members at the outset of the study.
- **Inclusion criteria**: deciding which publications will be included or not included in the review (e.g., by time period, language, geographic scope, etc.). A key aspect here is also the applicable publication types (e.g., peer-reviewed journal articles, non-peer reviewed academic research outputs, conference proceedings, scientific and technological foresight reports, government commissioned research, policy documents, grey literature, etc.).
- **Search strategy**: detailing the sources of material (e.g., the databases, such as EBSCO, Scopus, Web of Science, and Science Direct, the academic research institutions and other research bodies, and the government departments and agencies) as well as Google and Google Scholar.
- **Database search terms, and combinations of terms**: A repository of search terms will also be defined (e.g., “intra-day storage”, “BECCS”, “agroforestry”,

[5] http://eppi.ioe.ac.uk/cms/

"carbon dioxide removal", etc.). Beyond specifying obvious words such as climate neutrality and net carbon removal, key words can include examples of existing innovative technologies or examples of technological challenges (e.g., load management), etc. The initial long-list of key words will be discussed with DG RTD during the inception phase of the project. Upon identification of gaps, further keywords may be added later during the process e.g. to cover novel technologies.[6]

Step 2. Map and identify appropriate sources, using relevant search terms

The study team will undertake a preliminary document mapping to review and assess available information sources, identify any trends (e.g., growing number of publications on BECCS), and locate in particular areas where little information is available (e.g., use of synthetic biology for climate mitigation). Then, the team will "snowball"[7] the review, identifying further sources by following the sources cited in the bibliography and the sources which have cited the source in question. An initial list of information sources to begin the literature review is shown in Table 2.3.

Table 2.3 Initial mapping of relevant sources

Public information sources
Climate Change
Climate Change 2021, The Physical Science Basis: https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/
6th Assessment report 2022, synthesis: https://www.ipcc.ch/report/sixth-assessment-report-cycle/
Climate Neutrality
European long-term strategic vision for a modern competitive and climate neutral economy: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773
'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality: https://ec.europa.eu/info/sites/default/files/chapeau_communication.pdf
2021 Strategic Foresight Report: https://ec.europa.eu/info/sites/default/files/strategic_foresight_report_2021_en.pdf
EU vision to go climate neutral by 2050: https://op.europa.eu/en/publication-detail/-/publication/92f6d5bc-76bc-11e9-9f05-01aa75ed71a1
IEA Roadmap to Net Zero by 2050: https://www.iea.org/reports/net-zero-by-2050
FIT FOR NET – ZERO: 55 Tech Quests to accelerate Europe's recovery and pave the way to climate neutrality: https://www.capgemini.com/gb-en/wp-content/uploads/sites/3/2020/10/Full-Report.pdf
EU Reference Scenario 2020: https://energy.ec.europa.eu/data-and-analysis/energy-modelling/eu-reference-scenario-2020_en
Policy scenarios for delivering the European Green Deal: https://energy.ec.europa.eu/data-and-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en
International Cooperation
Research on innovation international cooperation: http://www.bluemed-initiative.eu/wp-content/uploads/2021/05/Factsheet-Global-Approach.pdf
Analysis of the Intellectual Property portfolios of the world's top 2000 R&D investors: https://publications.jrc.ec.europa.eu/repository/handle/JRC126788

[6] BECCS is for example a category of many different approaches (which would likely to emerge if one was looking for the keyword "BECCS"); many combinations of tech are also only emerging as possibilities (PY-BE-CCS-Biochar, etc.).
[7] Snowballing refers to using the reference list of a paper or the citations to the paper to identify additional papers. Starting with a few articles that currently exist in or around your topic of interest, this is referred to as 'start set'. Once the start set is decided, the team starts to conduct backward and forward snowballing.

European strategy for international cooperation in a changing world: https://ec.europa.eu/info/sites/default/files/research_and_innovation/strategy_on_research_and_innovation/documents/ec_rtd_com2021-252.pdf
Study on accelerating the low carbon transition with targeted and coordinated international action: https://www.brookings.edu/wp-content/uploads/2019/12/Coordinatedactionreport.pdf
Negative emissions technologies
Direct Air Capture, A key technology for net zero: https://www.iea.org/reports/direct-air-capture-3?utm_content=bufferb4e85&utm_medium=social&utm_source=linkedin.com&utm_campaign=buffer
The role of negative emission technologies in achieving Paris Agreement targets: https://easac.eu/fileadmin/PDF_s/reports_statements/Negative_Carbon/EASAC_Report_on_Negative_Emission_Technologies.pdf
Scoping paper on setting the context for an EU policy framework for negative emissions: https://www.ceps.eu/wp-content/uploads/2021/09/PI2021-12_EU-policy-framework-for-negative-emissions.pdf
Cross-cutting policies on negative emission technologies: https://www.breakthroughenergy.org/~/Media/Files/BEV/Playbooks/EU/Cross-Cutting/EUCCPNETs.pdf
Inter-model assessment of the role of direct air capture in deep mitigation pathways: https://www.nature.com/articles/s41467-019-10842-5
Disruptive General-Purpose Technologies
Using Analytics and AI to help achieve carbon neutrality: https://www.forbes.com/sites/forbestechcouncil/2021/12/29/how-analytics-and-ai-can-help-achieve-carbon-neutrality/
Our future in the Anthropocene biosphere: https://link.springer.com/article/10.1007/s13280-021-01544-8
How Internet of Things and Artificial Intelligence pave the way to climate neutrality: https://www.euractiv.com/section/digital/opinion/how-internet-of-things-and-artificial-intelligence-pave-the-way-to-climate-neutrality/
The role of Artificial Intelligence in the European Green Deal: https://www.europarl.europa.eu/RegData/etudes/STUD/2021/662906/IPOL_STU(2021)662906_EN.pdf
The role of Deep Tech to build a better future: https://medium.com/eleks-labs/what-is-deep-tech-and-how-it-builds-a-better-future-7310fdb163fd
5 Disruptive Technologies shaping the future: https://www.iotforall.com/5-disruptive-technologies-shaping-our-future
100 Radical Innovation Breakthroughs (RIBs): https://ribri.isi-project.eu/#page_RIB
Low-carbon technologies
Industrial technology prospect - Research and Innovation evidence on EU development of low-carbon industrial technologies: https://op.europa.eu/en/publication-detail/-/publication/f59d2692-cf12-11eb-ac72-01aa75ed71a1/language-en
Energy Technology Perspectives 2020: https://iea.blob.core.windows.net/assets/7f8aed40-89af-4348-be19-c8a67df0b9ea/Energy_Technology_Perspectives_2020_PDF.pdf
A new ERA for Research and Innovation COM(2020) 628 final: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0628&from=EN
Pilot - Industrial technology prospect report: R&I evidence on EU development of low-carbon industrial technologies: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC125684/itpr-on-low-carbon-industrial-technologies-jrc_lr.final.pdf
55 Tech Quests to accelerate Europe's recovery and pave the way to climate neutrality: https://www.capgemini.com/gb-en/resources/investments-in-next-generation-clean-technologies/
Main Science and Technology Indicators: https://www.oecd-ilibrary.org/science-and-technology/main-science-and-technology-indicators_2304277x

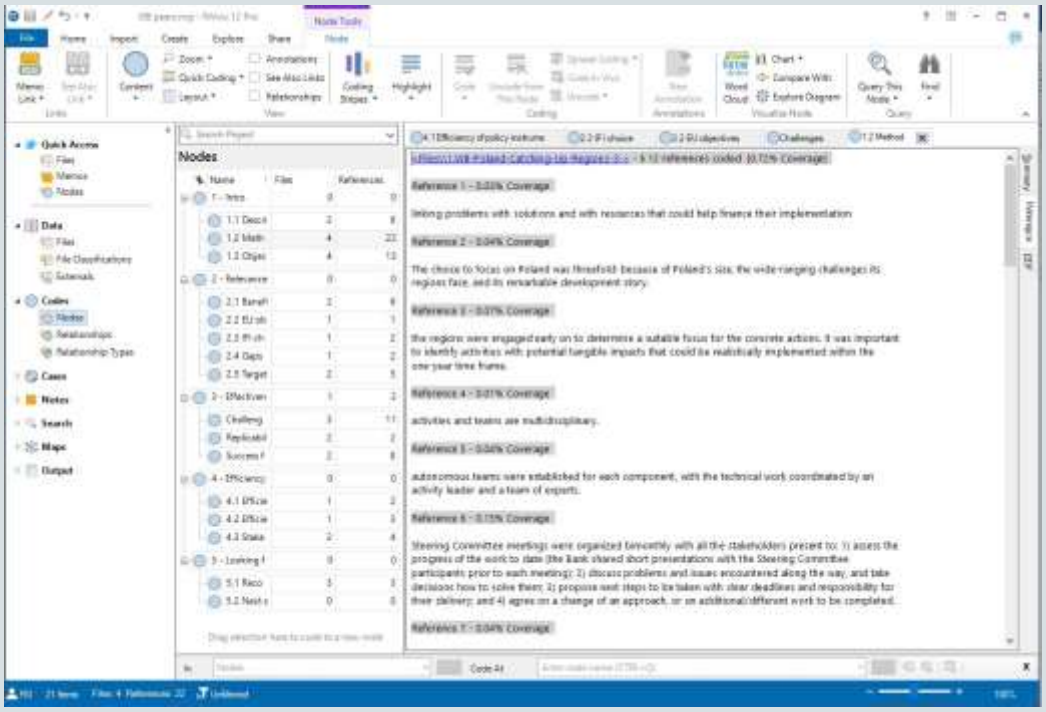
Clean Energy Technology Innovation
European Strategic Energy Technology (SET) Plan: https://energy.ec.europa.eu/topics/research-and-technology/strategic-energy-technology-plan_en
SET Plan progress report 2021: https://setis.ec.europa.eu/set-plan-progress-report-2021_en
Renewable Technology Innovation Indicators: https://www.irena.org/publications/2022/Mar/Renewable-Technology-Innovation-Indicators.
Energy Technology Perspective 2020: https://www.iea.org/reports/energy-technology-perspectives-2020
Special Report on Clean Energy Innovation: Accelerating technology progress for a sustainable future: https://www.euneighbours.eu/sites/default/files/publications/2020-07/Energy_Technology_Perspectives_2020_-_Special_Report_on_Clean_Energy_Innovation.pdf
Report on innovation landscape for renewable-powered future: https://www.irena.org//media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Innovation_Landscape_2019_report.pdf
Analysis to track clean energy innovation: https://www.iea.org/reports/tracking-clean-energy-innovation
Energy trends
World Energy Transitions Outlook, 1,5°C Pathway: https://www.irena.org/publications/2022/Mar/World-Energy-Transitions-Outlook-2022
World Energy Outlook 2021: https://www.iea.org/reports/world-energy-outlook-2021
Innovation Investment Needs
Global innovation needs assessment – Energy and land use synthesis report: https://www.climateworks.org/wp-content/uploads/2021/10/GINAs-Energy-and-land-use-synthesis-report-10-12-21.pdf
Energy Innovation Needs Assessment Overview Report: https://platformduurzamebiobrandstoffen.nl/infotheek/energy-innovation-needs-assessment-overview-report/
Innovation Financing for Climate Report: https://www.climateworks.org/report/ginas/
Social Innovation
Study on industrial transition towards a climate-neutral economy: https://www.oecd-ilibrary.org/sites/81ebdb4c-en/index.html?itemId=/content/component/81ebdb4c-en
SMEs
Report on how government can support clean energy start-ups: https://iea.blob.core.windows.net/assets/c0efd465-a914-4fe6-b3cfcbbf96a9d8c6/Howgovernmentssupportcleanenergystart-ups.pdf

Step 3. Implement the review strategy according to a specifically designed review template

Once the scope of the literature review in terms of the covered sources and search terms has been determined, the team will systematically implement the literature review strategy to establish the state-of-the-art. To ensure transparency and traceability, the results of the literature review will be collected using NVivo, a data management tool which allows for systematic analysis.

Box 2 NVivo will be used throughout the study to support the robust and systematic analysis of qualitative sources of information

NVivo is the benchmark computer assisted qualitative data analysis software that ICF has considerable experience of using. It is a sophisticated data management package that significantly aids the analysis process by housing all data in one place and facilitating the quick and easy allocation of 'codes' to data that can then be cut in different ways to develop key analytical insights. The systematic coding it promotes ensures precise and rigorous analysis. NVivo will be used to organise all data for the project – the reviewed literature, expert interview write-ups, stakeholder survey data, and even the results of the foresight future dialogues.



Information about each reviewed source will be collected and coded in NVivo according to a specifically designed review template. The "codes" will be developed in relation to the study questions and mitigation areas and can be collaboratively fine-tuned as the research progresses. Table 2.4 below shows an initial review template, which will be revised and finetuned during the inception phase. The benefit of collecting and coding the information in NVivo, is that it allows for a researcher to pull together and analyse all sections of all reviewed sources that deal with trade-offs for example, or all sources that mention BECCS. The tool allows for relationships between the sources to be discovered even if separate team members review different sources.

NVivo can provide a variety of different outputs – for example, a list of all reviewed sources that have been tagged with the code "public investment already in place", or a summary extraction of all text tagged with the code "trade-offs". These are intermediary outputs; they will help researchers sort and manipulate the data, find connections, analyse the data, and draft the project deliverables.

Table 2.4 Sample review template

Information collected and coded for each review source
Bibliographic information
■ Type of publication (e.g., peer-reviewed journal, conference presentation, foresight report, etc.)
■ Title
■ Author
■ Year
■ Journal title/Book/etc.
R&I focus
■ R&I area (e.g., net carbon removals, nature-based solutions, etc.)
■ Stage of development of solution (e.g., nascent, early stages, established)
■ Specific technology (e.g., BECCS)
NVivo node codes relevant to study questions
■ Mitigation potential
■ Feasibility of deployment
■ Risk level
■ Barriers to implementation
■ Socio-economic implications
■ Environmental implications
■ Interactions/dependencies with other mitigation solutions
■ Trade-offs
■ Public intervention already in place
■ Private investment interest

Step 4. Analysis of relevant climate neutrality scenarios

A specific analysis will be carried out on a selection of detailed climate neutrality scenarios. These scenarios provide insights on the importance of individual technologies in achieving climate neutrality, on their expected implementation time, on their techno-economic characteristics as well as on system aspects under which the technologies evolve.

Thus, the exploitation of scenario results will contribute to: (1) identifying the R&I intervention areas in most need of support; (2) informing the selection process for the key R&I areas; and, (3) informing, in a later stage, the in-depth analysis of the selected key R&I areas.

Such climate neutrality scenarios have been developed at:

- **World-wide level** – for example, the IRENA World Energy Transitions Outlook: 1.5°C Pathway[8]; major reports of the International Energy Agency IEA, such as

[8] https://www.irena.org/publications/2022/Mar/World-Energy-Transitions-Outlook-2022

the World Energy Outlook 2021[9]; the Net-zero-by-2050 Roadmap[10]; the Energy Technology Perspectives[11]; and, the 6th Assessment Report of the IPCC[12];

- **European level** – notably the most recent reference projections from 2020[13], as well as the policy scenarios for delivering the Green Deal[14]; and,
- **National level** – for example, the Long-term Scenarios for Germany[15], published in 2021, which have a very high sectoral and temporal-spatial resolution.

Naturally, there is no unique transformation pathway. However, a number of them, lead to climate neutrality with unequal implications. For example, the picture set out below - from the German Long-term scenarios - emphasises three pathways to climate neutrality:

- very heavy use of electricity (scenario TN-Electricity);
- very high use of hydrogen (TN-H2-G scenario); and,
- very high use of synthetic hydrocarbons (scenario TN-PtG/PtL).

Not surprisingly, and as illustrated for one of these scenarios in Figure 2.3 below, there are different implications for the selection of key R&I areas from these scenarios. The selection process must identify the uncertainties linked to the different scenarios paths and reflect the uncertainties in the selection of key R&I areas.

[9] https://www.iea.org/reports/world-energy-outlook-2021

[10] https://www.iea.org/reports/net-zero-by-2050

[11] https://www.iea.org/reports/energy-technology-perspectives-2020

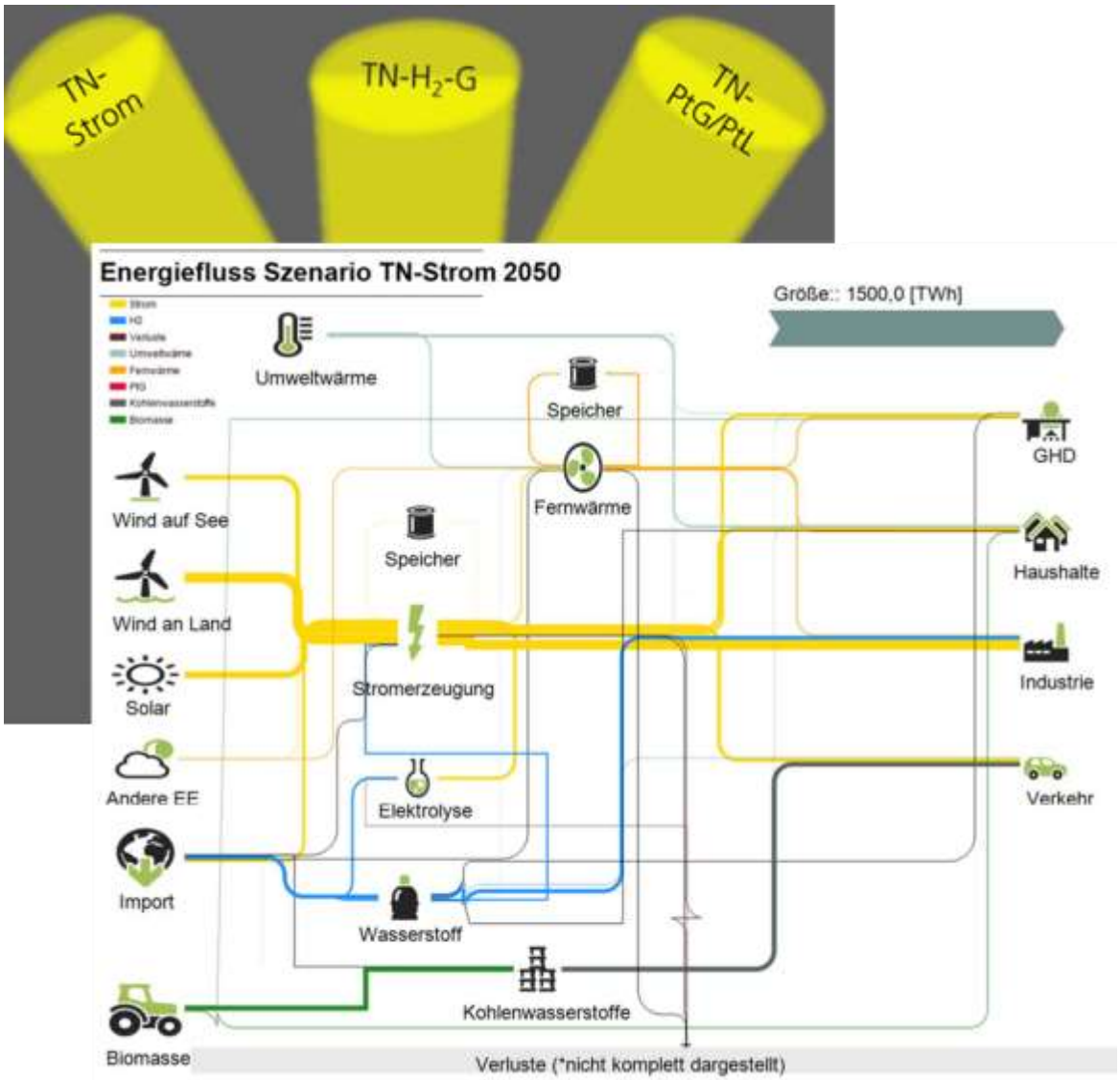
[12] https://www.ipcc.ch/report/sixth-assessment-report-cycle/

[13] https://energy.ec.europa.eu/data-and-analysis/energy-modelling/eu-reference-scenario-2020_en

[14] https://energy.ec.europa.eu/data-and-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en

[15] https://www.langfristszenarien.de/enertile-explorer-de/

Figure 2.3 Overview of the scenarios analysed in the 2021 "Long-term scenarios for the transformation of the energy system in Germany" and the implication of the “very heavy use of electricity” for the German energy system

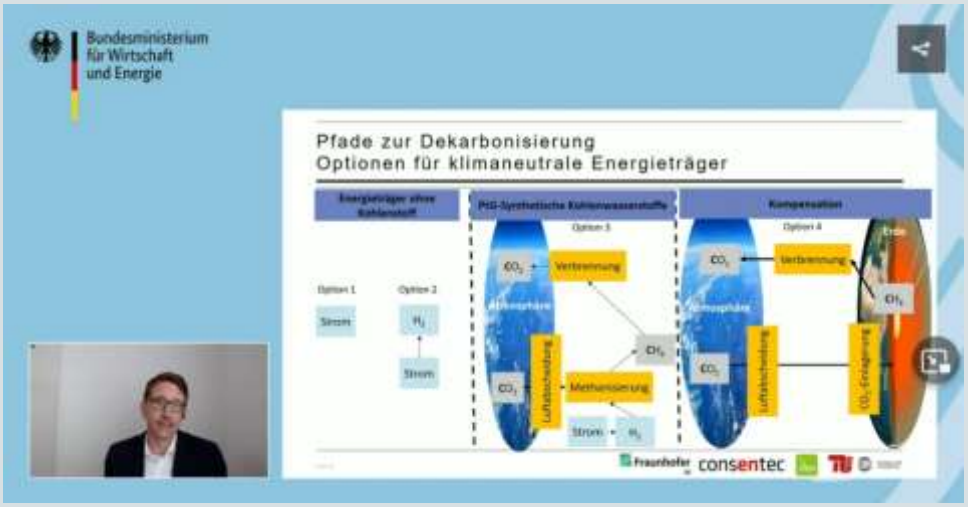


Source: German Long-term Scenarios 2021 (https://www.langfristszenarien.de/enertile-explorer-de/)

Building on their experience with the design of decarbonisation scenarios (see Box 3 below), this specific piece of analysis will be led by Fraunhofer ISI and the relevant sources will be collected and coded in NVivo, to inform our overall analysis and literature review.

Box 3 Fraunhofer ISI supported the German government with the design of different climate neutrality scenarios

In the project "Long-term scenarios for the transformation of the energy system in Germany", Fraunhofer ISI is guiding a large consortium for the German government, which develops and models scenarios for the future development of the energy system, with which climate neutrality can be achieved. The modelling encompasses the entire energy system, i.e., overarching the generation of electricity, heat and hydrogen as well as the demand for energy in the industry, transport, buildings and appliances sectors. The future energy infrastructures (electricity and gases) are also analysed. The focus of the analysis is not the development of a single "lead scenario", but the investigation of different scenario worlds, in order to gain insights into the advantages and disadvantages of alternative paths for the transformation of the energy system through comparative analyses.



Source: Presentation of the German Long-term scenarios by Fraunhofer ISI, together with the Secretary of State Andreas Feicht, Ministry of Economic Affairs and Energy (25 June 2021)[16]

Step 5. Outputs: Initial findings and draft list of high-risk high-impact R&I areas

Under Step 5, task leads will build on the results of the literature review (collected, coded and analysed in NVivo), to draft initial findings to the four research questions that will form the basis for the literature review report, to be drafted at the end of Task 1. This process will be coordinated by Ralitsa Donkova, Task 1 lead, who has extensive experience of coordinating teams of researchers, both as a consultant and academic researcher.

Task 1.1 will also inform the basis of our long-list of high-risk, high-impact R&I solutions. This list, built in an **Excel document**, will be continuously updated during the course of the study, in order to ensure it becomes as comprehensive and inclusive as possible.

2.2.3 Task 1.2. Horizon scanning and participatory foresight dialogues to prioritise possible solutions

The objective of Task 1.2 is to go beyond the state-of-the-art and the innovative low-carbon solutions that have already reached the established literature and to identify

[16] https://www.bmwi.de/Redaktion/DE/Videos/2021/20210625-Langfristszenarien/20210625-Langfristszenarien.html

new ideas, concepts, business models and solutions. The goal is to **elaborate a post-2030 narrative** for climate neutrality, together with stakeholders, experts, and policymakers, in the domain of R&I, which covers transformative shifts at several systemic levels. It will provide a long-term, multiple system-levels view on challenges for achieving the climate goals under impacts of global shocks (such as the COVID-19 pandemic or the war in Ukraine) on the European Green Deal.

To do so, Task 1.2 will be structured around three steps:

1. An **horizon scanning exercise**, building on machine-learning techniques to identify new solutions and trends;
2. A **scoping survey** of the high-level experts to capture their initial views on promising R&I intervention areas and the solutions requiring most support (See also Task 2.1); and,
3. A **participatory foresight exercise** to open, on the one hand, the scope of the research and to ensure we do not remain blocked into pre-existing scenarios and solutions; and, on the other hand, start making sense of the results of the literature review, horizon scanning and scoping survey, and translate them into actionable intelligence for DG RTD.

The design of these tasks builds on the work completed by Fraunhofer ISI on the design of Horizon Scanning and Foresight methodologies to notably inform EU R&I policies. More details about this work, as well as a reminder of the differences between Horizon Scanning and Foresight, is provided in Box 4 below.

Box 4 The difference between Horizon scanning and foresight analysis

Fraunhofer ISI led a study in 2015 focusing on "*How to integrate Horizon Scanning into European Research and Innovation Policies?*". That study defined **horizon scanning** as:

"*the systematic outlook to detect early signs of potentially important developments. These can be weak (or early) signals, trends, wild cards or other developments, persistent problems, risks and threats, including matters at the margins of current thinking that challenge past assumptions. Horizon Scanning can be completely explorative and open or be a limited search for information in a specific field based on the objectives of the respective projects or tasks. It seeks to determine what is constant, what may change, and what is constantly changing in the time horizon under analysis. A set of criteria is used in the searching and/ or filtering process. The time horizon can be short-, medium- or long-term*".[17]

By comparison, the author of the research defined Foresight, in a follow-up article, as: "*the systematic debate of complex futures […] whereas Foresight is more process-oriented and always includes an Horizon Scanning phase, Horizon Scanning is rather found at the beginning of any forward-looking activity"*[18].

Step 1: Horizon scanning

First, we will undertake a 360-degree **horizon scanning approach** to identify (weak) signals for long-term technological and non-technological trends and key drivers in R&I, particularly disruptive technological breakthroughs[19]. This element

[17] https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccv/2015/Models-of-Horizon-Scanning.pdf
[18] https://onlinelibrary.wiley.com/doi/pdf/10.1002/ffo2.23

[19] Cuhls, K., Erdmann, L., Warnke, P., Toivanen, H., Toivanen, M., Van der Giessen, A., et al. (2015). Models of Horizon Scanning - How to integrate Horizon Scanning into European Research and Innovation Policies. Brussels: European Commission.

will largely draw on the broad literature review, as laid out in Task 1.1, and will also include systems aspects related to potential key R&I areas.

The Horizon Scanning exercise will be complementary to the literature review presented in Task 1.1, as it will look at other sources of information. In practice it will consist of a machine-learning approach that will allow the scanning of news websites (using NewsAPI) and/or scanning scientific papers[20] with Google dimensions (using specific key words resulting from the scoping exercise).

The result of the scanning is a large set of articles/text, which will then be used for text analysis. This second step of text analysis of all identified articles from the web-based search will be supported by a topic modelling, which will identify emerging topics across all articles.

The **outcome** of the machine-learning based horizon scanning is a set of topic models, visualised on word-clouds. This will both inform our answers to the study research questions, as well as the Excel-based long-list of high-risk, high-impact solutions.

[20] 10.3389/fcomm.2022.750614; see also: Geurts, A., Gutknecht, R., Warnke, P., Goetheer, A., Schirrmeister, E., Bakker, B., et al. (2021). New perspectives for data-supported foresight: the hybrid AI-expert approach. Fut. Foresight Sci. e99. doi: 10.1002/ffo2.99

Box 5 Example of previous Horizon Scanning exercise completed by Fraunhofer ISI

RIBRI – Radical Innovation Breakthrough Inquirer – this report[21] identified, for the European Commission, 100 potential innovation breakthroughs in fields such as AI, robotics or biomedicine, and indicated how the EU can prepare for them. The project team developed a semi-automated process to search for radical innovations and applied this at EU level for the first time. The 100 Radical Innovation Breakthroughs (RIBs) include technical developments, for example biodegradable sensors and 4D printing, as well as societal concepts, such as basic income or car-free cities.

An innovative, semi-automated process was used to identify and analyse the RIBs. A learning language-analysis algorithm (NLP Natural Language Processing) analysed the contents of around 500,000 news items on scientific and technical platforms. Topics were filtered out that appeared for the first time during the period of investigation. These topics and any related patents and publications were evaluated by scientists from the respective field. The evaluation was carried out in relation to the degree of maturity, the probability of widespread use in 20-years time and Europe's position.

Source: https://www.isi.fraunhofer.de/en/competence-center/foresight/projekte/ribri.html and https://ribri.isi-project.eu/

Step 2: Scoping survey

This step will consist of running an initial survey of our 50 high-level experts. The survey objective is to broaden the scope of our research and collect initial insights from our experts regarding the key high-risk, high-impact R&I intervention areas that can have the largest impact on the EU's ability to achieve climate neutrality by 2050 - and therefore require more support, from both the public and private sector.

Our detailed methodology for the running of online survey is presented under Task 2, however, Table 2.5 presents example of questions that will be asked in the scoping survey.

21 https://ec.europa.eu/info/sites/default/files/research_and_innovation/knowledge_publications_tools_and_data/documents/ec_rtd_radical-innovation-breakthrough_052019.pdf

Table 2.5 Example of questions that will be asked in the scoping survey

Open-ended questions	Closed-text questions
What are the breakthrough climate neutrality technologies you are tracking?	Rate the following list of technologies according to their climate mitigation potential?
What are the key barriers for these breakthrough technologies to be deployed?	Rate the following list of technologies according to their riskiness?
What are the key opportunities that can be magnified to hasten these technologies' deployment?	Which of the following technologies are likely to have the worst socio-economic impact?
What general-purpose technologies have the potential to bring us closer to climate neutrality?	Which of the following technologies are likely to have the worst environmental impact?

The **results** of the survey will feed into our Excel-based long-list of high-risk, high-impact solutions and will inform the structure of the Participatory foresight dialogue under the next step.

Step 3: Participatory foresight dialogues

Participatory foresight is defined as a process of "*stakeholder involvement and empowerment in desired futures visioning*"[22]. The academic literature has demonstrated how participatory foresight methods can provide "*an essential forum and process for the expression of plural, socio-technological imaginaries*"[23], which is precisely what is needed for this study. In a recent policy briefing of the European Parliament, participatory foresight was introduced as a logical step to complement the EU sustainable resilience framework and prevent the creation of an impact gap (i.e., the mismatch between citizens' and stakeholders' expectations in terms of sustainable transformation, on the one hand, and actual outcomes of policies, on the other) (Kononenko 2021[24], Rosa et al. 2021[25]).

Conducting a successful participatory foresight exercise is challenging however, since it requires a very structured approach to ensure it leads to clear results and does not simply open many doors without coming to any conclusion. To make this exercise successful, our Foresight exercise will build on good practices and the extensive experience of Fraunhofer ISI in conducting these exercises. Based on their experiences, key elements to consider when designing such an exercise include:

- **The need for it to be structured**: it is a systematic approach by applying methods of futures research, science-based, and is based on new theories of futures research;
- **The need to create a debate**: it includes interactions of relevant actors, active preparation for the future or different futures, and orientation towards shaping the future;
- **The need to allow for complex thinking**: it includes the consideration of systemic interdependencies, takes a holistic view; and,
- **The need to recognise that futures is plural**: it is an open view on different paths into the future with thinking in alternatives.[26]

[22] https://medium.com/@ai.y/participatory-foresight-9c16d6c9893a
[23] https://eujournalfuturesresearch.springeropen.com/articles/10.1186/s40309-021-00171-6
[24] https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690048/EPRS_BRI(2021)690048_EN.pdf
[25] https://link.springer.com/content/pdf/10.1186/s40309-021-00171-6.pdf
[26] https://onlinelibrary.wiley.com/doi/pdf/10.1002/ffo2.23

While participatory foresight often includes the involvement of citizens, for the purpose of this project, we will focus the exercise on a sample of our 50+ high-level experts. We will engage in dialogue with them through a series of discussions and combine two approaches: (1) **Future dialogue**, which provides a flexible framework for structuring future-oriented discussions; and (2) **Narrative generation**, which is a technique for creating qualitative storylines about the future. As stressed in the note from the European Parliament, to be effective (in terms of their ability to shape the way people think about the future), these narratives need to be participatory, multidimensional, and pragmatic.

These two approaches seem to be most suitable for structuring future-oriented discussions between stakeholder groups and policymakers from multiple scales of systems and their governance. Furthermore, explorative foresight dialogues could also contribute to the reduction of an 'assessment gap', which underlies the problem of lacking coherence between various understandings of sustainability and resilience and methods to assess the complex dynamics of sustainability transitions.

Concretely, the above approaches will translate into two rounds of dialogue organised in the form of bilateral interviews or small-scale workshops:

- The first future dialogue (**Gap analysis**) with experts will focus on the analysis of strategic gaps and prioritisation of R&I fields based on their relevance for the green transition and achievement of the European Green Deal. Therefore, the participants will evaluate and prioritise the trends and possible breakthroughs, analyse related risks and challenges for the achievement of the Green Deal goals and link them to R&I areas.

  ➔ The **outcome** will be identified emerging needs for action in specific R&I fields.

- The second future dialogue (**Solution narratives**) with experts will explore possible actions and solutions in a co-creative way, leading to ideas for strategic action and narratives for long-term actions.

  ➔ The **outcome** serves to draft key messages to support emerging breakthrough innovations for different actor groups across the systems in transformation.

Both dialogues will be organised through workshops with smaller groups of experts, supported by specific interviews with individual experts. Task 2, presented in section 2.3, provides more details on our specific approach for the organisation of expert interviews and small-scale workshops.

Each future dialogue will result in a short note that will inform the literature review report to be produced at the end of Task 1. It will also serve as basis for the deployment of Tasks 3, 4 and 5.

With the combination of the classical foresight approaches of (1) horizon scanning for emerging signals of change and (2) sense-making via stakeholder involvement in future dialogues, we will apply interactive methods and tools and draw on latest insights on the success factors of participatory foresight approaches for sustainability transitions.

Another effect of participatory methods of foresight is the widening of perception filters and addressing of unconscious biases in sense-making and dealing with uncertainties in long-termed strategic processes, such as the adjustments of the European Green Deal and Climate mitigation under current (and unforeseen) shocks like the COVID-19 pandemic and the war in Ukraine.

The above presented methodologies are suggestions for how to proceed. They will be discussed with DG RTD at the kick-off meeting and refined based on the required information and focus of the project. Subsequently, in close coordination with DG RTD, the framework will be adjusted and finalised.

Step 4. Outputs: out-of-the-box results to inform the answers to the research questions and the long-list of high-risk, high-impact R&I areas

Task 1.2 will result in a set of out-of-the-box findings identified through original approaches and co-created with the 50 high-level experts that will inform the answers to the research questions and our Excel based long-list of high-risk, high-impact R&I areas.

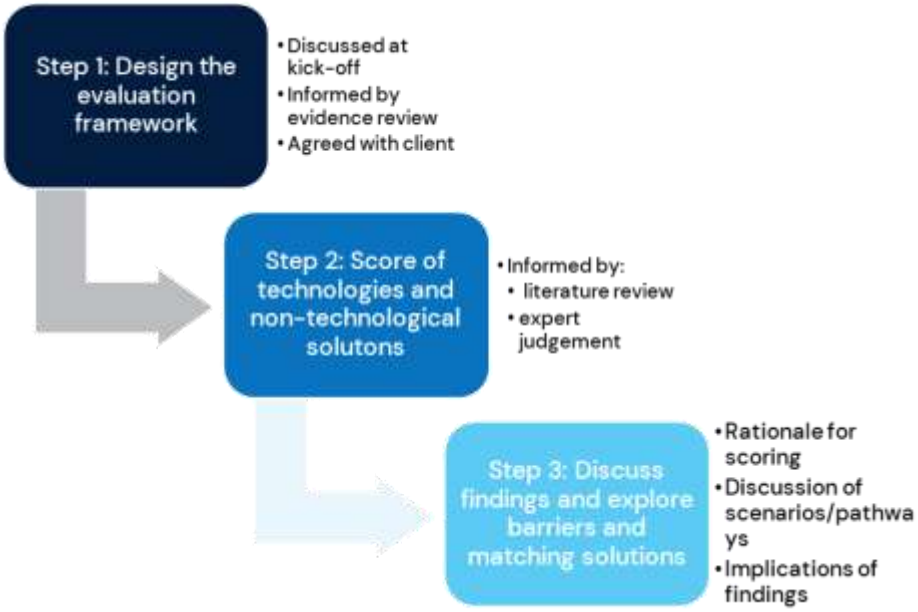
2.2.4 Task 1.3. Evaluation framework for the selection of key R&I intervention areas

Starting from the Excel-based long-list of R&I interventions developed under Task 1.1 and 1.2, the objective of Task 1.3 will be to identify the 10-15 high-risk, high-impact intervention areas that will be examined in-depth under Tasks 3, 4 and 5. It will include a preliminary assessment of the techno-economic feasibility, GHG mitigation potentials, socio-economic impacts, and environmental impacts of the identified technologies and non-technological solutions to identify the solutions with the most potential to contribute to the 2050 climate neutrality target. Beyond this potential, Task 1.3 will also capture the current level of support targeting the identified solutions, to not only prioritise the solutions with the highest mitigation potential, but also to consider where future R&I programmes could make a significant contribution by supporting new R&I areas.

Given the uncertainty around the adoption of future technologies and other possible solutions, and the associated lack of data on their exact performance, our suggestion is to assess them through a comparative analysis structured around a detailed evaluation framework. This section introduces our framework and the key steps we will go through to complete it. It is important to stress that the finer details of the framework's design will be determined through coordination with DG RTD.

As illustrated in Figure 2.4 below, this task will be structured around three main steps. Each of these steps are discussed below.

Figure 2.4 Proposed approach to assessment



Source: Cambridge Econometrics, 2022.

Step 1: Design the evaluation framework

Broadly, we propose an evaluation framework consisting of five pillars: (1) techno-economic feasibility; (2) mitigation potential, (3) socioeconomic implications, (4) environmental implications; and, (5) current level of support. Each pillar will be made up of a complementary set of criteria, against which each solution will be evaluated and scored based on transparent judgment criteria. Our suggestion is to define a Red-Amber-Green (RAG) rating for each criterion to be able to easily score each solution and visually present this to DG RTD and its stakeholders. A numerical value will be associated with the RAG rating to be able to compute aggregated scores at both the pillar and overall level for each solution. For aggregating the assessment within each pillar, criteria might be weighed, but some criteria might also be identified as essential and hence associated with a minimum threshold.

Table 2.6 below provides examples of criteria and associated judgment criteria for each pillar. For this exercise to be effective, it is important to minimise overlap between criteria. For example, the analysis is weakened if within the socio-economic impacts pillar, there is a *pollution reduction* criterion and an *air quality* criterion, as air quality is linked to pollution. Maintaining both criteria would just inflate scores without adding information.

Table 2.6 Example of criteria and associated judgment criteria

Criteria	Judgement criteria
Pillar 1: Techno-economic feasibility	
Current Technology Readiness Level (TRL)	■ Red: TRL 4 and above ■ Amber: TRL 3 ■ Green: TRL 1-2
Scalability potential	■ To be discussed.
Regulatory feasibility	■ Red: Regulatory framework explicitly preventing the deployment of the solution ■ Amber: Unclear regulatory framework

Criteria	Judgement criteria
	■ Green: Regulatory framework explicitly allowing the deployment of the solution
Financial feasibility	■ Red: Business model has not been demonstrated yet ■ Amber: Unclear business model ■ Green: Existing business model
Cost-efficiency	■ Score based on EUR / tonnes of GHG emission avoided, exact judgement criteria to be determined.
Resource requirements with likely competition (biomass, electricity, heat)	■ Red: High resource requirement. ■ Amber: Medium resource requirement. ■ Green: Low resource requirement.
Institutional feasibility (including risk of carbon lock-in)	■ *To be discussed.*
Pillar 2: Mitigation potential	
GHG abetment potential	*Score based on amount of GHG emission avoided, exact judgement criteria to be determined.*
Pillar 3: Environmental impact	
Land requirements and implications	*To be discussed.*
Air pollution	*To be discussed.*
Water pollution	*To be discussed.*
Other environmental impacts	*To be discussed.*
Feasibility in light of resource-requirements and expected environmental impacts	*To be discussed.*
Pillar 4: Socio-economic impact	
Jobs creation	*To be discussed.*
Distributional effects	*To be discussed.*
Feasibility in light of public favourability	*To be discussed.*
Etc.	*To be discussed.*
Pillar 5: Current level of support	
Support at EU level	■ Red: Not supported by any R&I programme at EU level. ■ Amber: Low-level of support at EU level (budgetary threshold to be determined) ■ Green: High-level of support at EU level (budgetary threshold to be determined).
Support at Member State level	*To be discussed.*
Support beyond the EU	*To be discussed.*

Using the above evaluation framework, an overall score will be given based on the five identified pillars. Given the ultimate objective of the assignment is to identify high-risk, high-reward areas for which R&I might hold greatest potential to make a difference, the evaluation framework will – within each pillar – examine to what extent the areas' performance may be improved through R&I support. This is to ensure that priority is also given to areas with very high uncertainty, where further R&I could hold serious potential.

The framework design will initially be discussed during the project kick-off meeting and will then be informed by the insights gained in the literature review. Each

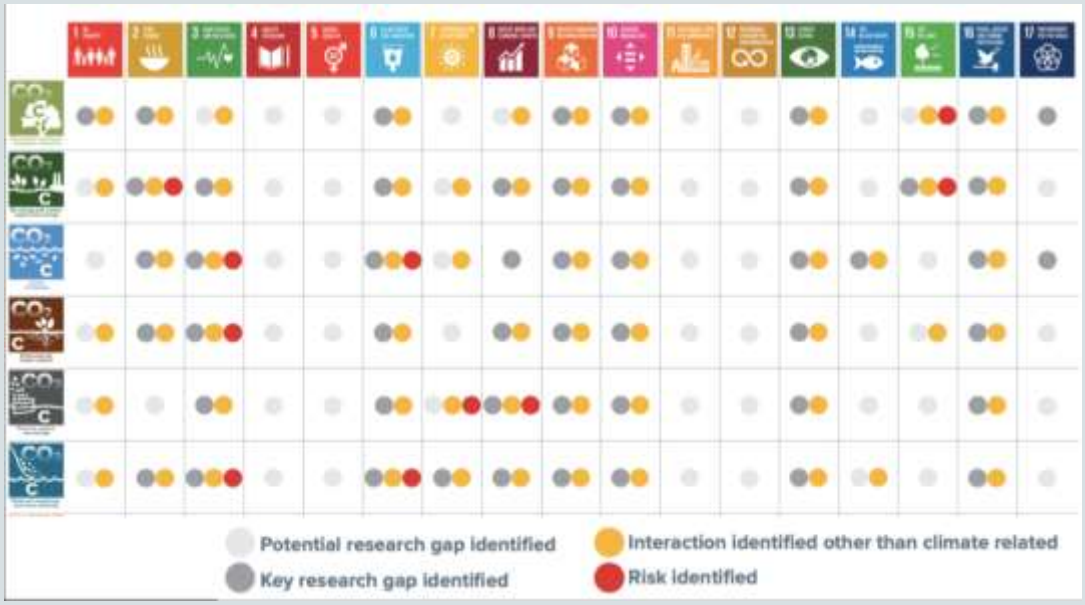
proposed criterion will be discussed in terms of its importance, merits, and weaknesses. The design will then be agreed with DG RTD, allowing the scoring to be carried out under the next step. As such a scoring process is undoubtedly subjective, it is essential that the framework is designed and agreed before the analysis begins. This will ensure that bias is removed as far as practicable before the evaluation stage.

The design of our evaluation framework will also benefit from ICF's and Fraunhofer ISI's recent experience with the preliminary assessment of potential projects for the Innovation Fund. This work, which covered similar criteria as those presented above, served as the basis to inform the design of the Innovation Fund application and grant evaluation process. Our framework also builds on the recent work of Perspectives regarding the assessment of different CDR approaches against the UN Sustainable Development Goals, which is briefly presented in Box 6 below.

Box 6 Preliminary assessment of potential implications of carbon dioxide removal (CDR) approaches (against the normative backdrop of the UN Sustainable Development Goals):

A first comprehensive literature and expert-elicitation based mapping of potential implications of CDR approaches for the achievement of the 17 Sustainable Development Goals has clearly shown the importance of local context (geography, socio-economic conditions, and political structures) as well as the specific design of public policy targeting the implementation of CDR actions for their overall performance (Honegger, Michaelowa and Roy, 2021).

Three simple examples illustrate this: (1) For mitigation potential performance, it is crucial that incentives are not perverse, but correctly reflect overall carbon-flows and e.g. do not incentivize deforestation of primary forest resulting in carbon emissions for later operation of biomass plantations; (2) For socio-economic performance, the fair and efficient design of public policy is a prerequisite to enable small and large economic actors to participate while also keeping transaction costs acceptable; and, (3) environmental performance is heavily influenced by details in technology-design and operation, which again can be influenced by local environmental regulation, building codes, and other – e.g. sector-specific – regulation.



Source: Honegger et al., 2018; see also the short summary of the updated publication (Honegger, Michaelowa and Roy, 2021) here.

Step 2: Scoring of technologies and non-technological solutions

Each of the technologies and non-technological solutions identified in our long-list will be scored against the identified criteria under the five pillars, based on a template similar to the one presented in Table 2.7 (below).

Scoring will be based on the literature review and expert judgement (for which we may already draw on selected individuals among the 50 high-level experts). The scoring will be systematically documented, and key reflections will be reported. Therein, we will reflect on:

- how different frameworks and scoring rationales might affect outcomes;
- how different scenarios, in terms of future development, might impact scores; and,
- how these may be updated in later re-evaluations. The discussion will include a presentation of preliminary findings pertaining to recommendations for a future focus of R&I activities.

Table 2.7 Illustrative example of scoring template

Pillars	Criteria	Technologies				Non-technological solutions		
		DACCS	BECCS	AI-enabled smart grids	…	Forestry	Peatlands	…
Techno-economic feasibility	Current Technology Readiness Level (TRL)							
	Scalability potential							
	Etc.							
Pillar score								
Mitigation potential	GHG abatement potential							
Pillar score								
Environmental impact	Land requirements and implications							
	Air pollution							
	Water pollution							
	Etc.							
Pillar score								
Socio-economic impact	Jobs creation							
	Distributional effects							
	Etc.							
Pillar score								
Current level of support	Support at EU level							
	Support at Member State level							
	Etc.							
Pillar score								

Pillars	Criteria	Technologies				Non-technological solutions		
		DACCS	BECCS	AI-enabled smart grids	…	Forestry	Peatlands	…
Overall score								

Given the inherently reductionist approach of such a scoring system, much emphasis will be given to the systematic documentation of interlinkages (systemic aspects): where systemic interdependencies may determine performance (e.g. mitigation potential driven by competition over land-/energy or biomass resource-availability), they will be noted and possible ranges will be identified.

While multi-criteria assessments often trend towards easily quantifiable (and often linear) criteria, this sometimes fails to properly capture the innovation potentials and dynamics of emerging technologies or ideas. To account for this, we will make a deliberate effort to include harder-to-quantify considerations among or within the criteria. An example for this – within the 'mitigation potential' pillar – would be to account for breakthrough potential and potential for adoption through logistical (or exponential) growth curves.

Careful consideration must be given to the level of granularity included in terms of solutions. Where this granularity is likely to lead to different scores, it should be observed. For example, two varieties of DACCS are liquid absorbent and solid adsorbent; and BECCS also is an umbrella term for different approaches, even spanning different sectors (i.e., paper, energy, and waste). If the distinction between these varieties is likely to influence scoring, they must be considered separately. If, however, none of the criteria relate to the differences in technology, then the solutions can be combined for the purposes of this assessment.

Box 7 illustrates how the above framework would apply when comparing DACCS and BECCS, based on their TRLs and scalability potential.

Box 7 Techno-economic feasibility: comparative assessment of the scaling dynamics and limitations of BECCS versus DACCS

All DACCS technologies currently have lower TRLs compared to BECCS technologies. This means that they are further away from commercial market deployment (but, crucially, the gradient of the learning curves of technologies may be different). By comparison, BECCS are at a more advanced stage.

However, in terms of expected scalability, the two technologies may face inverse positions: DACCS is not attached to a specific industrial process. Institutionally, scaling is thus only limited by the technology-owners' capability to scale production or licensing to other actors. In resource-terms DACCS is limited only by energy and storage availability. By contrast, BECCS plants are embedded in existing industrial processes (electricity generation, cement production, waste-incineration). This implies a different adoption dynamic. The biomass-requirement, may also impose upper limits of scalability.

Step 3: Outputs: Discuss findings and explore barriers and matching solutions

A final step in the assessment framework is the presentation of the results, i.e. a draft list of key R&I interventions to be prioritised. This will be complemented by the

identification of limiting factors (to the deployment potential, such as resource-conflicts), barriers (including institutional, regulatory, economic, and technological) and solutions (e.g. incentives, regulatory changes, new institutions or mandates, capacity building and other collaborations) that could alleviate limiting factors and erode or overcome barriers. This will be done across the five pillars and within each criterion as applicable to offer a systematic search. This approach will then be further advanced and refined for the in-depth analysis of weak spots of each area and for systematic identification of possible interventions.

2.2.5 Task 1.4. Outputs: Literature review report & draft list of high-risk, high-impact R&I areas

Task 1.4 will consist in bringing together the findings from Task 1.1, 1.2 and 1.3. Our suggestion is to gather all these insights into an extended version of the Literature review report, since it will represent the body of evidence required to move on with the next project Tasks, i.e., Tasks 2 to 6.

This approach will be discussed and validated with DG RTD at the start of the project. In case DG RTD agrees with our proposition, our suggestion is to structure the extended Literature review report based on the structure presented in Box 8.

Box 8 Suggested structure of the extended Literature review report

- Objectives and scope of work
- Methodology
- Key findings
  - Study question 1: Which technologies or non-technological solutions can be identified as both high-risk and high-impact and require particular public intervention and significant investments upstream of the innovation cycle, in order to reach market maturity in the next 10-15 years?
    –Results from the literature review, scenario analysis, horizon scanning & participatory foresight accompanied by Excel based long list of solutions.
  - Study question 2.1. Which are the opportunities and challenges of breakthrough and disruptive technologies in net carbon removals?
    Results from evaluation framework.
  - Study question 2.2. Which are the opportunities and challenges of breakthrough and disruptive technologies in disruptive general-purpose technologies?
    Results from evaluation framework.
  - Study question 3. How can systemic interactions of mitigation approaches be taken into account in the development of the R&I agenda towards long-term carbon neutrality?
    Results from the literature review & participatory foresight.
  - Study question 4. How can EU engagement in international fora be strengthened to facilitate rapid development and diffusion of breakthrough solutions in the next 10-15 years at European level, and worldwide?
    Results from the literature review.
- Conclusions & next steps

2.3 Task 2. Expert and Stakeholder Consultation

***Lead**: Irina Dobre, ICF.*

2.3.1 Objective(s) and scope

To answer the four study questions, the ICF team will build on the outputs of Task 1 and will also deploy a large expert and stakeholder consultation effort. The objective

of Task 2 will be to structure and centralise this stakeholder consultation process. It is by essence a functional task that sits at the centre of the project and will inform all the other tasks, as illustrated in our method diagram under section 1.

As presented under Task 0.3., we make a distinction between three group of stakeholders for this consultation: 5 external reviewers, 50+ high-level experts and a group of 20-30 additional stakeholders. These stakeholders will inform different parts of the project and our engagement with them will serve two main purposes:

- First, build the evidence base and gather expert knowledge on the study questions to complement the findings from Task 1; and,
- Second, validate the policy recommendations and overall conclusions of the study.

To achieve these two objectives, different consultation tools will be used for different purposes. Table 2.8 provides a high-level overview of these different consultation tools. Each of them is then discussed in more details in the remaining of the section.

Table 2.8 Overview of the consultation tools

	External Reviewers	High-Level Experts	Additional stakeholders
Surveys	x	x	
Small-scale workshops		x	
Semi-structured interviews		x	
Expert online conference	x	x	
Stakeholder conference			x
Review and QA	x		

2.3.2 Task 2.1. Expert consultation to collect input on the study questions

The aim of expert consultation conducted through surveys, small scale workshops and interviews is to provide input for a forward-looking research and innovation agenda which will thereafter be consolidated under Tasks 3-6.

Online surveys

In the second month of the study, a **scoping survey** will be sent to the entire pool of experts (both external reviewers and high-level thematic ones) to detect early signs of potentially important developments and low-carbon solutions in the R&I space. The **results** of the survey will complement the horizon scanning exercise under Task 1.2 and feed into our Excel-based long list of high-risk high-impact solutions. It will also inform the structure of the **Participatory foresight dialogue** under the Task 1.3

The feedback from the experts will be gathered via an online questionnaire distributed through the EU Survey platform. The EU Survey platform has the necessary functionality to manage the distribution of the feedback form and tracking the responses and has the benefit of being recognised as a trusted tool for surveys and consultations conducted by EU institutions. It is also fully GDPR-compliant. Having received all feedback through the online survey will also allow for a structured analysis.

Given the survey will the first active engagement of the 50+ high-level experts in the research, we will keep it rather simple and easy to complete to secure their buy-in. From good practices survey should remain short and to the point to ensure experts complete them on time and the results can be easily analysed. Table 2.5 under Task 1.2 provides examples of questions that will be asked during the scoping survey.

External reviewers and high-level experts will also be able to upload relevant academic papers and reports before submitting their survey responses to complement our literature review under Task 1.1.

Conducting the survey via EU Survey will allow the study team to gather structured feedback, easily track the responses received and send reminders to those experts who have not submitted feedback after, for example, one week.

Small-scale workshops

Small-scale workshops are very efficient to engage experts in dynamic discussion and co-create solutions. We will therefore use small-scale workshops to inform the **participatory foresight dialogues** under Task 1.2. As described under Task 1.2, we will engage experts through two different dialogues. A first one focusing on the gap analysis and aiming to identity emerging needs for action in specific R&I fields, and a second one focusing on identifying and designing the solutions in a co-creative way (solution narrative).

We will build on ICF-extensive experience with the design of online small-scale workshops to design these two participatory dialogues in a very interactive way. Building on good practices accumulated over the last two years we know that such events are most effective if they:

- Are no longer than 60/90 minutes in length or organised in blocks of 60/90 minutes;
- Are delivered on Tuesday, Wednesday or Thursday in the morning, around 10am;
- Include interactive activities to keep participants engaged and include opportunities to ask questions throughout;
- Use software packages that do not require any specific downloads and thus maximise access and participation, our standard solution is MS Teams;
- Are advertised via invitations circulated three to four weeks in advance of the workshop;
- Are organised and delivered by a team with clear responsibilities to cover all eventualities, so that the workshop achieves its objectives effectively, leaving no participant behind; and,
- Are backed by Data Protection Agreements with the software provided to ensure GDPR compliance.

To make the workshop engaging for the experts we will build an interactive agenda and make sure that they receive sufficient briefing material ahead of the workshop. We will also use support tools such as Mural or Slido to collect input in a structured way and allow participants to contribute in the way they find the most appropriate, i.e. orally, in writing, or via short online polls. We will also use the break-out rooms option of Team to allow for brainstorm sessions in smaller group. Table 2.9 presents a suggested agenda for the first future dialogue focusing on the gap analysis. Box 9 provides an overview of ICF approach to co-creation.

Table 2.9 Example of agenda for the first future dialogue focusing on the gap analysis

Time	Session
10:00 – 10:10	Introductions, purpose of meeting
10:10 – 10:30	Presentation of initial findings from Task 1 and key questions to be addressed with the group ➢ Round of feedback on how to phrase these questions to make sure they are inclusive and go beyond the usual questions
10:30 – 11:30	Brainstorm sessions (break-out rooms), to address the following questions: ➢ What are the strategic gaps in the current R&I landscape? ➢ Which typical sectors/set of solutions that could significantly contribute to mitigating GHG emissions are typically excluded from existing R&I support Programmes? ➢ What systemic solutions exist or are in development but are still under the radar of public administrations? ➢ How to priorities these solutions and how to move forward to progress form a static problem approach to a dynamic solution approach?
11:30-12:00	Break to allow the project team to structure the outcomes of the breakout session and prepare the material for the solutioning session
12:00 -13:00	Debrief and solutioning session to co-create and agree on the key conclusions of the workshop

Our process to organise the workshop will consist of the following steps:

- Design a scoping note and agree on the workshop design with DG RTD (and potentially the external reviewers);
- Communicate the agenda to the relevant high-level experts in the pool (10-15 participants);
- Set-up the logistics of the event and send a registration link to the participants;
- Design a detailed noted agenda describing in detail the workshop (who will speak and when, who will take note, etc.); and,
- Run the event.

Immediately following the workshop, a “de-briefing” session will be held by the study team, to consolidate the findings, and identify potential follow-up steps for the research and analysis. The study team will draft notes within two days from the workshops which thereafter will go through a full round of quality assurance internally. This includes reviewing content, commenting for clarification, further guidance on structure and length, and editing where necessary.

Box 9 ICF approach to co-creation

ICF has been running successful online workshops, virtual strategy development meetings, webinars and other internet-based forums long before the COVID-19 pandemic transformed the way people meet and interact. Our proven capabilities range from online focus groups to large online conferences that engage many hundreds of people at one time allowing for interactions through various functionalities, including breakout rooms, Q&A, polls, chat, live drawing, and through the use if digital interactive whiteboards enabling visual collaboration.

We understand that successful virtual event delivery is about much more than access to a single video-conferencing application (e.g. Adobe Connect, Microsoft Teams). It requires:

- an understanding of how to match the software platform to the event, the goal and the audience based on considerations such as preferred client technology, size and characteristics of audience, including technological factors (e.g. telephone dial-in options, user's accessible bandwidth), event format and functional requirements, e.g. virtual break-out groups
- an ability to build resilience into the event design, e.g. having back-up platforms to support audio/video as contingency in case of internet bandwidth issues;
- the technical ability to operate and support the platforms effectively;
- expert skills, specifically in facilitation of online events – the ability to fully engage people in a discussion in an online environment and support all participants through the event.

For the future dialogues, we will rely on our experience with the blended learning approach, or hybrid learning, combining research materials online with interactive sessions together with other participants to get the most out of exchanges and the sharing of experiences and ideas.

The various elements should be part of a coherent learning and transformative journey. Participants should be engaged and able to contribute to the workshops. In preparation for the various elements, throughout the sessions and for the follow-up, Mural – a visual collaboration workspace - will be used to allow participants to post questions and ideas and to work together in similar ways they have been collaborating at face-to-face events. ICF has successfully delivered projects that included series of interactive workshops, including for (i) Align project - Aligning accounting approaches for nature (DG ENV), where we developed recommendations for a standard on biodiversity measurement and valuation engaging with 50 technical experts as part of a Technical Hub and more than 150 businesses and other stakeholders of the Community of Practice, and (ii) the Development of Theory of Change for improving biodiversity (UK Department for Environment, Food and Rural Affairs), working with a range of environment and nature conservation experts.

Above all, workshops rely on the talent of the moderator moving through the different elements of the session, responding to the planned and unplanned twists in the storyline, and drawing out the learning connections and insights from the topic being discussed. Without this talent, participants will quickly switch off and be passive listeners, rather than active contributors feeding in comments and questions. Jerome Kisielewicz, Project Manager for this project, has moderated webinars and workshops online and in-person for more than 20 projects for DG CLIMA, DG ENV and DG REFORM and has therefore the required skills and experience.

Semi-structured interviews

Semi-structured interviews will be used to serve two objectives during the project:

- In a first stage a sample of interviews will be organised to sense-check at a more granular level the results of the horizon scanning and foresight dialogues (conducted through the literature review, surveys and small-scale workshops) and translate them into actionable intelligence for DG RTD. This first round of interviews will inform the participatory foresight exercise whose aim is to open

the scope of the research and bring new ideas into pre-existing scenarios and come up with solutions regarding specific technologies (Solution narratives). The number of interviews will depend on the results of the small scale workshop but is likely to be between 5 and 10 interviews.

- In a second stage, detailed semi-structured interview will be organised with the 50+ experts to (1) inform the assessment and scoring of our long list of high-risk high impact solutions under Task 1.3; (2) collect detailed information about the key R&I intervention areas identified and to be assessed in details under Task 3, 4 and 5; and (3) collect information on how the EU could better engage with partners at international level to accelerate the uptake of the identified solutions (Task 6).

The ICF team will draft the interview topic guide starting from the long list of high-risk and high-impact areas (such as in the example below) and will also include a number of forward-looking questions (to be developed during the study).

Table 2.10 Example of question themes that will be added in the topic guide

Provide a summary of the current status and trajectory of removal technologies.
Provide a preliminary identification of limiting factors: • Generally for the category of removal technologies; • Specifically for individual technologies; and • Where possible, also for technology ensembles.
Preliminary identification of opportunities to accelerate removal technology development and implementation, including removal-technology-specific novel business-case development in the fields of: • R&I policy; • Climate change mitigation policy; and, • International cooperation policy.
Provide a summary of key international initiatives where the EU should get involved to ensure an inclusive international cooperation on key R&I intervention areas

Interviews are expected to last approximately 1 hour. The topic guide will be drafted in English and validated with DG RTD. However, should some experts prefer to have the interview in another language, the team has the capacity to conduct interviews in English, French, Spanish, German, and Dutch.

The study team aims to have 50 interviews organised and conducted according to the following protocol:

- **Interview preparation**: To prepare the interview we will share the topic guide with the interviewees at least 3 working days before the interview.
- **During the interview**: The study team will carry out the interviews via MS Teams. During the interview, the ICF team will explain to the interviewee how the evidence will be analysed and reported highlighting the anonymity of the process. The interview will be structured around the topic guide but it will not be used as a rigid script to allow experts to think outside the box and provide detailed input. We will first organise a series of pilot interview to test the topic guide and adjust it accordingly.
- **After the interview**: The study team will write up minutes immediately following each interview and share these with the interviewee to validate our understanding and offer the opportunity to the interviewee to fill in any gap. These minutes will then be coded within NVivo and used to inform the short list

of high-risk and high-impact areas, document the shortlisted solutions under task 3, 4, 5, inform task 6 and draft policy recommendations.

Box 10 NVivo for survey and interview analysis

As described in Task 1, NVivo will be used as the data management and analysis tool for the project. All data will be stored and analysed with NVivo.

NVivo is especially useful in analysing a large number of interviews which have been conducted by a team of researchers. All interviewers will produce write-ups from the expert interviews. The write ups will omit content irrelevant to the research questions and will paraphrase some segments where verbatim content is not necessary. They will be optimised for analysis by being written directly in the first person (i.e., not having been subject to any significant process of interpretation) and separating out different points.

The interview write-ups will be coded with the same codes developed for the literature review in Task 1 and will be further "tagged" with codes emerging specifically from the interviews. These codes will be developed from the specific questions and issues in the interview topic guides.

Each interview write up will be classified according to a set of attributes that are relevant for subsequent analysis. These are independent variables which will be cross-references with the codes. Examples of these attributes include:

- Type of respondent (e.g., investor, innovator)
- Key climate mitigation area
- R&I solution

2.3.3 Task 2.2. Expert conference (online) to validate findings and recommendations

Nine months into the study, the team will organise a 1.5 day online conference with a view to validate the hypothesis derived from earlier efforts (10-15 key R&I intervention areas and policy recommendations) and to build consensus around the technologies and need for interventions required to enable systemic change. The conference will involve all the 50+ high-level experts that took part in the survey, small-scale workshops and semi-structured interview as well as our 5 external reviewers. DG RTD and other Commission services will also be invited. To ensure the event is focused and deliver additional insights to the study, our suggestion is to not organise a standard online conference but rather opt for a dynamic design around the blocks presented in the table below. We will have up to five block of focused discussion to allow us to cover the 10-15 key R&I interventions area in details and for each of them present the findings of the study regarding:

- The current status of the solution;
- Its future pathways, limiting factors (bottlenecks), and barriers; and,
- Its outlook and action points (to address limiting factors and overcome barriers).

Task 3 provides more details about the above bullet points. Each session will start by an overview of the study results. We will then gather feedback through interactive tools such as Mural or Slido similarly as what is described under the small-scale workshops. Each group session will end with 15-20 minutes of co-creation to build consensus on the conclusions of the study and its key recommendations.

Table 2.11 Example of agenda for the online expert conference

Time	Session
Day 1	
10:00 – 11:00	General introduction to the project and its objective, preferably supported by high level representatives from DG RTD
11:00 – 12:30	First block of focused discussion (2-3 in parallel)
13:30 – 15:00	Second block of focused discussion (2-3 in parallel)
15:30 – 17:00	Third block of focused discussion (2-3 in parallel)
Day 2	
10:00 – 11:30	Fourth block of focused discussion (2-3 in parallel)
11:30 – 13:00	Fifth block of focused discussion (2-3 in parallel)
13:30 – 14:30	Closing session

During the plenary sessions, the five external reviewers will be invited to present their views on the project and how they informed its implementation. The organisation of the conference will follow the same process as the organisation of the small-scale workshops. We will seek permission to record the conference and minutes will be drafted in the days that follow the discussion. The outputs will be used to continue the refine the innovative technologies, resources and support needed.

2.3.4 Task 2.3. Stakeholder consultation to discuss recommendations and broader R&I direction of travel

As requested in the ToR, on top of the close involvement of the external reviewers and the consultation with the 50+ high-level experts, we will run a broader stakeholder consultation during the project. The objective of this consultation will be to inform a broader set of stakeholders about the project, gather additional views and insights and ensure the project is transparent and inclusive. Based on the ToR we have identified an initial set of organisations to involve in this consultation in Table 2.2 (under Task 0.3). These stakeholders will be involved through an online event underpinned by a questionnaire to gather structured feedback on the study findings.

We see two potential timing for the organisation of this consultation during the project:

- Either before the preparation of the draft final report to present draft findings and recommendations with the objective to collect more feedback; or
- At the very end of the project to in that case only present the study findings and open the floor for discussion, without offering the possibility to really impact the results of the project.

Our preference would be to opt for the first option, but this will be agreed with DG RTD during the inception phase of the project.

No matter the timing, given the targeted stakeholders will be new to the project, they will receive a **short background paper** ahead of the online conference together with the short questionnaire we will ask them to complete during and just after the event – they will also have the option to complete the questionnaire online via EU Survey. The background paper will cover the study background and methodology, together with the findings and proposals (draft policy recommendations and draft list

of high-risk and high-impact areas) from previous tasks. Both documents will be circulated one week in advance and that will serve as basis for discussion during the stakeholder workshop.

The **questionnaire** will seek to gather opinions, views and insights regarding the preliminary findings of the study, as well as on the broader role, direction and investment needs of R&I in achieving the long-term goal of climate neutrality (including socio-economic implications).

The organisation of the event will follow the same approach as the one presented for the small-scale workshop, although we will engage earlier on with the targeted stakeholders to ensure their buy-in. The outcome of the stakeholder consultation, including the responses to the questionnaire, will be synthesised in a short and concise manner (5-10 pages) and be included in the final report.

2.3.5 Output(s)

As explained at the start of Task 2, Task 2 is a functional task that will be used to collect expert and stakeholder views to inform all the other tasks of the project. While there will not be a dedicated Task 2 report, the tasks will results in the following outputs:

- Analysis of the responses to the scoping survey informing Task 1.2;
- Minutes of the small-scale workshops informing Task 1.2;
- Minutes of the interviews informing Tasks 1.2, 1.3, 3, 4, 5 and 6;
- Minutes of the expert online conference informing Task 3, 4, 5 and 6; and,
- Minutes and responses to the broader stakeholder consultation informing Task 3, 4, 5 and 6.

2.4 Task 3-5. Analysis of key R&I intervention areas

2.4.1 Task 3. In-depth analysis of 10-15 R&I intervention areas

***Lead**: Jakob Wachsmuth, Fraunhofer ISI.*

Objective(s) and scope

The objective of Task 3 is two-fold: Develop a common methodology (template) for the in-depth analysis of 10-15 R&I intervention areas – to guide the analytical work throughout Tasks 4 and 5 (see Task 3.1) and to analyse the key R&D intervention areas identified in addition to those already proposed in the ToR and those reflected in Task 4 (carbon removal technologies) and Task 5 (general purpose disruptive technologies) (see Task 3.2).

The common methodology for in-depth analysis will build on the framework used to select the 10-15 intervention areas (see Task 1.3), but will offer a greater level of detail. The in-depth analysis itself will also include examination of systemic aspects (interlinkages between intervention areas as well as systemic transition opportunities) and thus contribute (along with Tasks 4 and 5) to answering study question 3:

- How can systemic interactions of mitigation approaches be taken into account in the development of the R&I agenda towards long-term carbon neutrality?

- Which are the policy choices that permit the sustainable transition at systems level?

Task 3.1. Common methodology for the in-depth analysis of 10-15 R&I intervention areas

The main purpose of the methodology for the in-depth analysis of the R&I intervention areas is to systematize the analytical approach for (1) identifying high-impact areas (which can contribute in the time frame 2030-2040/2050 to the establishment of a climate neutral economy), (2) analysing their respective limiting factors; and, (3) how those limitations could be overcome.

As part of the methodology, we will develop a common template to guide the analysis of each of the 10-15 intervention areas. This will provide the basis for the analysis report (around 10 pages per R&I intervention area). The template may span the topics specified in 0 below. For presenting the results, the template could also be translated into a web-based format that enables interlinkages to be highlighted and offers details of the analysis.

The dimensions of analysis outlined in 0 build on the selection criteria, used in Tasks 1 and 2 to select the R&I intervention areas. Those analysis parameters are deepened in Task 3 for the selected areas (notably concerning the mitigation potentials and the contributions to systems aspects).

Through a dedicated workshop session among the core study team, we will refine this first set of analysis parameters with further parameters, including in particular examining *limiting factors (bottlenecks)*, *technology maturity*, and *technology learning* with regards to the time frame relevant to reaching climate neutrality by mid-century.

Box 11 Experience with indicators for strategic R&D decision-making

Similar R&D indicators have been previously established by a variety of organisations, notably in the energy fields, e.g. by the European Union with the Strategic Energy Technology SET-Plan[27], IRENA[28], IEA[29], OECD[30] and national levels. Notably the activities related to the SET-Plan and the stakeholder interaction tie this project closely to the general development of the SET-Plan[31] (notably the many European Technology and Innovation Platforms, developed for individual fields of R&D within the SET approach). We will build on these examples and seek synergies wherever appropriate to the objectives of this assignment (including for the methodology for in-depth analysis).

27 https://energy.ec.europa.eu/topics/research-and-technology/strategic-energy-technology-plan_en

28 IRENA (2022): Renewable Technology Innovation Indicators: Mapping progress in costs, patents and standards. https://www.irena.org/publications/2022/Mar/Renewable-Technology-Innovation-Indicators

29 Energy Technology Perspectives. https://www.iea.org/reports/energy-technology-perspectives-2020

30 Main Science and Technology indicators. https://www.oecd-ilibrary.org/science-and-technology/main-science-and-technology-indicators_2304277x

31 SET-PLAN Progress Report. https://setis.ec.europa.eu/set-plan-progress-report-2021_en

Table 2.12 Template for the in-depth analysis of the R&I intervention areas

Chapter	Issues analysed in the Chapter
Summary fact sheet	One page summary reporting the headline messages and main carbon neutrality R&I indicators
1. Current status	1 Description of the R&I intervention area and value chains 2 Carbon neutrality R&I indicators for the R&I intervention area 2.1 Technology maturity (including for key components/key process steps) 2.2 Mitigation potential 2.3 Economics 2.4 Resource requirements 2.5 Permanence of the climate neutrality impacts 2.6 Key actors /companies on a world-wide basis and competitive context 2.7 Technology dependency 3 Existing (or potential) business cases
2. Pathways, limiting factors (bottlenecks), and barriers	4 Possible future pathways of the carbon neutrality R&I indicators developed in Chapter 1 (at various time horizons (5 years – short-term; 5-10 years - medium-term, > 15 years - long-term) 5 In-depth analysis of potential barriers/bottlenecks to the uptake of the R&I intervention area 5.1 Technical barriers along the value chain 5.2 Economic barriers in the present economic eco-system 5.3 Societal aspects/acceptance 5.4 Policy environment and regulatory barriers/requirements for the R&I intervention area to develop 6 Systems aspects: 6.1 Dynamics of the role of the R&I intervention area in the overall pathways to climate neutrality and key decision points 6.2 Interdependencies with other R&I intervention areas 7 Infrastructure-related issues
3. Outlook and action points (to address limiting factors and overcome barriers)	8 R&D-related actions to overcome the identified barriers 9 Outlook on non-R&D related actions (e.g., institutional and market-related changes) 10 Narrative for the R&I intervention area in a post-2030 climate-neutrality path

To make the above compiled information publicly available we may develop an open-access website following the example of the *RIBRI – Radical Innovation Breakthrough Inquirer* project[32] (see Box 5). This website would present the analysis and interconnections, as structured above. It could also contain information on how Climate Neutrality Technology Indicators can be a useful decision-making support tool for policy drivers, programme managers, investors, decision makers, financiers, and technology end-users in order to monitor the status of research, technological development and industrial evolution.

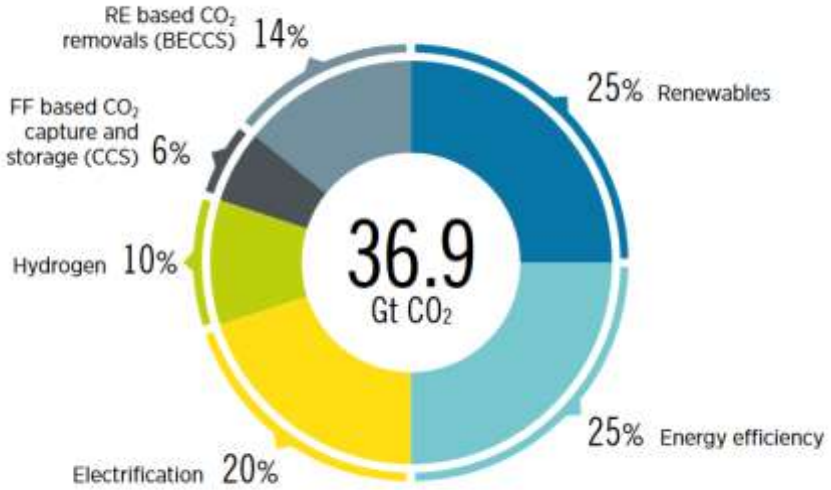
32 https://ribri.isi-project.eu/

Task 3.2. Analyse the key R&I intervention areas identified in addition to those already proposed in the ToR

In this task we will analyse the R&I intervention areas selected, in addition to those already proposed in the ToR and reflected in Task 4 (CDR technologies) and Task 5 (general purpose disruptive technologies).

Without predetermining the selection of intervention areas in Task 1 and 2, we anticipate a number of intervention area-candidates. In the section below we have illustrated their potential relevance for further analysis:

- **Advanced energy efficiency solutions in buildings, industry, transport:** While there are numerous energy efficiency options technically available today, their penetration is partly hampered by a variety of non-R&D related barriers, such economics, informational barriers, split incentives etc. For example, new buildings need to be constructed today which are "nearly zero energy buildings" according to the Energy Performance Directive for Buildings (EPBD). Nevertheless, events like the recent Ukraine war have shown that we need to be more ambitious on energy efficiency. Also, the increased use of energy due to the use of hydrogen and synthetic carbon-free energy carriers require a maximum effort on energy efficiency. Otherwise, huge amounts of renewables will be needed with large environmental impacts, acceptance problems and large import dependencies on uncertain regions. Most scenarios come up with a contribution of energy efficiency in the range of 25-35% to climate mitigation (see IRENA, 2022[33] below).



Source: IRENA, 2022.

Nevertheless, long-term ambitious scenarios with respect to energy efficiency, coupled with the issues raised above, and given its overall positive co-benefits, advocate enhancing the contribution of energy efficiency. To achieve such an ambitious reduction, R&D on advanced energy efficiency options is necessary. For example, in the industrial sector it is not sufficient to introduce hydrogen in replacing coal for steel making, because large amounts of hydrogen and renewables are necessary. This requires enhanced research on new industrial process routes based on ongoing research projects in H2020 and Horizon

[33] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA_World_Energy_Transitions_Outlook_2022.pdf

Europe. In the building sector, concerning existing buildings, we are still a way from climate neutrality and solutions need to be developed which can be applied readily in the daily work of the craft sector. Various transport modes will make large progress in efficiency with the penetration of electric mobility, which has inherently higher conversion efficiency to motive power, as compared to internal combustion engines. However, light-weight construction and research to achieve a single-digit figure for kWh per 100 kilometres for a wide range of cars sets a more ambitious target, as well as new intermodal connections.

- **Circular economy:** the circular economy as a second leg for energy efficiency requires large R&D efforts to save on materials, rare resources and critical materials.
- **Underground and sub-seabed storage of CO_2** (often referred to as CCS): Permanent storage of CO_2 in large quantities may be a prerequisite to decarbonisation of many industry sectors (notably cement, but arguably also steel), as well as for the achievement of many forms of CDR (notably BECCS and DACCS). As such we anticipate underground storage (in various forms – for example in depleted oil and gas reservoirs, as well as mineralisation in basalt) to constitute a key intervention area, with far-reaching implications for reaching climate neutrality.
- **Smart and flexible infrastructures** for electricity, district heating, hydrogen, CO_2 will need to develop largely to cope with increased sector coupling and a larger number of interacting infrastructures contributing to climate neutrality. This area is strongly interlinked, naturally with the general-purpose cross-cutting technologies (Task 5), but it also has specific importance in its own right, because it is the cornerstone for large amounts of variable renewable energy sources.
- **(Energy) Storage technologies**: (Energy) Storage technologies for mobile and static applications, short-term as well as seasonal, are a second important contributor to integrate large amounts of renewables, especially in regions/countries which do not benefit from large-scale, interconnected areas which mitigate the variability of renewable energy sources.
- **Hydrogen economy**: a newly arising field for climate neutrality (though the technology has been discussed for decades), notably due to the strong decrease in the cost of renewables. This field shows in particular, how different contributors to climate neutrality enhance each other. Next to the electrolyzer technology, this also includes research on down-stream technologies such as full ammonia economy (including for storage and electricity generation).

Outputs and reporting

Task 3 and the Task 3 lead will closely interact with the other tasks of the project to ensure study question 1, 2 and 3 can be fully answered. Specifically, the key interaction between Task 3 and the other project tasks will include:

- **Input to Task 1 to:**
  - design the literature review protocol and identify sources of information
  - inform the framework of the horizon scanning exercise and the foresight dialogue
  - inform the preliminary answers to research questions 1, 2 and 3 to be presented in the literature review report

- **Input to Task 2 to:**
  - Inform the design of the consultation tools (e.g. topic guides, workshop design, scoping of the expert conference, etc.)
  - Run interviews with high-level experts
  - Assess the information collected to ensure it provides sufficient content to inform the two sub-tasks described above.
- **Input to the interim, draft final and final report to answer research questions 1, 2 and 3.** The work under Task 3 will among other results in:
  - Input into the Interim Report: Outline of the in-depth analysis methodology and template
  - Input into the Draft Final & Final Report: the completed in-depth analysis of intervention areas (other than those covered in T4, T5)
- **A final presentation.**

2.4.2 Task 4. In-depth analysis of carbon dioxide removal (CDR) approaches R&I Intervention Areas

***Lead**: Matthias Honegger, Perspectives.*

Objective(s) and scope

The overall objective of Task 4 is to outline a detailed description of currently discussed negative emissions technologies (NETs; or carbon dioxide removal, CDR) both technological and non-technological (e.g. land-use related). This will identify various CDR technologies and practices, their anticipated carbon removal potentials, their Technology Readiness Level (TRL), the R&D and investment needs for the technologies to be (commercially) viable in the next 10-15 years and their long-term potential to achieve a business-case (including if required through continued public policy and regulatory requirements).

This task adopts a 3-step approach to review: (1) the status of these technologies; (2) their growth pathways and obstacles; and, (3) the outlook and action points for their development.

Step 1: Current status of technologies

Our analysis of the current status of existing solutions will be structured around the following elements: readiness, economics, resource requirements, permanence, overall business case and scalability.

- On **readiness**, the assessment assesses the likelihood that the innovation will be able to be successfully demonstrated at TRL 7-8 (i.e., large-scale, pre-commercial) in the next 10-15 years, paving the way for mass market deployment.
- On **economics**, the assessment considers capital investment requirements, operating costs and resulting mitigation cost levels.
- On **resource requirements,** the assessment examines issues related to energy, land, carbon-storage, and biomass needs of each approach, which could result in conflicts with other mitigation options or other forms of economic activity and thus limit their scalability. Resource requirements of NETs are as diverse as the

technologies themselves. The heterogeneity of needs is especially distinct between biogenic and non-biogenic solutions: the former typically require large areas, whereas the latter typically require high renewable energy loads (electric and/or heat). The distinction is not only apparent on the capture side, but also regarding the storage component: land-based approaches store GHG in biomass, thereby depending on area availability in suitable climatic zones; whereas non-biogenic techniques require special storage sites, e.g., in or under the ground and/or the seabed.

- **Permanence** is a central measure of NET effectiveness. It differs fundamentally between different forms of storage. Most notably, storage in biomass can be considered to be relatively short-lived, as the CO_2 from biomass may be re-emitted through burning (e.g. in wildfires) or consumption by humans or animals within approximately a decade. As we consider removals resulting in relatively permanent (e.g. underground[34] or mineralized) storage, as well as CO_2-sequestration in biomass, such as in agriculture, forestry, and carbon farming, a key focus will also be on assessing the carbon storage permanence, from the potential risks of storage failure, as well as possible interventions to mitigate risks and storage solutions with non-inherent permanence.
- All above considerations will flow into the examination of existing (or absent) **business cases for each approach**, drawing on the assessment of economics, other resource requirements, permanence of storage. These then flow into the assessment of scalability and thus overall mitigation potential.

Step 2: Growth pathways and potential obstacles

Step 2 focusses on the systemic interdependencies and the embedding of individual approaches in (specific sectoral) economic ecosystems. This step is required to identify where ensembles of NETs, other mitigation or non-mitigation activities might enter into (limiting) conflict or synergies (see box below for systemic interdependencies examples).

Box 12 Examples of possible systemic interdependencies (limiting or enabling)

biomass. This plays a key role in several mitigation options (forestry and other land-use, climate-neutral heating, BECCS, and climate neutral building materials).

Another likely limiting factor is the availability of electricity from renewable sources, which represents a mitigation option in and of itself (to displace fossil fuel-based electricity generation), but simultaneously serves as the basis of green hydrogen, as well as of DACCS.

An example for potential synergies is the application of high-quality biochar to productive agricultural or forest soils, which can result in medium-term increases of agricultural yields and potential declines in GHG emissions from those same activities.

For this, we will map sector-contexts of technologies and their respective trajectories based on existing and emerging assessments of European removal-pathways. The analysis will cover anticipated cost-trajectories resulting from technological learning curves, including (but not limited to) novel approaches such as:

- biomass pyrolysis with agricultural biochar application, resulting in CCS;

[34] Note that although the permanence of underground storage is under debate, the term permanent here is used in comparison to biomass techniques.

- production options for carbon-binding cement; and,
- waste-incineration combined with energy-use and CCS.

The interactions with high-level experts, external reviewers and stakeholders throughout Task 2 in this project will enable us to provide a comprehensive and up-to-date coverage of available and upcoming technologies. A multi-facetted view on NETs will also enable us to expand our analysis from a technology-specific to a systemic level, at which resource-requirements for technology-ensembles are considered.

Apart from physical resources, NETs require a functioning infrastructure to be successfully implemented. This includes transport and storage networks, but also aspects related to governance, e.g., an enabling and guiding regulatory framework and clarity of MRV and accounting practices. This holds especially true on the international (e.g., the European) level, as CO_2-removal value-chains are often of transboundary nature and therefore complex and loaded with risks for practitioners. We will cover these topics based not only on the existing literature, but also on expert and stakeholder interactions to learn about the practical barriers technology developers and other involved parties face.

For the provisioning of supportive infrastructure and governance structures, an equally supportive political and public environment is substantial, especially given that substantial investments will have to be undertaken. Therefore, our stocktaking will also investigate the current political-economic landscape and public perception of NETs in the EU. We will outline the role of public perception of NETs as well as that of historic and current narratives regarding CDR.

Step 3: Outlook and action points

Based on the investigation above, in Step 3 we will identify the key limiting factors to implementation, adoption, and scaling of NETs in the EU. This will allow us to develop options to overcome such barriers. On the road to scaling NETs, it is likely that institutional action will be required, e.g., establishment of novel policy instruments or reorientation of existing institutions dedicated to accelerating the NET landscape. Furthermore, existing and novel CDR-specific policy instruments which target NETs support will have to be adjusted and/or developed by the EU and its Member States. These adjustments should be based on a sound, ethical basis in order to sustainably increase the public support of NET implementation. Developing respective narratives, pathways, and safeguards against (perceived) risks associated with CDR will be key.

Box 13 Integrated systemic analysis of a possible CDR portfolio pathway

Analysis conducted by Perspectives for specific cases (city and canton of Zurich, Switzerland), as well as on the global level (implications for UN SDGs), shows the importance of viewing CDR as ensembles embedded within specific socio-economic, political and geographical contexts for assessing their respective individual and aggregate mitigation potentials. This is in part due to competing resource-requirements of various CDR (and other mitigation) approaches, as well as owing to the varying fit into existing business-cases and actor-constellations.

Outputs and reporting

Task 4 and the Task 4 lead will closely interact with the other tasks of the project to ensure study question 2.1 can be fully answered. Specifically, the key interaction between Task 4 and the other project tasks will include:

- **Input to Task 1 to:**
  - design the literature review protocol and identify sources of information
  - inform the framework of the horizon scanning exercise and the foresight dialogue
  - inform the preliminary answers to research question 2.1 to be presented in the literature review report
- **Input to Task 2 to:**
  - Inform the design of the consultation tools (e.g. topic guides, workshop design, scoping of the expert conference, etc.)
  - Run interviews with high-level experts
  - Assess the information collected to ensure it provides sufficient content to inform the three steps described above.
- **Input to the interim, draft final and final report to answer research question 2.1**. The work under Task 4 is expected to yield a set of insights for which we have developed a tentative structure, as set out below. We will discuss this with DG RTD at the kick-off meeting and we envisage it featuring in the literature review report, as well as the draft final and final report.
- **A final presentation.**

Box 14 Suggested reporting structure for Task 4

- Identify current status of removal technologies (including approaches in agriculture, forestry, and other land-use)
  - Economics; existence or absence of business-case
  - Technology-readiness-level
  - Knowledge on the inherent permanence of storage
  - Resource-requirements including:
    - renewable energy;
    - low/zero-carbon heat;
    - underground-/sub-seabed CO_2-storage;
    - agricultural- and forestry land;
    - biomass.
  - Range of actors presently involved in their implementation.
- Map sector-contexts of technologies and their respective trajectories based on existing and emerging assessments of European removal-pathways
  - Technology-learning based cost-trajectories including for emerging, novel approaches such as:
    - Biomass pyrolysis with energy-use, carbon capture and storage, and agricultural biochar application;
    - Various production options for innovative carbon-binding cement;
    - Combined waste-incineration with energy-use and CCS;
    - And many more (most up-to-date list thanks to involvement of diverse experts)
  - Resource-constraints-based examination of potentials embedded in their respective production systems (including systemic perspective of resource-requirements for technology-ensembles).
  - Infrastructure-related constraints and enabling factors:
    - Existence of CO_2-transport and storage networks; and,
    - Existence of enabling and guiding regulatory framework and clarity of MRV and accounting practices for complex and sometimes transboundary CO_2-removal value-chains.
  - Political-economic interest-structures that may drive or inhibit advancement of various removal technologies.
  - Social and political limiting- and accelerating factors including public perception and narratives.
- **Identify key limiting factors to the scaling and adoption among the above points**
- **Identify opportunities for acceleration and overcoming key limiting factors**
  - Possible institutional action (e.g. establishment of novel- or reorientation of existing institutions dedicated to accelerating the removals technologies landscape).
  - Possible policy instrument development/implementation at the reach of the European Union or Member State.

2.4.3 Task 5. In-depth analysis of disruptive general-purpose technologies

***Lead**: Heike Brugger, Fraunhofer ISI.*

Objective(s) and scope

In Task 5 we again apply the methodology for in-depth analysis and corresponding template (see Task 3) to analyse key R&I areas for disruptive general-purpose technologies and their potential relevance for climate neutrality and the transformation of the energy systems. This task answers in particular study question 2: *Which are the opportunities and challenges of breakthrough and disruptive technologies in the areas listed below regarding their contribution to climate neutrality by 2050?*

Based on our previous experience, we expect that the following could be considered as part of this group of potential intervention areas[35]. However, the final list will be subject to the work done under Tasks 1 and 2:

- Artificial intelligence (AI), machine learning and Big Data
- Blockchain
- 3D printing
- Virtual/Augmented Reality VR/AR
- Internet of Things (IoT)
- Quantum-computing
- Advanced material science
- Photonics and electronics
- Synthetic biology
- Sensor technology

These technologies may prove important enablers for climate neutrality through numerous – in part, hard to anticipate – use-cases. We expect the following four application fields to play a particularly important role:

- **Saving on resources** (energy and materials), e.g.
  - Autonomous vehicles may lead to more efficient use of vehicles, more efficient fuel consumption, and reduced traffic congestion (while they may also increase demand for mobility);
  - Virtual assistants may support us to reduce unnecessary use of energy and resources;
  - Big Data analysis helps agricultural systems to make more efficient use of resources (e.g., water, fertilizers,…); and,
  - Synthetic biology will help to replace non-renewable energy and material sources.

35 https://medium.com/eleks-labs/what-is-deep-tech-and-how-it-builds-a-better-future-7310fdb163fd; https://www.iotforall.com/5-disruptive-technologies-shaping-our-future

- **Providing flexibility to the energy system** and allowing for a large number of agents to interact intelligently, e.g.
  - Artificial intelligence, big data, quantum computing and IoT will help to run virtual power plants which also includes a large number of individual generators as well as storage systems, electric vehicles and load shifting;
  - Blockchains make transactions between individuals possible (by cutting transaction costs through decentralisation, transparency and security), allowing for new business models to arise in a decentralised energy system, which is characterised by prosumagers (consumers, producers and managers of energy). In such a way, energy markets may run in a totally different way, as today. However, blockchain technologies may also lead to largely increased energy consumption.
- **Improving materials and production processes**, e.g.
  - 3D printing may help to simplify production processes and allow for adaptation to individual needs, rendering them cheaper and more quickly implemented, and cut down on input waste;
  - Advanced material science helps to develop more resistant materials (e.g. for wind converters or solar plants); and,
  - Improved logistics chains through AI and Big Data analyses may help to improve production processes.
- **Improve the reliability and resilience of climate neutral systems**, e.g.
  - Improving the predictability of variable renewable energy sources through AI, Big Data analysis and quantum computing will help to handle the new arising energy systems in a reliable manner, notably in case of strong changes in the offer of energy;
  - Rendering inter-connected layers (energy, IT, IoT...) safer through early detection of failures and attacks; and,
  - Improving knowledge on extreme weather events to allow for more efficient adaptation to climate change.

It is important to underline that a number of these disruptive general-purpose technologies offer perspectives of large benefits. However, they do not come without risks: a growing dependency on interlinked digital and energy infrastructures, threats from data security etc potentially generate risks and require robust risk-mitigation and resilience strategies from national, regional and local stakeholders.

While we will follow the same approach set out in Task 3 and exemplified with Task 4 for the in-depth analysis, we will add a layer of specificity here by grouping technologies[36] – provisionally by the four application fields outlined, but we would like to discuss the possible grouping in the kick-off meeting to find the most meaningful approach. The importance of such an approach is to immediately examine the general-purpose technologies from a systems perspective and towards their relevance for climate neutrality.

36 The RIBRI – Radical Innovation Breakthrough Inquirer (https://ribri.isi-project.eu/) presents a large number of such technologies, see Box 5)

Outputs and reporting

Task 5 and the Task 5 lead will closely interact with the other tasks of the project to ensure study question 2.2 can be fully answered. Specifically, the key interaction between Task 5 and the other project tasks will include:

- **Input to Task 1 to:**
  - design the literature review protocol and identify sources of information to ensure it addresses the above objectives regarding disruptive general-purpose technologies
  - inform the framework of the horizon scanning exercise and the foresight dialogue
  - inform the preliminary answers to research question 2.2 to be presented in the literature review report
- **Input to Task 2 to:**
  - Inform the design of the consultation tools (e.g. topic guides, workshop design, scoping of the expert conference, etc.)
  - Run interviews with high-level experts
  - Assess the information collected to ensure it provides sufficient content to inform the three steps described above.
- **Input to the interim, draft final and final report to answer research question 2.2.**
- **A final presentation.**

2.5 Task 6. International cooperation on key R&I intervention areas (Task 6)

***Lead**: Arianna Griffa, ICF.*

2.5.1 Objective(s) and scope

Climate change is a global challenge that requires global solutions. As an increasing number of countries around the world are committing to net-zero targets, they are faced with similar technological challenges to develop and scale-up the needed solutions that will enable climate neutrality by mid-century. The next decade will be crucial to meet those targets, hence significant effort is needed to help move key emission reduction technologies from early-stage development into diffusion stage.

International cooperation on R&D and innovation policy can greatly accelerate the pace at which critical net-zero innovations are brought to market by: (1) mobilising international expertise and providing platforms for knowledge sharing and policy discussion/ coordination; (2) helping direct resources towards promising technologies; and, (3) setting expectations and providing confidence to stakeholders

of what actions can be taken.[37] Critically, it also enables countries to share risks when funding high-risk and costly technologies e.g. CCUS, clean hydrogen, etc.[38]

The objective of this task will be to answer study question 4 (*How can EU engagement in international fora be strengthened to facilitate rapid development and diffusion of breakthrough solutions in the next 10-15 years at European level, and worldwide?*) and to explore concrete opportunities for the EU to use existing international fora and mechanisms for cooperation – at European and global level – to drive international alignment on R&I priorities and greatly accelerate the development and diffusion of innovative solutions for climate neutrality within the EU and beyond. The study will take stock of the achievements so far, identify gaps and opportunities, and provide recommendations for expanding international cooperation on new R&I areas.

The scope of the research will consider existing bilateral and multilateral mechanisms of which the EU and/or its Member States are members, and which focus on the R&I areas identified and analysed in detail under Tasks 3, 4 and 5. The task will also explore other international initiatives where the EU is not currently a member and highlight potential opportunities for engagement.

2.5.2 Approach

Step 1: Mapping of the existing landscape

Firstly, the analysis will start by mapping the current landscape of international cooperation, with the aim to provide an overview of the existing international initiatives/ institutions/ partnerships and cooperation mechanisms (bilateral/ multilateral) more broadly. The scope of the exercise will consider primarily existing bilateral and multilateral international fora of which the EU and/or its Member States are members; some other relevant initiatives where EU membership is currently missing will be listed separately and further discussed in the final recommendations section. In particular, the analysis will assess initiatives against key criteria including:

- **Scope** – the specific scope of action that these initiatives have been set up to cover (as defined in their remit/ mandate/ mission);
- **Membership** – the level of international coverage by its members (e.g. global/ regional/ high- and low income countries, etc.);
- **Governance** – the decision-making process and the actor involved (e.g. working level vs Ministerial; tiered membership); and,
- **Delivery mechanisms** – the mechanisms employed by each initiative to deliver work (e.g. knowledge sharing platform, programmes, policy roundtables, etc.).

As shown in Figure 2.5 below, examples of existing initiatives that will be covered include, but not limited to:

- Mission Innovation;
- Mission Possible Partnership;

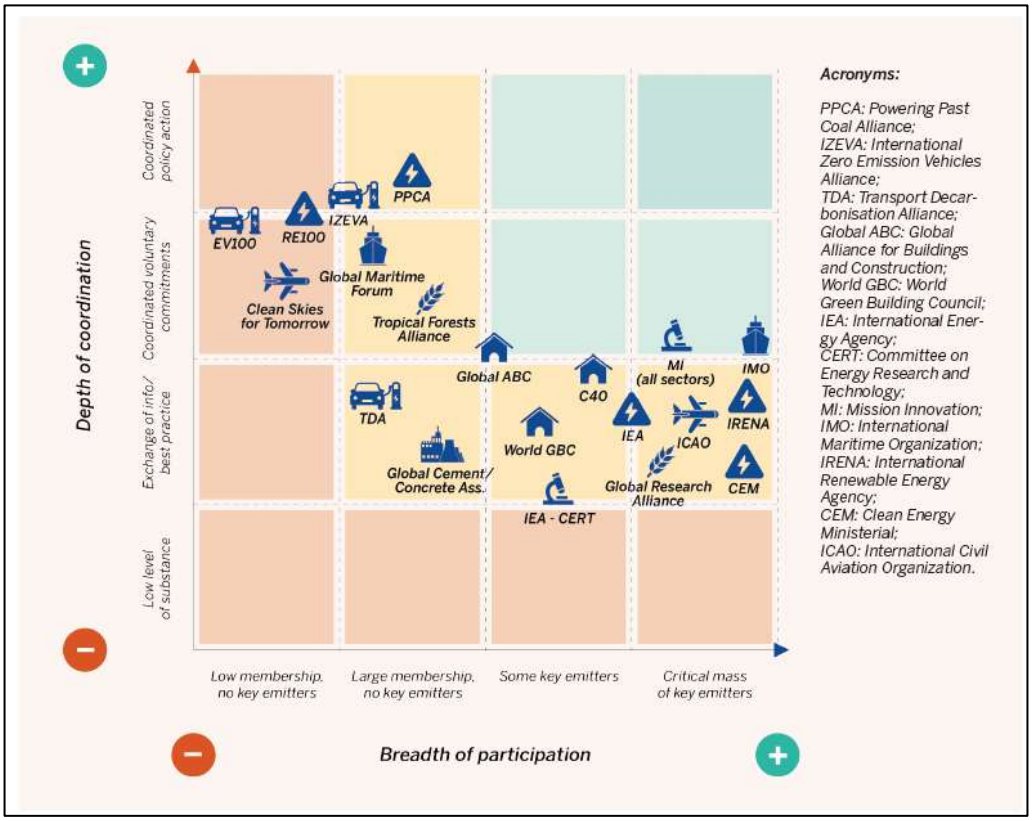
[37] Victor, D.G., Geels, F.W. and Sharpe, S., (2019) Accelerating the Low Carbon Transition: The Case for Stronger, More Targeted and Coordinated International Action. Available from: https://www.energy-transitions.org/publications/accelerating-the-low-carbon-transition/

[38] IEA (2020) Energy Technology Perspectives 2020 - Special Report on Clean Energy Innovation. Available from: https://iea.blob.core.windows.net/assets/04dc5d08-4e45-447d-a0c1-d76b5ac43987/Energy_Technology_Perspectives_2020_-_Special_Report_on_Clean_Energy_Innovation.pdf

- IEA Technology Collaboration Programmes (TCPs);
- UN Innovation Network; or,
- Global Covenant of Mayors / C40.

The results of the mapping exercise and criteria assessment will be detailed in a comprehensive table, as well as summarised in a heat map (similar to the one showed below), to enable a quick visualisation of the current landscape, as well as of potential existing gaps.

Figure 2.5 The institutional landscape for coordination within sectors



Source: Victor, D.G., Geels, F.W. and Sharpe, S., 2019. Accelerating the Low Carbon Transition: The Case for Stronger, More Targeted and Coordinated International Action.

Step 2: Challenges and opportunities of international cooperation

Secondly, the research will identify current challenges and opportunities of international cooperation. The initial evidence gathered during the literature review (Task 1) will be complemented and enhanced with the input of the high-level experts committed to the project (Task 2). A sample of these experts are directly involved in the leading international fora and initiatives for the deployment of low-carbon solutions and our engagement with them will therefore focus on these questions. We will however also ask all the other 50 high-level experts about their views on the key international initiatives that the EU should engage with to ensure an inclusive coverage under this task.

The discussion of challenges and opportunities with experts will not only help improve the understanding around the key challenges of coordinating R&D efforts internationally (including issues with lack of ministerial buy-in/ backing, limited funding commitments, difficult coordination/ consensus among members, etc.); it will

also help to identify specific examples of successful cooperation which will be presented as short case studies.

The analysis of the knowledge and insights collected through this exercise will enable the study team to capture and discuss common trends and key features of successful international cooperation. Additionally, it will help identify: (1) opportunities to further mobilise international expertise and innovation efforts around shared R&I priorities (e.g. via existing mechanisms); (2) specific international actors that could be included in successful partnerships and collaborations, particularly, governments that have established themselves as global innovation leaders and have publicly committed to net-zero (e.g. US, UK, China, India, etc.).

Step 3: Key gaps and recommendations

Thirdly, the mapping and assessment of the current landscape will enable us to identify key gaps in the technological scope of these initiatives as well as areas where significant synergies can be drawn, and the scope expanded to cover new R&I themes. The analysis of the gaps will mainly focus on technological areas and innovative solutions that have the greatest potential for development and deployment within the European Union – these will be identified as part of Tasks 3-5 and informed by the expert consultations in Task 2. However, the discussion will also highlight where there is significant potential for knowledge sharing and technology transfer that could enable these solutions to be exported and deployed beyond Europe. Particular attention will be given to solutions that could be easily adopted or adapted to support the transition of emerging economies and developing countries.

Key examples where further international cooperation and coordination efforts would be needed include, hard-to-abate sectors and sectors at the earliest stages of the transition such as aviation, shipping, heavy road transport, high-emitting industries (e.g. cement, steel, etc.) as well as digital and other general purpose technologies where standardisation/ harmonisation of data could unlock decarbonisation opportunities across borders.

Lastly, based on the findings presented and discussed so far, the study will offer recommendations for EU decision-makers to better seize the opportunities of international cooperation to facilitate a more rapid development of critical innovations for its climate neutrality goals. The recommendations will include suggestions on:

- 4-5 R&I areas that have the greatest potential to benefit from international cooperation;
- routes/ mechanisms to pursue collaboration with identified global innovation actors within existing initiatives;
- opportunities to strengthen international cooperation and establish strategic partnerships with key third countries (outside existing fora/ initiatives).

Finally, it will also highlight where remaining gaps are and steps to address them (e.g. create new institutions, expand mandate of existing ones, etc.).

2.5.3 Outputs and reporting

Task 6 will closely interact with the other tasks of the project to ensure research question four4 can be fully answered. Specifically, the key interaction between Task 6 and the other project tasks will include:

- **Input to Task 1 to:**
  - design the literature review protocol, identify sources of information (e.g. Flagship reports published by key international fora/ partnerships/ initiatives or Online documentation on initiatives' objectives, programme scope, governance frameworks, delivery mechanisms);
  - inform the framework of the horizon scanning exercise and the foresight dialogue; and,
  - inform the preliminary answers to research question four to be presented in the literature review report.
- **Input to Task 2 to:**
  - Inform the design of the consultation tools (e.g. topic guides, workshop design, scoping of the expert and stakeholder conference, etc.)l;
  - Run interviews with high-level experts involved in relevant international fora and initiatives (e.g. Jennie Dodson, Head of Mission Innovation Secretariat; Julia Reinaud, Senior Director – Europe at Breakthrough Energy; Hanna-Mari Ahoned, Senior Consultant at Perspectives Climate Group); and,
  - Assess the information collected to ensure it provides sufficient content to inform the three steps described above.
- **Input to the interim, draft final and final report to answer research question 4**. The suggested structure of the chapter dedicated to this research question is presented in Box 15 below.
- **A final presentation**.

Box 15 Suggested reporting structure of the chapter on international cooperationfor Task 6

- Overview of current landscape
  - Mapping of existing international cooperation mechanisms
  - Assessment of their scope of action
  - Membership types (e.g. global, regional, etc.)
  - Governance and delivery mechanisms (e.g. working level vs Ministerial; knowledge sharing platform, programmes)

- Challenges and opportunities
  - Bilateral vs Multilateral cooperation
  - Key challenges (including operational issues, funding, ministerial buy-in, optimal membership breadth, etc.)
  - Opportunities
    - Areas of successful cooperation – examples/ short case study
    - Successful delivery mechanisms – examples/ short case study
    - Analysis of common trends and key features of successful international cooperation

- Gaps and synergies
  - Sectoral/ technological gaps not currently covered by any initiatives
  - Potential synergies between existing programmes and new R&I areas

- Key recommendations
  - Priority R&I areas that could mostly benefit from international cooperation
  - Key routes (bilateral/ multilateral) to cooperation via existing initiatives
  - Remaining gaps and way forward

2.6 Summary of deliverables

The main deliverables of the study are listed in Table 2.13 below. This summarises the key content, format (including submission) of each deliverable, together with the deadlines. Deliverables will be submitted to the Commission in line with the following requirements:

- All deliverables (interim and final reports, slide decks, etc.) will all be supplied to the Commission electronically in Microsoft Word, PowerPoint, Excel and PDF format.
- All deliverables shall be written in English in a clear and concise form.
- The executive summary of the final report will be translated in French.
- The structure of all deliverables will be agreed in advance with DG RTD.

Table 2.13 Overview of the main study deliverables

Deliverable	Deliverable description	Due time after contract signature
Reports		
Draft Inception report	The inception report will include: ■ Our updated methodology building on the feedback received from DG RTD during the inception phase; ■ List and CVs of chosen external high-level experts and external reviewers ■ Draft outline of literature review report ■ Structure of surveys and questionnaires ■ Themes of workshops on dedicated topics ■ List of criteria and underlying methodology regarding the screening and prioritising amongst possible technologies/solutions.	3 weeks
Final Inception report	Final version of the Inception report following DG RTD's feedback.	1 month plus 5 working days
Literature review report	The literature review report will summarize the findings of Task 1. It will be structured around the four study questions but also include the long-list of high-risk high-impact solutions and the suggested short list to be further analysed under Task 3, 4 and 5.	4 months
Interim report	The interim report will include the literature review (Task 1) and a preliminary synthesis of the expert consultation (Task 2), addressing each of the study questions (Tasks 3 to 6). It will also include a final list of high-risk and high-impact areas, as well as draft policy recommendations.	8 months
Draft final report	The Draft Final report will build on all the work completed during the project and structured as follows: ■ Overview of the project objectives ■ Overview of the methodology ■ Answer to the study question 1 (building on task 1, 2 and 3) ■ Answer to study question 2.1 (building on task 1, 2, 3 and 4) ■ Answer to study question 2.2 (building on task 1, 2, 3 and 5) ■ Answer to study question 3 (building on task 1, 2, 3, 4 and 5) ■ Answer to study question 4 (building on task 1, 2 and 6) The draft final report will also include an annex presenting the results of the two stages expert consultation process and the broader stakeholder consultation. The report will contain an abstract (200 words) and an executive summary (6 pages) in both English and French.	11 months
Final report	Final version of the Inception report following DG RTD's feedback.	12 months
Meetings		
Online expert conference and	The objective of the online expert conference to validate the conclusions and policy recommendations developed by the contractor. The contractor will present the findings of the interim report. Beyond the experts working directly in the framework contract, the external reviewers will also take part in the conference.	9 months
Online stakeholder consultation	The Stakeholder consultation will be organised to engage with a broader set of stakeholders.	Tbc
Presentation of final report at dissemination event	PowerPoint presentation on the scope, methodology and key findings of the report as well as infographics of the key findings and recommendations.	14 months

3 Organisation of work

The Commission will benefit from a world-class ICF-led team of experts that provides the breadth of expertise and experience to immediately add value

Our team will ensure that the study identifies the relevant breakthrough low/zero carbon technologies and solutions, robustly evaluates their potential climate mitigation, socio-economic and environmental impacts, and recognises the relevant links and trade-offs between them. The European Commission needs a project team that has the breadth of expertise, past experience and resources to review a comprehensive set of literature, engage with a number of wide-ranging experts, and provide a systemic thinking lens.

The ICF-led team's expertise covers all key climate mitigation R&I areas and transversal considerations, including net carbon removal technologies, general purpose disruptive technologies, the current EU innovation ecosystem and a detailed understanding of EU support instruments, as well as international cooperation on innovation. The team also has leading expertise in strategic foresight methodologies and processes, as well as socio-economic and environmental impact assessment.

Study efficiency and effectiveness will be enhanced using a team that has established processes for all study requirements, with partners that have worked successfully together and delivered high quality studies for Commission services

The need for comprehensive and robust literature reviews; for horizon scanning and foresighting; and a tried-and-tested approach to extensive stakeholder engagement to add value to the core team's existing knowledge of R&I areas and enhance the overall body of study outputs and policy recommendations, requires excellence in project management, stakeholder engagement and close cooperation and mutually reinforcing support across all partners.

The proposed core team experts are a well-rehearsed team. Together, the partners have successfully collaborated in multiple projects and have delivered successfully complex studies for various DGs of the European Commission, including DG RTD. Indeed, our proposed ICF project manager, Jerome Kisielewicz, has worked directly with Fraunhofer ISI, Perspectives, Cambridge Econometrics, and the Cleantech Group over the last two years, delivering well-received studies for Commission services that include DG CLIMA, DG GROW and DG REFORM.

The Commission will benefit from the core expertise across ICF, Fraunhofer ISI, Perspectives, Cleantech Group and Cambridge Econometrics, together with their broad network of external experts

Our team is closely inter-connected with the ecosystems that DG RTD wishes to liaise with during this study: **Fraunhofer ISI**, **Perspectives** and **Cambridge Econometrics** operate at the border between academia and policy-making and bring rigour and excellence to the team; the **Cleantech Group** is uniquely positioned in the European cleantech ecosystem and benefits from direct contact with innovators, technology leaders, and investors; and, **ICF** brings unique expertise of engaging and working with governments across the globe to progress the fight against climate change, and will ensure all the findings stemming from the research are translated into actionable policy recommendations for DG RTD.

Together the five partners can mobilise a global network of experts across multiple disciplines, specialities, and geographies.

The following sections meet the service request requirements:

Roles and responsibilities	Allocation of time and resources
■ The team structure (section 3.1.1). ■ Summary of team credentials relevant to this study (section 3.1.2). ■ Role and responsibilities of team members (section 3.1.3). ■	■ Work plan illustrating timing of tasks and deliverables (section 3.2.1). ■ A breakdown of Global time and resource allocation by each task for the study (section 3.2.2). ■ Further information on the rationale behind the allocation of time (3.2.3).

Further information on the team's credentials is provided Annex 1 (Project References) and Annex 3 (CVs).

3.1 Roles and responsibilities of the team

3.1.1 Team structure

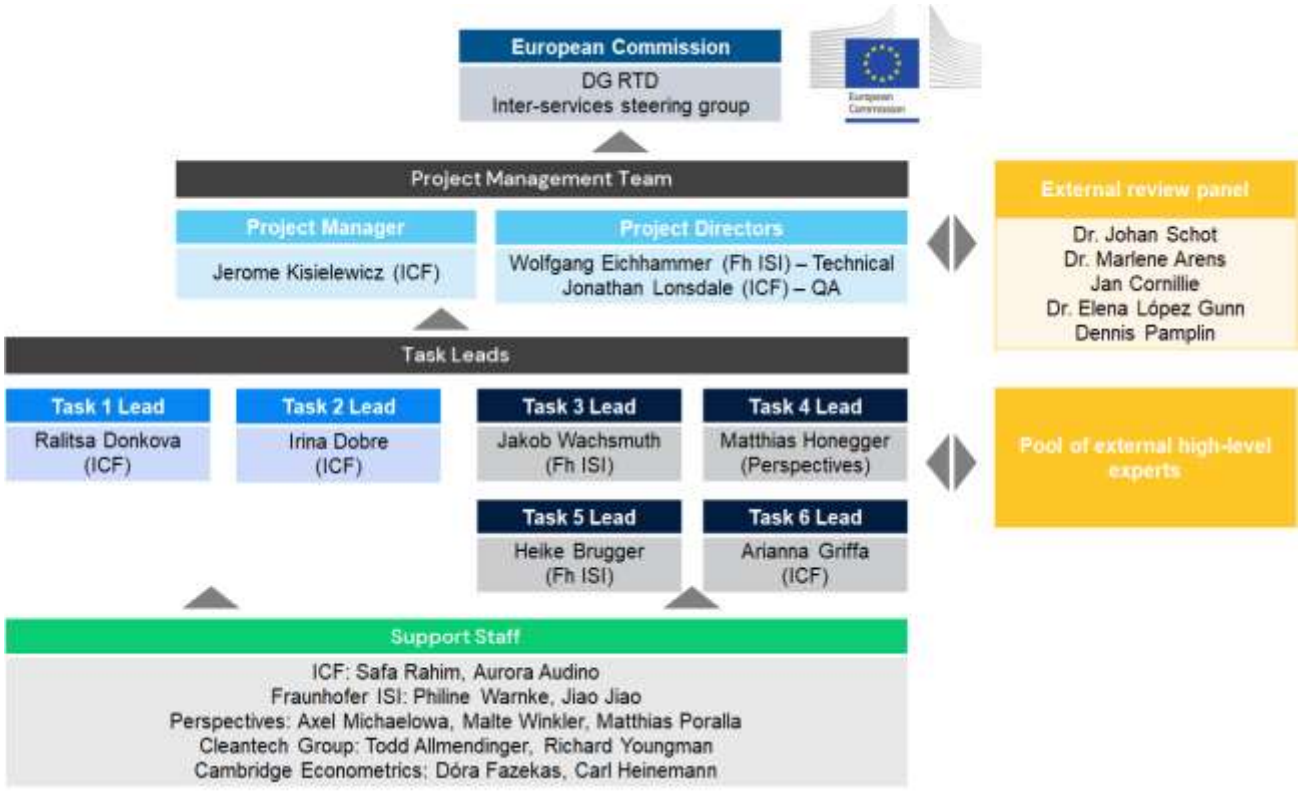
The ICF Management team, comprising the Project Manager and two Project Directors (one covering Technical, one covering overall QA), have extensive experience working with the Commission and are familiar with the quality standards that the project and deliverables should meet.

The PM team is augmented by a core team of technical task leads. A team of support staff will help deliver this project, all of whom have relevant experience in climate mitigation technologies, innovation development, and the relevant methodological skills.

We have drawn experts from our subcontractors (Fraunhofer ISI, Perspectives, Cambridge Econometrics, and the Cleantech Group), who have supported different DGs of the European Commission (DG ENER, DG CLIMA, DG GROW and DG REFORM) in numerous projects together with ICF for many years.

Additionally, we have mobilised five external reviewers to critically challenge the study's methodology, findings, and key deliverables. We have also compiled an extensive pool of 50+ external experts to provide independent input at multiple points in the course of the study. We have chosen the team carefully to give the Commission the diversity and breadth of experience required for success within the tight timelines.

Figure 3.1 Team organisation



3.1.2 Team credentials

ICF comprises highly experienced individuals who offer the technical capability, project management expertise and systemic thinking necessary to make this a successful assignment. ICF has worked with the Commission and other international institutions and organisations regarding industrial innovation, energy and meeting climate change and decarbonisation targets. We believe we will be (again) successful in meeting the goals of this assignment as well, since:

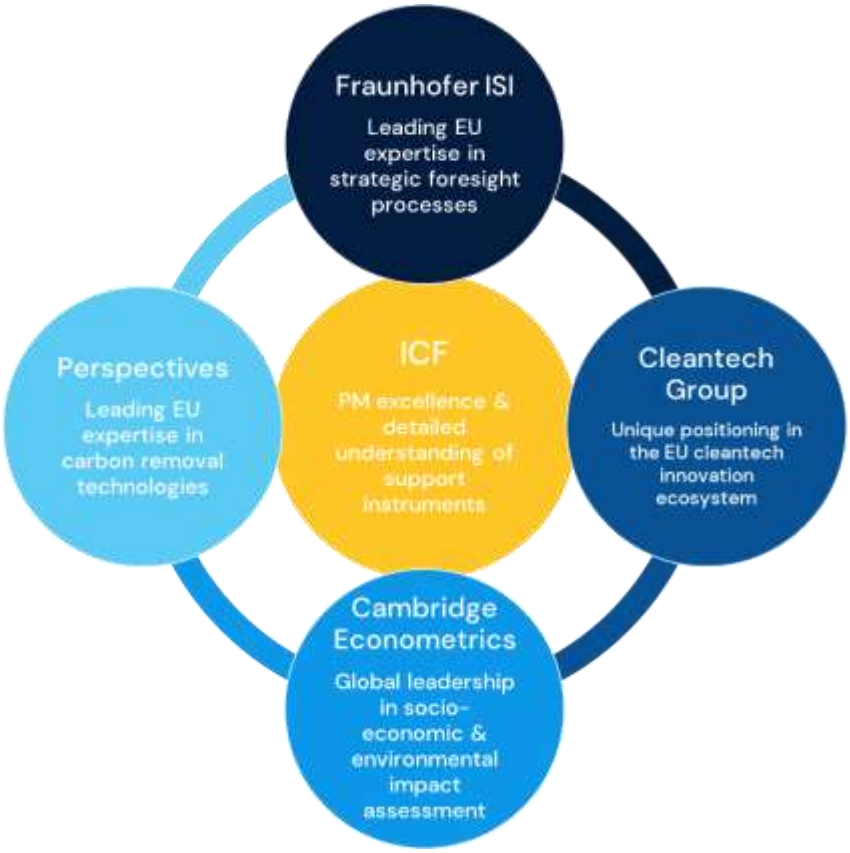
- **The team has solid knowledge of breakthrough innovative technologies across RES, energy storage, CCU/CCS and industry**. Recent projects undertaken by ICF cover the relevant technologies, enabling policies and funding instruments needed. This includes two recent support studies for the Innovation Fund as well as recent work to support DG GROW on climate neutral value chain competitiveness, which involved DG Energy and DG RTD on the steering group. This study inter alia involved analysis of European hydrogen value chains, covering large-scale production, as well as key RES technologies. Extensive insights from ICF's work were published in October 2020 in the Commission's first Competitiveness Assessment of Energy Technologies.
- **ICF is leading on the provision of advice regarding the decarbonisation of EU industry as well as the financing of the transition.** We support the EU and Member State governments in the design and deployment of decarbonisation plans. For example, in a successful project for DG REFORM, ICF worked with the Czech authorities to design robust modalities for the deployment of the EUR 5 billion EU ETS Modernisation Fund in Czechia. And in Italy, also for DG REFORM, ICF recently concluded a study which provided Italy with a Sustainable Finance Action Plan as well a Sovereign Green Bond (SGB)

Framework, enabling Italy to raise EUR 8.5 billion in its inaugural SGB issue in March 2021 – the largest ever debut SGB raise in the Eurozone.

- **ICF has long track record of managing complex studies for the European Commission and DG RTD**. ICF delivered a ground-breaking study for DG RTD to investigate Innovative Financial Instruments for First-of-a-Kind demonstration projects in the field of Energy (directed by Jonathan Lonsdale, this study's QA Director) which justified the rationale for the Commission to increase the scale of the InnovFin Energy Demonstration Project (EDP) facility from €150m to €250m.
- **ICF is one of the leading providers of evaluation services for the Commission**. We are conducting ex-ante, interim and ex-post evaluations of policies, legislation and programmes. ICF has an analytical team with a high-level of capability in assessing the impact of climate and environmental policies in the energy sector and industry. Delivering economic evaluations and impact assessments for the Commission is a core business, with several projects ongoing at any time. Recent successes include the assessment of product policy for the Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) and the study on employment impacts of the low carbon transition for DG CLIMA. ICF has held framework contracts for the provision of evaluation and other policy-relevant services for well over a decade with many different parts of the European Commission, including DGs CLIMA, ENER, RTD, ENV, MOVE, HOME and SANTE.
- **ICF will provide overall leadership, quality assurance and management of the project,** and lead in the delivery of Tasks 1, 2 and 6 building on current delivery of projects for the European Commission that involve comprehensive literature reviews and extensive stakeholder consultations.

ICF has partnered with Fraunhofer ISI, Perspectives Climate Group, Cambridge Econometrics, and the Cleantech Group to bring in relevant expertise across all relevant climate mitigation areas, industry sectors and innovative technologies and processes to meet the Commission's needs for this study.

Figure 3.2 What ICF and partners will bring to this study



Perspectives is a leader in environmentally integer carbon market solutions for carbon capture and storage (CCS) and carbon dioxide removal (CDR). Perspectives co-initiated – and is serving as the secretariat to – the CCS+ initiative the objective of which is the development of a coherent and environmentally integer ensemble of carbon market methodologies that allow the implementation of CCS through voluntary carbon markets and – medium-term – also through compliance markets or other carbon-results-based policy instruments with credible tracking of results. Perspectives and its four staff Matthias Honegger, Malte Winkler, Axel Michaelowa, and Matthias Poralla, who will act as (senior) experts on the study are highly involved in applied interdisciplinary academic and innovation-oriented research with important stakeholder engagement components on policy instruments for responsibly and ethically mobilizing CDR in projects funded by the German research ministry (project name CDR-PoEt), the Swiss Innovation Agency (project name: DECIRRA), jointly by the Swiss Environment Ministry and the Swiss Energy Ministry (project name: DemoUpCarma), and the Swedish Energy Agency (project name: Nordic BECCS cooperation through Article 6).

Cambridge Econometrics is an economics consultancy that works globally from offices in Cambridge (UK), Brussels, Budapest and Northampton, Massachusetts. We specialise in economic research and the application of economic modelling and data analysis techniques for policy assessment and scenario planning. We have particular expertise in the application of whole-economy macro-sectoral models, notably our global E3ME model. We work on challenges facing economies, societies and the natural environment. The scope of our work includes:

- Economy: innovation, infrastructure, tax & finance, sectors, trade & competitiveness and regions, cities & local areas
- Society: jobs & skills, inequality & poverty, population, migration & housing and health & social care; and
- Environment: energy, climate, circular economy and natural resources.

The **Fraunhofer Institute for Systems and Innovation Research ISI** is part of the **Fraunhofer Society**, Europe's largest organisation for applied research. Founded in 1949, the Fraunhofer Society currently operates 76 institutes and research institutions throughout Germany. The majority of the organisation's 30,000 employees are qualified scientists and engineers, who work with an annual research budget of 2.9 billion euros, of which 2.5 billion euros through contract research.
The Fraunhofer Institute for Systems and Innovation Research (Fraunhofer ISI) investigates on behalf of its customers the scientific, economic, ecological, social, organisational, legal and political framework conditions for generating innovations and their implications. In two Competence Centres, *Energy Policy and Energy Market*s as well as *Energy Technologies and Energy Systems*, we contribute towards developing the political and institutional framework for a sustainable energy system and climate neutrality. The Competence Center *Foresight* develops and conducts strategic foresight processes in enterprises, politics and society. This Competence Center develops future strategies, e.g. by applying horizon scanning, trend analyses, creative dialogues, scenario processes or road mapping. It promotes the exploration of alternative future scenarios, initiate learning processes, question biases and open up new options to create insight into possible future developments. This also includes participatory methods for stakeholder involvement, e.g., in scenario development or co-creation workshops.

The **Cleantech Group** is uniquely positioned in the cleantech ecosystem, having existing connection with numerous key stakeholders, experience with stakeholder engagement and conferences focusing on low-carbon innovation. It provides research, consulting and events to catalyse opportunities for sustainable growth powered by innovation. The Cleantech Group brings clients access to the trends, companies and people shaping the future and the customised advice and support businesses need to engage external innovation. Industries are undergoing definitive transitions toward a more digitised, de-carbonised and resource-efficient industrial future. At every stage, from initial strategy to final deals, Cleantech's services bring corporate change makers, investors, governments and stakeholders from across the ecosystem, the support they need to thrive in this fast-arriving and uncertain future. The company was established in 2002 and is headquartered in San Francisco, with people based in London, Paris and Boston.

3.1.3 Roles and responsibilities of team members

We have selected the core ICF staff and all subcontractors strategically to provide a team that can deliver 'best in class' expertise and support and fulfil DG RTD's needs over the duration of the project. We have checked with our core team of experts that they are independent and free from conflicts of interest in the responsibilities accorded to them.

The following subsections provide an overview of the experience and rationale for the roles and responsibilities of all team members.

3.1.3.1 Project management team

This section provides an overview of the experience and rationale for selection of our project management team – ensuring that the Commission receives the best possible support over the course of the project. The Project Manager, **Jerome Kisielewicz**, is based in our Brussels office and has over 11 years of professional experience and more than 8 years' experience as a Project Manager. We believe a study of this size and complexity requires a project manager with considerable experience, to ensure the project will stay on track to meet required timelines.

To provide further reassurance, we have proposed two project directors – one focused on the technical aspects of the study and another focused on the overall quality of the deliverables. **Wolfgang Eichhammer** will be the technical project director, and oversee the robustness of the methodological approach and technical analysis. **Jonathan Lonsdale** will have the responsibility for Quality Assurance of deliverables and provide native English language oversight of all deliverables. Jonathan has supported numerous European Commission Directorates-General (RTD, CLIMA, ENER, REFORM, GROW, ENV, RTD, ECFIN) and EASME and EIB/EIF on mechanisms to support climate change mitigation and climate adaptation.

ICF and Fraunhofer ISI have been involved in the development and evaluation of the successful EUR 25+ billion Innovation Fund from the very beginning.

Jonathan Lonsdale and Wolfgang Eichhammer have been collaborating as respective Project Directors of teams from ICF and Fraunhofer ISI since 2019 to deliver a successful launch of the Innovation Fund. This will increase the quality of results for this study, particularly given the Task leads.

The PM will be further supported by Ralitsa Donkova (Task 1 Lead); Irina Dobre (Task 2 Lead); Jakob Wachsmuth (Task 3 Lead); Matthias Honegger (Task 4 Lead); Heike Brugger (Task 5 Lead); and Arianna Griffa (Task 6 Lead). See Section 3.1.3.2.

Name	Role	Responsibilities
Jerome Kisielewicz	Project Manager	■ Organising and managing the team. ■ Ensuring each team member has clear work instructions and is aware of the wider context of the study and how the different tasks link together. ■ Tracking and reporting progress against the work plan, resource plan and cost plan. ■ The organisation of progress meetings with the core team to assess progress against work plan and any issues/solutions. ■ Making sure regular progress updates are provided to the Commission. ■ Ensuring draft/ final outputs are timely, high quality and meet the Commission's needs. ■ Being the first contact point for the Commission.

Name	Role	Responsibilities
		■ Contribute to all tasks in a coordinating function, and through targeted expert inputs for the overall methodological approach. ■ Support with the organisation of the workshops and lead in speaking role. ■ First-order QA on all deliverables.
Wolfgang Eichhammer	Project Director – Technical	■ Undertake overall QA/QC review of the technical aspects of all deliverables to ensure DG RTD's needs are met.
Jonathan Lonsdale	Project Director – QA	■ Undertake overall QA/QC review of all deliverables to ensure language quality and that DG RTD's needs are met.

Back-up staff for the Project Management and Task Lead roles have been identified from staff with equivalent experience in Table 3.1 below (sections 3.1.3.2 detail the roles, responsibilities and expertise of the Task Leads).

Table 3.1 Overview of key roles and back-up staff

Project role	Assigned staff member	Back-up staff
Project Manager	Jerome Kisielewicz (ICF)	Thibaud Lemercier (ICF)
Project Director - Technical	Wolfgang Eichhammer (FhISI)	Frank Sensfuss (FhISI)
Project Director - QA	Jonathan Lonsdale (ICF)	Mark Allington (ICF)
Task 1 Lead	Ralitsa Donkova (ICF)	Thibaud Lemercier (ICF)
Task 2 Lead	Irina Dobre (ICF)	Ralitsa Donkova (ICF)
Task 3 Lead	Jakob Wachsmuth (FhISI)	Johannes Eckstein (FhISI)
Task 4 Lead	Matthias Honegger (Perspectives)	Axel Michaelowa (Perspectives)
Task 5 Lead	Heike Brugger (FhISI)	Frank Sensfuss (FhISI)
Task 6 Lead	Arianna Griffa (ICF)	Laurent Petithuguenin (ICF)

Summary profiles of our Project Management team are provided below.

Team member	Jerome Kisielewicz (ICF)
Role	**Project Manager**
Experience overview: ■ Jerome is a Certified expert in climate and renewable energy finance and an environmental economist working as a Managing Consultant in the Climate and Energy team of ICF. He is an experienced researcher and project manager of large and complex evaluations and research studies for the European Commission, working across energy, environment and climate related topics, and with substantial experience in distilling and assessing large volumes of information.	

Team member	Jerome Kisielewicz (ICF)
■ In recent years, Jerome worked on various studies linked to the financing of innovative low-carbon and environmentally friendly technologies and business models. ■ Jerome holds an MSc in Ecological Economics from the University of Edinburgh (UK) as well as a Master in EU Studies from the University of Ghent (BE). ■ He obtained his "Certified expert in climate and renewable energy finance" following training at the Frankfurt School - UNEP Collaborating Centre for Climate & Sustainable Energy Finance.	
■ **Specific relevant experience:** ■ He is recently completed the project management of a project for DG REFORM to advise the Italian government on their first SGB and sustainable finance strategy to take them to climate neutrality in 2050. ■ Jerome has acted as deputy project manager on ICF's current first call support to the Innovation Fund as well as the preceding DG CLIMA 'Support to preparation of the first call for proposals under the Innovation Fund - methodologies for calculation of relevant costs and effectiveness of GHG emissions avoidance'. ■ He was the deputy project manager for a large DG CLIMA project reviewing the NER 300 programme and its potential expansion. Jerome's tasks in this project include among others the review of NER 300 project data (i.e. TRL level, composition of the consortium, scale of public support and co-financing, etc.), review of other EU, Member States and international programme supporting first-of-a-kind renewable energy projects and coordination of the consultation with NER 300 project sponsors. Through this project Jerome gained a very good understanding of the financing needs of innovative RES projects. Jerome is also an accomplished project manager. ■ Through his role of project manager and researcher for DG ENV and DG CLIMA, Jerome has developed strong analytical skills as well as qualitative and quantitative research skills. ■ In the past Jerome managed a DG ENV project aiming to support the deployment of the new Natural Capital Financing Facility set up by the European Commission and the European Investment Bank. He also led a research on EU and MS support programmes for emerging air pollution abatement techniques (at TRL 7 -8) for DG ENV.	
Education and languages: ■ University of Edinburgh 2010-2011 - MSc Ecological Economics, distinction ■ Frankfurt School - UNEP Collaborating Centre for Climate & Sustainable Energy Finance 2017-2018 (online course) - Certified expert in climate and renewable energy finance ■ Universiteit Gent 2008-2010- Master EU Studies, greatest distinction ■ French (native), English (fluent), Dutch (fluent)	

Team member	Wolfgang Eichhammer (Fraunhofer ISI)
Role	**Project Director - Technical**
Experience overview: Wolfgang is Head of Competence Center Energy Policy and Energy Markets at the Fraunhofer Institute for Systems and Innovation Research ISI. He is further Professor for Energy Efficiency and Energy Systems Modelling at Utrecht University, Copernicus Institute of Sustainable Development, Netherlands	

Team member	Wolfgang Eichhammer (Fraunhofer ISI)

Physicist with professional experience gathered in various countries of the European Union and world-wide in designing and evaluating energy efficiency and renewables policies as well as climate policies. Project coordinator of numerous national and international studies on modelling and simulating the impacts of climate protection measures, energy conservation and renewable energy policies. Technical advisor to the EU-Commission on the Innovation Fund, the implementation of EU Emission Trading (Benchmarking), the EU Effort Sharing Decision, the Directive on Energy Efficiency, among others. Advisor for various projects in these fields for international organizations such as the World Bank, the International Energy Agency, UNIDO etc.

Specific relevant experience:

- Designing and implementing a Multi-Disciplinary Innovations Analysis for the Energy Transition - setting up a multi-disciplinary centre of expertise for the energy transition (EnTEC)
- Supporting the EU Innovation Fund (EU IF)
- Representative of the Fraunhofer Society in the EU IF Innovation Fund Expert Group
- Project coordinator of a larger number of projects

Education and languages:

- Doctorate degree in physics, Louis Pasteur University, Strasbourg (France)
- M. Sc., Universities Heidelberg (Germany), Nancy (France) and Freiburg (Germany)
- Native German, English (C2), French (C2), Spanish (C2/C1)

Team member	Jonathan Lonsdale (ICF)
Role	**Project Director – QA**

Experience overview:

Jonathan is a Senior Consulting Director with ICF, bringing over 25 years of experience working in public policy consulting, UK government and VC fund management. At ICF, Jonathan has supported numerous European Commission Directorate-Generals (RTD, CLIMA, ENER, REFORM, GROW, ENV, RTD, ECFIN) and EASME and EIB/EIF on mechanisms to support climate change mitigation, job creation and competitiveness. He has also assessed national and EU innovation systems and their influences on investment and demonstration of new technologies, including for climate neutral innovations – an area in which he leads ICF's European work. Jonathan is recognised as an expert in the design and assessment of novel financial instruments for funding low-carbon innovations. Over the past 12 years, Jonathan has evaluated (ex-ante/ex-post) inter alia InnovFin EDP, EU ETS financing mechanisms (NER 300, Innovation Fund, Modernisation Fund), as well as the EFSI, LIFE, P4fEE and IEE.

Specific relevant experience:

For the past 2.5 years - and continuing until 2023 - Jonathan has directed an ICF-led project, working closely with Fraunhofer ISI, to help shape the development of underpinning evaluation methodologies on finance and GHG emissions avoidance, as well as provision of on-going evaluation to DG CLIMA of the Innovation Fund. The successful launch of the Innovation Fund in July 2020 has already enabled grant awards of €1.2 billion to be announced. In 2020 to 2021, Jonathan also directed an ICF-led team, working with Cleantech Group, providing support to DG GROW in an assessment of EU competitiveness in climate neutral value chains. In 2019 to 2020, Jonathan's team also supported Breakthrough Energy Ventures,

Team member	Jonathan Lonsdale (ICF)
advising on co-investment mechanisms globally, which in part helped to shape the Catalyst public private partnership, which includes the European Commission. Jonathan is currently managing two studies entitled 'Support to the review of storage permits under Directive 2009/31/EC on the geological storage of CO_2' in relation to a Dutch CO_2 storage permit application for DG CLIMA; and forthcoming CO_2 storage permit application for projects in Iceland and Norway for the EFTA Surveillance Authority (ESA), giving Jonathan and team excellent insights on the market challenges of current CCS projects. Jonathan has conducted an ex-ante assessment of the InnovFin Energy Demonstration Projects (EDP) facility, delivered by EIB and supported via a risk-sharing mechanism funded by DG RTD. This work was part of a ground-breaking study for DG RTD to investigate Innovative Financial Instruments for First-of-a-Kind demonstration projects in the field of Energy (2016) which Jonathan directed. His work justified the rationale for the Commission to increase the scale of the InnovFin EDP facility from €150m to €250m. Jonathan also advised on an Evaluation of the Fast Track to Innovation pilot (2015-2016), funded by DG RTD, in which ICF surveyed applicants and assessed findings. Prior to ICF, Jonathan led the research and investment analysis activities at Low Carbon Investors Limited, manager of the £55m Low Carbon Accelerator fund. He evaluated over 300 early-stage investment opportunities across the areas of renewable energy, energy efficiency, CCUS (e.g. mineralisation) and CDR technologies (e.g. biochar), cleaner fuels and sustainable buildings in the UK, EU and North America. This work allowed him to build an excellent network across VC and private equity firms globally which he has used to inform his work at ICF.
Education and languages: ■ M.Phil in Environment & Development, University of Cambridge, 1994 ■ BSc Honours (First Class) Geology, University of Bristol, 1992 ■ Native English, French (B1) and Spanish (B1)	

3.1.3.2 Task leads

Each task will be led by a designated task lead to ensure that the work for each task progresses on track, and the outputs of each are of the required quality. As many of the tasks are interlinked, this core team of task leads will coordinate with each other and the Project Manager to ensure that the sequencing built into the methodology is followed so that the required data and inputs produced from each task are delivered on time for the next task(s).

Name	Role	Responsibilities
Ralitsa Donkova	Task 1 Lead	■ Technical lead in the delivery of Task 1 including methodology development ■ Set-up and maintenance of NVivo project database ■ Coordination with other task leads on Task 1 links and inputs to other tasks ■ Draft deliverables
Irina Dobre	Task 2 Lead	■ Technical lead in the delivery of Task 2 including methodology development

Name	Role	Responsibilities
		■ Set-up and maintenance of expert and stakeholder contacts database ■ Coordination with other task leads on Task 2 links and inputs to other tasks ■ Draft deliverables
Jakob Wachsmuth	Task 3 Lead	■ Technical lead in the delivery of Task 3 including methodology development. ■ Coordination with other task leads on Task 3 links and inputs to other tasks ■ Draft deliverables
Matthias Honegger	Task 4 Lead	■ Technical lead in the delivery of Task 4, including methodology development. ■ Coordination with other task leads on Task 4 links and inputs to other tasks ■ Draft deliverables
Heike Brugger	Task 5 Lead	■ Technical lead in the delivery of Task 5, including methodology development. ■ Coordination with other task leads on Task 5 links and inputs to other tasks ■ Draft deliverables
Arianna Griffa	Task 6 Lead	■ Technical lead in the delivery of Task 6, including methodology development. ■ Coordination with other task leads on Task 6 links and inputs to other tasks ■ Draft deliverables

Summary profiles for the task leads are provided below.

Team member	**Ralitsa Donkova (ICF)**
Role	**Task 1 Lead**
Experience overview Ralitsa Donkova has more than 10 years of experience as a researcher. She has worked on topics ranging from climate policy, biodiversity, sustainable finance, and the just transition to a low-carbon economy. Ralitsa holds a Ph.D. in political science, and she is trained in both qualitative (process tracing; case studies; interviews; literature review) and quantitative methods (survey data and micro-data analysis; multi-level modelling), and in particular multi-method research design.	
Specific relevant experience ■ DG CLIMA (2021): Support services for the Innovation Fund first call for proposals; Task 4: Lessons learned – Evaluation of the application and evaluation processes ■ DG CLIMA (2023): Support services for the Innovation Fund – Launch of the 2021 Large- and Small-Scale Calls for proposals; Task 5: Lessons learned - Evaluation of the application and evaluation processes ■ DG REFORM (2022): Energy Efficiency Experts Platform in Poland, Deliverable 8: Platform pilot evaluation ■ DG CLIMA (2023): Climate Change Modelling Information ■ EIB (2020): Evaluation of EIB's Climate Awareness Bonds Programme (2007-2019) ■ DG CLIMA (2020): Employment effects of a transition towards a low-carbon and climate-resilient economy	

Team member	Ralitsa Donkova (ICF)
■ DG REFORM (2020): Supporting low-carbon transition of the Czech Republic by EU ETS funding mechanism; Task: Design of stakeholder surveys ■ DG HOME (2020): Final evaluation of the EU Drugs Strategy 2013-2020; Task: Design, implementation and analysis of Open Public Consultation	
Education/languages: ■ BA, MA and Ph.D. in Political Science ■ English and Bulgarian (mother tongue), French (B1), Spanish (A2).	

Team member	Irina Dobre (ICF)
Role	**Task 2 Lead**
Experience overview Irina Dobre has over 5 years of work experience in the energy and climate fields, having spent the last three delivering consulting projects for clients across the European Commission such as DG ENER, DG CLIMA and DG MOVE. Before that, Irina also worked for ACER, the energy regulator of the EU, and for an electricity transmission system operator (TSO) where she has built a solid understanding of the regulated aspects of the energy sector. Irina Dobre has a strong knowledge of energy policy and regulation at EU level complemented by a cross-disciplinary academic background. Before joining ICF, Irina was with COWI where she worked on various energy related tenders and projects. Prior to working in consultancy, Irina had specialized in the regulation of electricity infrastructure whilst working either for the Agency on the Cooperation of Energy Regulators (ACER) or the transmission arm of a large-scale British utility. Both these professional experiences provided her with insights into the technical, economic, and regulatory aspects of delivering large energy infrastructure projects such as interconnectors and onshore transmission grids. At ACER, Irina worked on electricity infrastructure planning and development, notably the TEN-E Regulation, where she was part of the team working on the annual monitoring report on the progress of Projects of Common Interest (PCIs). In her role as regulation analyst, Irina conducted extensive analysis of the UK regulatory and policy framework for developing energy infrastructure projects in order to provide regulatory input to the management of SSE and for responding to Ofgem public consultations on the topic.	
Specific relevant experience ■ Support services for the Innovation Fund – launch of the 2021 large-scale and small-scale calls for proposals (DG CLIMA) ■ Support to the review of storage permits for the Netherlands under Directive 2009/31/EC on the geological storage of CO2 (DG CLIMA) ■ Operation of the European Climate Pact Secretariat (DG CLIMA) ■ Sustainable finance and investments for the transition to a green economy in Italy (DG REFORM) ■ Competitiveness of the Renewable Energy Sector (DG ENER) ■ Launch and facilitate the implementation of a new EEFIG working group on Input on energy efficiency to the emerging EU Taxonomy and tagging energy efficiency loans (DG ENER) ■ Monitoring progresses made by overseas countries and territories (OCTs) in their sustainable energy transitions (Overseas Countries and Territories Association (OCTA))	

Team member	Irina Dobre (ICF)
■ Development of a Methodology to Assess the 'Green' Impacts of Investment in the Rail Sector (DG MOVE) ■ Evaluation of Regulation No 347/2013 on guidelines for trans-European energy infrastructure' (DG ENER)	
Education and languages: ■ MSc. Energy Politics and Law, University of Aberdeen; LL.B., University of Bucharest ■ Romanian (mother tongue), English (C2)	

Team member	Jakob Wachsmuth (Fraunhofer ISI)
Role	**Task 3 Lead**
Experience overview: Jakob studied mathematics with a specialization in mathematical physics at the University of Bonn. From 2006 to 2010 he was a research associate at the University of Tübingen, where he acquired his PhD in 2010. From 2010 to 2014 he was a post-doctoral researcher at the Center for Sustainability Research at University of Bremen. From 2014 to 2015 he was the managing director of the Smart Grids-Platform Baden-Wuerttemberg. Since May 2015 Jakob is a senior researcher at the Fraunhofer Institute for Systems and Innovation Research ISI in the Competence Center Energy Policy and Energy Markets. Jakob has long-standing experience with project coordination.	
Specific relevant experience: ■ Supporting the EU Innovation Fund (EU IF) ■ Analysis and design of energy system scenarios and transformation pathways (Evaluation of climate protection scenarios on behalf of the German Environment Agency ■ Sustainability assessment of power-to-gas technologies and gas infrastructures (The potential of hydrogen for decarbonising EU industry on behalf of the European Parliament) ■ Evaluation of targets and instruments in climate policy (GHG-neutral EU2050 - a scenario of an EU with net-zero greenhouse gas emissions and its implications, on behalf of the German Environment Agency)	
Education and languages: ■ Doctoral degree in Mathematical Physics, University of Tuebingen, Germany ■ Diploma in Mathematics, University of Bonn, Germany ■ Native German, English (C1/C2)	

Team member	Matthias Honegger (Perspectives Climate Group)
Role	**Task 4 lead**
Experience overview: Matthias Honegger is research associate at the University of Utrecht and senior research associate at Perspectives Climate Research. He is about to finish his PhD in Political Science and holds a master's degree in environmental sciences from the Swiss Federal Institute of Technology (ETH) in Zurich. In his research, Matthias examines policy instruments for Carbon Dioxide Removal, and governance of Solar Radiation Modification as emerging topics in climate	

Team member	Matthias Honegger (Perspectives Climate Group)

change governance. In two recent projects he has worked to integrate diverse expert opinions for strengthened policy-oriented research on CDR. He is o-leading a large research consortium in a multi-year project that co-creates and evaluates policy design options for carbon dioxide removal on multiple levels (CDR-PoEt).

Matthias has observed and contributed to Conferences of the Parties to the UNFCCC since 2012, including directly supporting the presidency of COP 18 in Doha, Qatar. In 2019, he was guest researcher at Harvard University. His studies have included a broad range of aspects on climate change spanning across system sciences, energy technologies, economics, atmospheric sciences, political science, psychology and more.

He attended courses at the Norwegian University of Science and Technology (NTNU), the University of Oxford, Yale University, University of Heidelberg, and Harvard University.

Specific relevant experience:

- Academic and grey-literature publications focussing on net zero scenarios, and carbon dioxide removal options and pathways
- Co-leading the CDR Policies and ethics research project (CDR-PoEt) (German Ministry of the Environment) (Research project, 2021-2024)
- Negative emission technologies: readiness assessment, policy instrument design, options for governance and dialogue (NET-RAPIDO) (Swedish Energy Agency) (Research project, 2018-ongoing)
- Development of a net zero emissions strategy (City of Zurich) (2019-2020)
- Study on the security and foreign policy relevance of climate engineering (Swiss Federal Office for Foreign Affairs) (2019)

Education and languages:

- BSc and MSc Environmental Science, both Swiss Federal Institute of Technology, Zurich, Switzerland, PhD candidate in Political Science, Utrecht University, Netherlands
- German (mother tongue), French (C1/C2), Spanish (B1)

Team member	Heike Brugger (Fraunhofer ISI)
Role	**Task 5 lead**

Experience overview:
Heike joined the Fraunhofer Institute for Systems and Innovation Research ISI in January 2018. She works as a senior researcher and project manager at the Competence Center Energy Policy and Energy Markets. Her research interests include the design and evaluation of energy and climate change policies, particularly in the field of energy efficiency, digitalisation and artificial intelligence as well as the modelling of the development of energy consumption in private households and the tertiary sector. An additional research interest lies in the analysis and consultation of local energy and climate policy and politics. Heike has long-standing experience with project coordination.

Specific relevant experience:

- Project coordinator of the H2020 newTrends project which focusses on the quantitative impacts of new societal trends such as prosumaging
- Impact of digitalisation and artificial intelligence on energy demand
- UBVi - Data-Driven Approach for User Behavior Forecast and Visualization
- CACTUS – Consolidating Ambitious Climate Targets with end-Use Sufficiency

Team member	Heike Brugger (Fraunhofer ISI)
■ Mentoring a PhD on text-mining approaches and smart buildings/smart cities in cooperation with Utrecht University	
Education and languages: ■ Doctorate in Social Sciences, University of Konstanz, Germany ■ Visiting Scholar, School of Government and Public Policy, University of Arizona, Tucson, USA ■ Academic studies for the teaching profession (Politics, Mathematics, Physics) ■ Native German, English (C1/C2)	

Team member	Arianna Griffa (ICF)
Role	**Task 6 lead**
Experience overview: Arianna is a policy, communication, and project management professional with solid expertise in climate, energy and innovation. She brings over 5 years of international experience across the public and private sector, combining multi-disciplinary approaches, strong analytical skills and strategic thinking to help organisations build critical relationships with global stakeholders, develop policies and deliver impact through successful programmes. She has led policy research projects based on whole energy system/ techno-economic modelling to develop climate and energy policies for long-term decarbonisation and provided policy and regulatory advice to clean energy innovation programmes. She has also significant experience in managing international programmes with a climate/ energy focus, ensuring efficient development and implementation of the activities as well as facilitating cooperation and engagement among all stakeholders and partners, including senior public officials from national governments, industry representatives, research and international organisations.	
Specific relevant experience: ■ Portfolio manager for UK-PACT overseeing delivery of international climate mitigation projects across various themes including green finance, nature-based solutions, electric mobility and clean energy systems. ■ Member of the Mission Innovation Secretariat and workstream lead for the development of the “Innovation Platform” launched a part of the second phase of Mission Innovation (2020-2021), ■ UK lead for the “Green Powered Future” Mission - new international energy innovation programme to decarbonise the power system in partnerships with Italy and China (2020-2021), ■ Buildings decarbonisation policy lead for the innovation programme “Smart Systems and Heat 2” funded by the UK government (2018-2019)	
Education and languages: ■ MSc. Climate Change and Environmental Policy (University of Leeds, UK) and MA. Economics, Politics and International Institutions (University of Pavia, Italy) ■ Italian (native), English (C2), French (A2), German (A1)	

3.1.3.3 External review panel

We have mobilised five senior experts in our team to serve as external reviewers.

Dr. Johan Schot is Professor of Global History and Sustainability Transitions at the Utrecht University Centre for Global Challenges. He is Academic Director of the Transformative Innovation Policy Consortium (TIPC) and the Deep Transitions

research project coordinated from the Science Policy Research Unit at the University of Sussex Business School. Johan Schot is an academic entrepreneur who builds bridges between science and practice by applying a transdisciplinary research approach. He works jointly with actors from different academic disciplines, policymakers, governments, civil society, NGOs, the media and business world to address the biggest challenges of our times such as climate change and social inequality. He is the author of influential publications including *Transitions Towards Sustainable Development. New Directions in The Study of Long Term Transformative Change* (Grin, Rotmans & Schot) and *Three frames for innovation policy: R&D, systems of innovation and transformative change* (Schot & Steinmueller, 2018).

Dr. Marlene Arens is Manager of Associations - Europe and Global within the Department of Environmental Social Governance at HeidelbergCement AG. In this role she represents HeidelbergCement in associations where the strategy to, and the policy needs for, a decarbonization of the cement industry are agreed on. Before joining HeidelbergCement, she gained extensive knowledge on industry transition working as a researcher for Fraunhofer Institute for Systems and Innovation Research (ISI), Germany, as well as a Post-doctoral Fellow at Lund University, Sweden. Marlene holds a Master's Degree Mechanical Engineering from the Technical University of Dresden, Germany, and a PhD from Utrecht University, the Netherlands, in the field of Resources, Innovation and Technological change.

Jan Cornillie is Head of Strategy & Policy at 3E, a renewable energy technology firm, and Research Associate at the School of Transnational Governance at the European University Institute. He specialises in the synergies between technology, finance and policy to realise the transition to a net zero carbon economy. Jan is currently assessing the integration of digital and renewable energy technologies, in order to realise the smart energy systems required for a net zero world. He advises companies and governments on the implementation of the Paris Agreement, including the adoption of cleantech, the innovation in renewable-powered technologies and attractivity for sustainable finance.

Dr. Elena López Gunn is Director of ICATALIST, a consultancy applying scientific knowledge to climate change adaptation and sustainability, and Visiting Fellow at the University of Leeds. Her work focuses on the strategic development of projects, vision of the future and innovation. She is currently working on climate change adaptation and the role of green infrastructure management. Elena is a member of the newly appointed European Scientific Advisory Board on Climate Change.

Dennis Pamlin is an entrepreneur and founder of 21st Century Frontiers, Senior Advisor at RISE Research Institutes of Sweden, and Senior Associate at the Chinese Academy of Social Sciences. His main skill is work with companies, governments and other organisations as a strategic economic, technology and innovation advisor in the area of sustainability. His background is in engineering, industrial economy and marketing. Dennis' current work includes work to establish a framework that can identify winners in a sustainable future, build a platform for global trend assessment, promote clusters capable of delivering transformative solutions, exploring the impact of our "digital twins" and develop tools that allow public procurement to support sustainable solutions

3.1.3.4 Support staff

A number of support staff across the five partner organisations will support the core team in performing the research, analysing data, organising events, and drafting the

deliverables. The support staff range in topical expertise, methodological skill, and seniority.

Team member	Aurora Audino (ICF)
Role	Support staff

Experience overview:
Aurora has worked in the field of environment, sustainability, energy and climate change in both the public and private sector. She currently works on climate policy and sustainable finance at ICF, supporting the work on the Innovation Fund, acting as a researcher for the Climate Change Modelling Information project, and the Business & Biodiversity Platform.

After graduating cum laude as an environmental and land engineer, she supported the European Parliament in the implementation of its sustainable management system and its EMAS-ISO14001 alignment, working on carbon footprint, sustainability reporting and planning and delivering awareness raising events and campaigns for all EP Staff, Members and Assistants, around 8000 employees.

In the private sector she worked as an environmental consultant intern at Sersys Ambiente (EDF - EDISON group) where she supported the environmental services unit on managing factories permits, environmental impact assessment, energy efficiency projects and R&D on a tool to assess the risks due to climate change.

Aurora is also part of a NGO, being an active member of the Advocacy division of the Italian Climate Network. Recently, she has been selected as Italy delegate to the G7 Youth summit, and she'll develop policy proposals on climate mitigation, nature and biodiversity, global partnership for sustainability.

Specific relevant experience:

- At ICF, Aurora has set up and conducted interviews with different stakeholders for the project "Sustainable finance and investments for the transition to a green economy" for the benefit of the Italian Ministry of Economy and Finance, both in Italian and in English (DG REFORM, European Commission, 2021). She has also supported during the interviews conducted with different stakeholders for the project on operationalising the Common Principles for Climate Mitigation Finance Tracking for the International Development Finance Club.
- Aurora acts as a key researcher for the Climate Change Modelling Information project (CCMI, DG CLIMA, European Commission), where she synthesises the most recent climate change modelling research and updates in a report that is issued on a quarterly basis by the European Commission. The aim of the CCMI project is to provide the EU and global climate change modelling community and interested policy makers with up-to-date information about ongoing modelling developments and projected results, focussing in particular on economic assessments of policies to mitigate climate change, ways to combine climate action with other global priorities, and assessments of the impacts of climate change and how to adapt to it.
- Aurora is familiar with innovative technologies thanks to her involvement providing technical and operational support for the Innovation Fund to support low-carbon innovative solutions whose aim is to decarbonise the economy. Aurora has previously worked for EDF -EDISON Group in Italy, where, among others she was performing research and developed of a pilot tool to assess the risks due to climate change.
-

Team member	Aurora Audino (ICF)

Education and languages:

- MSc cum laude in Environmental and Land Engineering at Polytechnic of Turin, Italy, studying for a full academic year at KTH - Royal institute of Technology in Stockholm, Sweden.
- BSc in Environmental and Land Engineering at Polytechnic of Turin, Italy.
- She performed her high school studies mostly in Italy, studying for a full academic year in the USA.
- Aurora is fluent in Italian and English and has a good understanding of French.

Team member	Safa Rahim (ICF)
Role	**Support staff**

Experience overview:
Safa Rahim is a Junior Consultant in the Sustainable Finance and Climate Policy Team with over 4 years of work experience in interdisciplinary sectors relating to finance, trade, and sustainable development. She has gained experience by working in various international organisations including the United Nations, World Trade Organisation, and International Institute for Sustainable Development. Safa has successfully completed projects for private and public institutions including the World Bank, national and regional governments.

Specific relevant experience:

- Inventory of innovative financing instruments for climate change adaptation (Government of Canada, IDRC)
- Mobilising innovative finance for partners from the global south – Nepal, Peru and Kenya (Government of Canada, IDRC)
- Infrastructure tokenisation: Does blockchain have a role in financing infrastructure? (World Bank)
- Providing second-party opinions for various sustainable bonds and loans issued by both public and private entities (green, sustainability-linked, sustainability) (with CICERO Shades of Green)
- Evaluating the costs and benefits of nature-based solutions (UNIDO, GEF)
- Integrating gender considerations sustainable bonds: How-to-Guide (UK Government, ASEAN Low Carbon Emission Program)
- Integrating gender considerations in sustainability-linked bonds (UK Government, ASEAN Low Carbon Emission Program)
- Integrating gender considerations in green bond frameworks (UK Government, ASEAN Low Carbon Emission Program)
- Developing a social taxonomy for an Asian developing country (World Bank)
- 11th Development Tranche Project to implement best-practices in sustainability reporting and accounting in Africa and Latin America (United Nations Conference on Trade and Development)

Education and languages:

- Masters in International Affairs (Sustainable Finance and Trade) - Graduate Institute Geneva, Switzerland
  Bachelor of Arts (Honours) Political Science – University of Delhi, India
- English (C2), French (B1), Hindi (Native)

Team member	Philine Warnke (Fraunhofer ISI)
Role	**Support staff**

Experience overview:
Dr. Philine Warnke has been coordinating the Business Unit Futures Dialogs in the Competence Center Foresight at Fraunhofer ISI since 2014. After finishing her studies of mechanical engineering Philine Warnke completed her PhD within the interdisciplinary DFG postgraduate program "technology and society" at the University of Darmstadt in an STS (social science technology studies) framework in 2002. Since then, she has been active as a researcher with a focus on Foresight processes/futures dialogues, socio-technical change and innovation studies. As project and team leader at Fraunhofer ISI, the "Institute for Prospective Studies" of the European Commission (JRC-IPTS) in Sevilla, Spain, and the Austrian Institute of Technology AIT in Vienna, Austria, she designed and implemented a number of Foresight processes in support to decision makers in policy, society and industry in Europe and beyond. Through many contributions to conferences, seminars, guidebooks and journals, she contributed to advancing and sharing insights on Foresight theory and practice. From June 2019 to May 2020, Philine Warnke worked at the Federal Chancellery in Berlin, Germany in the department "Strategic Foresight and Policy Planning" to support the establishment of a Foresight unit within this department.

Specific relevant experience:
- Advisor Foresight, Federal Chancellery, Department Strategic Foresight and Political planning (Support to building up the Strategic Foresight Group, Development of Foresight based strategic policy documents, Horizon Scanning, Coordination of Foresight activities across ministries)
- RIBRI – Radical Innovation Breakthrough Inquirer, Horizon scanning for radical innovation breakthroughs
- Large number of horizon scanning and forecast projects

Education and languages:
- Dr. phil., Technische Universität, Darmstadt, Germany
- Master of Science in Engineering, Universität-Gesamthochschule, Essen, Germany
- Native German, English (C1/C2)

Team member	Jiao Jiao (Fraunhofer ISI)
Role	**Support staff**

Experience overview:
Jiao Jiao studied information security as bachelor program in China, which focuses on anomaly detection and data privacy protection, especially for sensor controlling. Before coming to Germany, she worked as big data platform validation engineer in Gemalto for navigation system communication and data analyst in Jones Lang LaSalle for real estate management consulting, which focuses on user behavior prediction and demand prediction. Afterwards, she studied media informatics, particularly in the field of data mining and machine learning, in RWTH Aachen University. In the meanwhile, she took the working student position from Philips Lighting GmbH for IoT big data platform development and analysis. Since November 2019, she works as data scientist at the Fraunhofer Institute for Systems and Innovation Research ISI in Karlsruhe in the Competence Center Energy Policy and Energy Markets.

Team member	Jiao Jiao (Fraunhofer ISI)

Specific relevant experience:
- Spatio-temporal textmining
- AI-based speech recognition application

Education and languages:
- M.Sc. Media Informatics, RWTH Aachen University, Germany
- B.Sc. Information Security, Beijing University of Technology, China
- Native Chinese, English (C1/C2)

Team member	Dóra Fazekas (CAMBRIDGE ECONOMETRICS)
Role	**Support staff**

Experience overview:
Dr Dora Fazekas heads up Cambridge Econometrics' Budapest office. She specialises in the application of economic analysis to inform policy-makers in the fields of climate, circular economy, energy and sustainable investment. She has over fifteen years' experience in successfully bridging academic research with policy-making. Recently, she has been focusing on the expansion of Cambridge Econometrics' reach to Eastern European countries.

Dora leads CE's contributions to official European policy impact assessments, environmental and socio-economic evaluations, and consultancy projects for international organisations. Dora has been involved in CE's consultancy projects for the European Commission's various DG's, she has been leading CE's input to several recent modelling projects, including the impact assessment of renewable and fossil fuel subsidies (DG Energy), the analysis of global megatrends (DG Energy), support to the Preparation of Territorial Just Transition Plans in Romania and the Czech Republic (DG Reform) assessing the Transition Process Towards Climate Neutrality.

Dora is also leading CE's sustainable investment work quantifying climate-related financial risks. Dora has vast experience with project implementation, presents technical results to non-technical audiences and writes clearly for scientific reports, as well as blogposts. Dora speaks five languages, has been a reviewer to academic journals and an expert panellist to various policy events.

Specific relevant experience:
- Decarbonizing energy intensive industries, German country study. European Trade Union Institute, 2021-2022
- Modelling the economic impact of climate transition and physical risks for CEE, 2021
- Eletcromobility in the Visegrad region, European Climate Foundation, 2021-2022
- Impact on Households of the Inclusion of Transport and Residential Buildings in the EU ETS by Polish Economic Institute, the European Roundtable on Climate Change and Sustainable Transition and Cambridge Econometrics, 2021
- Exploring the trade-offs in different paths to reduce transport and heating emissions in Europe, European Climate Foundation, 2021
- Green Economic Recovery White paper and Macroeconomic assessment of possible Green Recovery scenarios in Visegrad countries, 2021
- Employment Benefits of a Green COVID-19 Recovery C40, 2020
- Study on energy costs, taxes, subsidies and investments, DG Energy, 2019-2020

Team member	Dóra Fazekas (CAMBRIDGE ECONOMETRICS)

- Macroeconomic analysis of the impact of economic diversification policies on the energy and labour market, 2019
- New Climate Economy (NCE) 2018 Report - modelling the climate, economic and social impacts of opportunities for growth and climate action for The Global Commission on the Economy and Climate, 2017-2018
- Sim4Nexus www.sim4nexus.eu Developing innovative methodologies to facilitate the
- design of policies and bridge knowledge and technology gaps in the field of the water-land-food-energy Nexus under climate change conditions, 2017-2018

Education and languages:

- Ph.D. in Environmental Economics, Corvinus University of Budapest, Hungary; Fulbright Scholar, Columbia University, New York, NY; M.Sc. in Economics, Budapest University of Economic Sciences and Public Administration, Hungary
- Hungarian (mother tongue), English (C2), French (C2), Spanish (B1), and Italian (B1)

Team member	Carl Heinemann (CAMBRIDGE ECONOMETRICS)
Role	**Support staff**

Experience overview:

Carl Heinemann is a Project Manager at CE. Carl has more than 5 years of experience as an economist in UK Government and has a track record of successfully delivering analytical projects on a variety of topics, including fiscal policy, innovation and industrial development.

From 2018 to 2021, Carl served as an Economic Advisor in BEIS's Industrial Strategy, Science and Innovation group, as well as BEIS's Business Sectors group, where he led small teams of analysts. He has particular expertise in transport topics which he gained in his role advising BEIS ministers on investment incentives for large automotive industry projects, and in overseeing the assessment process for bids to the Government's Advanced Propulsion Centre competition (£75m p.a.) for low-carbon automotive technology, where he worked directly with the industry. Carl also has expertise in innovation policy, having been responsible for quantifying the impact of EU exit on research and innovation in the UK, and developing strategic analysis (such as country rankings and performance indicators) guiding the implementation of the UK's new International Research and Innovation Strategy.

From 2015 to 2018, Carl delivered a variety of analytical projects in fiscal policy at Her Majesty's Revenue and Customs, such as developing revenue forecasts and impact analysis for landmark changes to UK corporate tax law (Corporate Interest Restriction, taxation of international hybrid structures and hybrid financial instruments, taxation of non-resident corporate landlords). He also has experience in operational and financial analysis (financial model development for HMRC's CFO), as well as policy evaluation (in-house impact evaluation of changes to corporate tax headline rates, development of an evaluation strategy for HMRC's digital transformation). Carl has represented the UK Government at OECD (Centre for Tax Policy and Administration, WP2 on BEPS implementation and monitoring) and European Commission working groups (Horizon 2020 monitoring and evaluation, European Innovation Scoreboard).

Team member	Carl Heinemann (CAMBRIDGE ECONOMETRICS)

Specific relevant experience:

- Assignment / Project Title: Economic assessment of project proposals for Advanced Propulsion Centre innovation funding, Department for Business, Energy and Industrial Strategy (BEIS), 2021
- Assignment / Project Title: Economic assessment of Government incentive package for a large automotive investment project in the Northeast, BEIS, 2021
- Prioritisation framework for selecting countries for targeted engagement under the UK's International Research and Innovation Strategy, BEIS, 2021
- Forecasting UK liabilities under the Horizon 2020 guarantee (EU Exit) and analysis lead for Horizon 2020 'no-deal' contingency programme, BEIS, 2018-2019
- Economic analysis and quantification of fiscal impacts of tax policy, HMRC/ HM Treasury, 2016-2018
- Evaluation Strategy for HMRC's Digital Transformation Programme (SR15), HMRC, 2015-2016

Education and languages:

- MSc in Economics, University of Freiburg, Germany; BA in social sciences, University of Stuttgart, Germany and Sciences Po Bordeaux, France
- German (mother tongue), English (C2), French (C2), and Italian (B2)

Team member	Dr. Axel Michaelowa (Perspectives Climate Group)
Role	**Support staff**

Experience overview:

Axel Michaelowa has a PhD in Economics and has worked on international climate policy instruments and the UNFCCC process since 1994. He is research director at the research institute Perspectives Climate Research, senior founding partner of Perspectives Climate Group, and part-time researcher at the Institute of Political Science of the University of Zurich.

Axel consults private, governmental and public institutions and has written more than 400 research articles and studies on international market mechanisms for mitigation and climate policy on various levels. He has been participating in Conferences of the Parties to the UNFCCC since 1995. Axel has worked on 10 approved baseline methodologies and three approved SBs under the CDM and done capacity building in over 40 developing countries, ranging from Algeria to Yemen. Axel has supported the COP presidencies of Qatar and Mexico and various country delegations in UNFCCC negotiations. He has been involved in NDC work and NAMA development in Algeria, India, Morocco, Peru, Rwanda, Tanzania, Saudi Arabia, Tunisia, Uzbekistan, and Vietnam.

Currently, Axel supports Article 6 pilot work for the Swiss KLiK Foundation, Sweden and ADB.

Specific relevant experience:

- Lead author for the chapter on mitigation policies in the 4th and 5th Assessment Report of the IPCC
- Member of the Executive Committee of the Adaptation Benefits Mechanism (ABM) (since 2019)
- Member of the CDM Registration and Issuance Team of the CDM Executive Board (2006-2013)
- Member of the Board of the Climate Cent Foundation (2005-2009)

Team member	Dr. Axel Michaelowa (Perspectives Climate Group)

- Member of the International Research Council of the Decarbonization Chair at the University of Quebec in Montreal (since 2021)
- Member of the roster of experts of the UNFCCC Secretariat (since 2001)
- Member of Ministry of Economy, Trade, and Industry Study Group: Overcoming Obstacles to GHG Mitigation Projects in Asia, Japan (2006)
- Evaluation of project proposals for the 5th EU Framework Programme on behalf of the EU Commission (1999)
- Policy and ethics of CO2 removal (CDR-PoEt) (German Ministry of the Environment) (Research project, 2021-2024)
- Demonstration and upscaling of carbon dioxide management solutions for our net-zero future (DemoUpCARMA) (Swiss Federal Office for Energy) (Research project, 2021-2023)
- Negative emission technologies: readiness assessment, policy instrument design, options for governance and dialogue (NET-RAPIDO) (Swedish Energy Agency) (Research project, 2018-2021)
- Designing Effective Regulation for Carbon Markets at the International, National and Regional Level (Swiss Network for International Studies) (Research project, 2018-2020)
- Transformative increase of ambition – the contribution of effective climate policy instruments (German Ministry of Research) (Research project, 2017-2018)
- Mobilizing and transferring knowledge on post-2012 climate policy implications (POLIMP) (EU 7th Framework Programme) (Research project, 2013-2016)
- Development of methodological concepts for GHG removal and carbon capture and storage (CCS+ Initiative) (Consultancy, 2021-2023)
- Study on legal and political frameworks for removals under Article 6 (Swiss Federal Office for the Environment) (Consultancy, 2021)
- Definitions of climate neutrality (German Energy Agency) (Consultancy, 2019-2020)
- Development of a net zero emissions strategy (City of Zurich) (Consultancy, 2019-2020)
- Support of diplomatic outreach of EU on adaptation issues (EU Commission) (Consultancy, 2019-2020)

Education and languages:

- Diploma in Economics, University of Mannheim, Germany, PhD in Economics, University of Hamburg, Germany
- German (mother tongue), English (C2), French (C1/C2), Spanish (A1/A2), Italian (A1/A2)

Team member	Dr. Malte Winkler (Perspectives Climate Group)
Role	**Support staff**

Experience overview:

Malte is a consultant for international climate policy at Perspectives Climate Group and holds a PhD from the Kiel Institute of the World Economy and a M.Sc. in Environmental Sciences from the University of Koblenz-Landau. In his studies he covered a broad range of environmental topics, writing his Bachelor´s Thesis on the ecology of cold-water corals and his Master´s Thesis on technological aspects of wave energy converters.

In his doctoral thesis Malte examines the role of carbon pricing schemes and international cooperation in light of the Paris Agreement, using and developing a global Computable General Equilibrium (CGE) model. A special focus of Malte´s

Team member	Dr. Malte Winkler (Perspectives Climate Group)

work lies on the EU ETS. Malte has worked on scientific as well as on consultancy projects on carbon pricing, extending emission trading schemes, and land-use changes. He has collaborated with numerous international partners from academia, governments, and NGOs.

At Perspectives, Malte focuses on carbon markets and carbon dioxide removals, applying his economic understanding of climate policies, his interdisciplinary background, and his experience in economic modelling.

Specific relevant experience:

- Multiple academic publications focussing on climate policy, carbon pricing and carbon markets
- Policy and ethics of CO2 removal (CDR-PoEt) (German Ministry of the Environment) (Research project, 2021-2024)
- EMF 36: Carbon Pricing after Paris (CarPri) (Research project, 2018-ongoing)
- ETSPLUS – Konsistente Förderung erneuerbarer Energien durch eine Ausweitung des europäischen Emissionshandels (Consultancy, 2017-2018)

Education and languages:

- BSc and MSc Environmental Science, both University of Koblenz-Landau, Germany, PhD in Economics, Kiel Institute for the World Economy, Germany
- German (mother tongue), English (C2), Spanish (A2), Latvian (A1/A2)

Team member	Matthias Poralla (Perspectives Climate Group)
Role	**Support staff**

Experience overview:
Matthias Poralla holds a Master's degree in Political Science and a BA in Politics, Public Administration and Economics from the University of Potsdam. During his academic education he focussed on aspects of international environmental and climate governance, sustainability policies and issues evolving around geoengineering. Before joining Perspectives, he held various positions at Friedrich-Ebert-Stiftung (FES) and at Deutsches Klima-Konsortium (DKK).

At Perspectives, Matthias is part of both the carbon dioxide removal team as well as the team acting as the secretariat of the CCS+ initiative. He also works on matters related to climate engineering, climate neutrality and corresponding mitigation policy planning and supports policy studies for various organisations including the SEA, EDA, DENA, GIZ, GGGI or C2G.

Specific relevant experience:

- Support staff in the CCS+ Initiative (Secretariat and coordinating Carbon Consultant inputs to the MRV development work
- Experienced project manager and Research Associate on CDR topics
- Political Science Masters Degree
- Experience in the work of political foundations and climate change policy strategy development

Education and languages:

- Master's degree in Political Science from the University of Potsdam
- BA in Politics, Public Administration and Economics from the University of Potsdam
- German (mother tongue), English (C2)

Team member	Todd Allmendinger (Cleantech Group)
Role	**Support staff**

Experience overview:
Todd leads the Research and Consulting for Cleantech Group as well as being a co-founder of Enovation Partners, Cleantech Group's parent company. He advises clients on engaging innovation, market assessment, strategic options and implementation, with an emphasis on clean, sustainable, emerging technologies and business models. He has worked with a wide range of clients including large industrials, utilities, technology manufacturers, project developers, start-up companies, banks, private equity, venture capital, NGOs and regulatory organizations. Todd has extensive global experience developing and managing consulting projects across North America, Europe, South America, and Asia.

His current focus is on helping corporates and organizations develop and implement strategies for engaging innovation. This involves analysis of clients' goals, capabilities and boundaries as well evaluating market opportunities and specific innovation partners. He also works with organizations to build cleantech ecosystems

Specific relevant experience:
- Director of Research & Consulting, Cleantech Group (March 2017 – Present) – Build the research methodology and team; lead consulting development, delivery and build team
- Founding Partner, Enovation Partners (July 2013 – Present) – Advise energy companies and utilities on critical strategy, operations, regulatory and technology

Education and languages:
- Thunderbird School of Global management: Master's International Management, 1993-1994
- University of Vermont: BA in Political Science, 1981-1985
- Languages: Native English, Spanish (Proficiency), Mandarin (Low proficiency)

Team member	Richard Youngman (Cleantech Group)
Role	**Support staff**

Experience overview:
Richard is the CEO of Cleantech Group, the pioneering research, consulting and events company which has been catalyzing opportunities for sustainable growth powered by innovation since 2002. Richard has more than 20 years' experience researching cleantech innovation, venture capital markets, and start-ups across Europe and globally. He is a regular keynote speaker at major cleantech events and is the driving force behind the annual Global Cleantech 100, a list of the world's most promising private cleantech companies. Before Cleantech Group, he ran the Research team at Library House, which discovered and collected the information about high-growth companies that underpinned that company's data, analytical, and event services. This followed nine years building a broad-based financial foundation to his career.

Specific relevant experience:
- CEO, Cleantech Group (Jan 2016 – Present) - Responsible for global activities and operations.

Team member	Richard Youngman (Cleantech Group)
■ Managing Director, Europe & Asia, Cleantech Group (April 2008 – Sept 2015) - drove the growth of Cleantech Group's activities outside North America, especially in Europe and Asia.	
Education and languages: ■ Theseus International Management Institute (now part of EDHEC): MBA, 2000-01 ■ University of Cambridge: BA in History, 1988-1991	

3.1.3.5 Pool of high-level external experts

We have compiled a pool of 50+ external experts to provide input at multiple points in the course of the study. The coverage in expertise is presented in Figure 2.1. Detailed CVs of the proposed experts are included in Annex 3.2.

3.1.3.6 Summary of technical skills and language skills

All team members have a working level of English (C1 level and the team collectively covers the two other EU official languages with 8 French, and 5 German team members being native speakers. Table 3.2 (overleaf) summarises the technical competence of the team, demonstrating how the 24 team members meet the technical, transversal and methodological requirements for this project. The table also illustrates how the team covers all the relevant language competence.

Table 3.2 Summary of team's technical and language expertise

Staff Name	Staff Category	Climate mitigation areas								Transversal considerations for the solutions / topics listed above				Methodological considerations								Languages (B2 level +)
		Energy	Transport	Industry	Built environment/	Bio-economy & bio-based materials	Carbon removal	General purpose disruptive technologies	Non-technological innovations	International cooperation	Current capacity needs of the European innovation ecosystem	Implications of the shift towards these solutions	Existing EU initiatives and financing	Foresight	Horizon scanning	Mitigation potential	Socio-economic & environmental	Techno-economic-social feasibility	Technology maturity assessment	Literature review	Stakeholder consultation	
Project management																						
Jerome Kisielewicz (ICF)	Cat II	✓	✓	✓	✓		✓						✓			✓	✓		✓	✓	✓	English, French (N)
Wolfgang Eichhammer (Fh ISI)	Cat I	✓	✓	✓	✓	✓	✓	✓	✓					✓		✓			✓		✓	German (N), English, French, Spanish
Jonathan Lonsdale (ICF)	Cat I	✓	✓	✓	✓	✓	✓				✓	✓	✓				✓	✓	✓		✓	English (N)
Task Leads																						
Ralitsa Donkova (ICF)	Cat II								✓				✓				✓			✓	✓	English, Bulgarian (N)
Irina Dobre (ICF)	Cat II	✓			✓			✓	✓				✓							✓	✓	English, Romanian

Staff Name		Climate mitigation areas								Transversal considerations for the solutions / topics listed above				Methodological considerations								
	Staff Category	Energy	Transport	Industry	Built environment/	Bio-economy & bio-based materials	Carbon removal	General purpose disruptive technologies	Non-technological innovations	International cooperation	Current capacity needs of the European innovation ecosystem	Implications of the shift towards these solutions	Existing EU initiatives and financing	Foresight	Horizon scanning	Mitigation potential	Socio-economic & environmental	Techno-economic-social feasibility	Technology maturity assessment	Literature review	Stakeholder consultation	Languages (B2 level +)
Jakob Wachsmuth (Fh ISI)	Cat II	✓		✓			✓		✓	✓			✓			✓			✓	✓	✓	German (N), English
Matthias Honegger (PCG)		✓		✓	✓	✓	✓			✓						✓	✓	✓	✓		✓	English, German, French
Heike Brugger (Fh ISI)	Cat II	✓		✓		✓	✓	✓	✓							✓	✓	✓			✓	German (N), English
Arianna Griffa (ICF)	Cat II	✓	✓	✓	✓				✓	✓		✓								✓	✓	English, Italian
Support staff																						
Safa Rahim (ICF)	Cat III	✓			✓		✓	✓	✓	✓		✓	✓		✓	✓	✓	✓		✓	✓	English, Hindi
Aurora Audino (ICF)	Cat III	✓	✓	✓					✓			✓	✓				✓			✓	✓	English, Italian (N)
Philine Warnke (Fh ISI)	Cat II	✓		✓				✓	✓		✓			✓	✓					✓	✓	German (N), English

Staff Name	Staff Category	Climate mitigation areas								Transversal considerations for the solutions / topics listed above				Methodological considerations								Languages (B2 level +)
		Energy	Transport	Industry	Built environment/	Bio-economy & bio-based materials	Carbon removal	General purpose disruptive technologies	Non-technological innovations	International cooperation	Current capacity needs of the European innovation ecosystem	Implications of the shift towards these solutions	Existing EU initiatives and financing	Foresight	Horizon scanning	Mitigation potential	Socio-economic & environmental	Techno-economic-social feasibility	Technology maturity assessment	Literature review	Stakeholder consultation	
Jiao Jiao (Fh ISI)	Cat III	✓			✓			✓							✓					✓		Chinese (N), English
Malte Winkler (PCG)	Cat I	✓					✓			✓			✓				✓	✓		✓		English, German
Axel Michaelowa (PCG)	Cat I	✓	✓	✓	✓	✓	✓			✓		✓	✓			✓	✓	✓	✓	✓	✓	English, German, French
Matthias Poralla (PCG)	Cat II	✓		✓			✓		✓	✓			✓					✓		✓	✓	English, German
Todd Allmendinger (CTG)	Cat I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	English, Spanish
Dora Fazekas (CE)	Cat I	✓	✓	✓	✓		✓		✓			✓	✓			✓	✓	✓		✓	✓	Hungarian, English, French, Spanish, Italian

Staff Name		Climate mitigation areas								Transversal considerations for the solutions / topics listed above				Methodological considerations								
	Staff Category	Energy	Transport	Industry	Built environment/	Bio-economy & bio-based materials	Carbon removal	General purpose disruptive technologies	Non-technological innovations	International cooperation	Current capacity needs of the European innovation ecosystem	Implications of the shift towards these solutions	Existing EU initiatives and financing	Foresight	Horizon scanning	Mitigation potential	Socio-economic & environmental	Techno-economic-social feasibility	Technology maturity assessment	Literature review	Stakeholder consultation	Languages (B2 level +)
Carl Heinemann (CE)	Cat II		✓						✓			✓				✓	✓	✓		✓	✓	German, English, French, Italian

3.2 Allocation of time and resources

3.2.1 Workplan

The team has allocated the necessary resources to ensure that support can be provided to DG RTD as required throughout the project duration. To ensure that the timeline and expectations of DG RTD are met, the ICF team will use its robust project planning approach which includes the following key elements:

- The Project Manager will schedule a project kick-off meeting, as described in the first task of the methodology (Task 0). The team will align and agree on the methodology and work plan during the meeting. Following the meeting, the detailed work plans (a preliminary version is included in this proposal) will be finalised.
- Detailed work instructions will specify the work to be undertaken by each team member, including a clear timeline. These can be provided to DG RTD, if requested. These instructions will be communicated and discussed via internal briefing meetings.
- Project progress will be closely monitored internally through **monthly progress calls with the DG RTD project officer(s), attended by key task leads and additional team members as appropriate**. The calls will discuss progress against the work plan and budget, and any issues arising, leading to a documented note of key points and actions.
- The team will attend **at least 3 project progress meetings with the Commission via video or audio conferences**: the kick-off meeting, the interim meeting and the final meeting for a presentation of the draft final report to DG RTD.
- The Project Manager will submit documents preparing the meetings, including the presentations that will be **sent at least 3 working days in advance to the Commission**. The Project Manager will prepare the brief agenda for each meeting and provide short minutes via email after each meeting or teleconference capturing the main issues discussed and outlining next steps.
- The team will deliver **online workshops and conferences for experts and stakeholders, including the foresight dialogues**.
- The team will deliver a **presentation of the final report** at a dedicated dissemination event.

The preliminary work plan is presented in the table below. This will be discussed at the kick-off meeting and a revised version will be issued as part of the inception report.

DG RTD will benefit from working with a team that understands the importance of meeting strict timelines. We are confident in meeting the deadlines for this project with the flexibility to respond to all of DG RTD's questions over the course of the project.

Table 3.3 The project plan provides deliverables in line with the schedule outlined in the Service Request

Tasks / Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Task 0: Inception														
Task 0.1 - Mobilisation of the team														
Task 0.2 - Kick-off meeting	M													
Task 0.3 - Validate the list of experts														
Task 0.3 - Inception report and meeting		M												
Task 1. Identification and selection of key R&I areas														
Task 1.1 - Literature review & Scenario analysis														
Task 1.2 - Horizon scanning and participatory foresight dialogues														
Task 1.3 - Evaluation framework for the selection of key R&I intervention areas														
Task 1.4 - Literature review report														
Task 2: Expert and stakeholder consultation														
Task 2.1 - Expert consultation to collect input on the study questions														
Task 2.2 - Expert conference (online) to validate findings and recommendations														
Task 2.3 - Stakeholder consultation to discuss recommendations and R&I direction of travel														
Task 3: In-depth analysis of 10-15 R&I intervention areas														
Task 3.1 - Common methodology for the in-depth analysis of 10-15 R&I intervention areas														
Task 3.2 - Analysis of key R&I intervention areas														
Task 4: In-depth analysis of carbon dioxide removal approaches R&I intervention areas														
Task 4.1 - Input to Task 1														
Task 4.2 - Input to Task 2														
Task 4.3 - Input to interim and final reports														
Task 5: In-depth analysis of disruptive general-purpose technologies														
Task 5.1 - Input to Task 1														
Task 5.2 - Input to Task 2														
Task 5.3 - Input to interim and final reports														
Task 6: International cooperation on key R&I intervention areas														
Task 6.1 - Input to Task 1														
Task 6.2 - Input to Task 2														
Task 6.3 - Input to interim and final reports														
Key deliverables														

Tasks / Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Draft Inception report	▲													
Final Inception report		▲												
Literature review report				▲										
Interim Report								▲						
Expert conference									M					
Stakeholder consultation									▲					
Draft Final Report											▲			
Final Report												▲		
Presentation of final report at dissemination event														M

Key ▲ Reports M Key meeting/ workshop

Key output Key time on tasks

3.2.2 Time and resource allocation

DG RTD will benefit from a diverse and expert team to meet the expectations in terms of quality and efforts from Day One on and to accommodate required changes during the period of the 14 months of the project. **ICF will ensure we have adequate staff in response to quick turnaround needs and planned surges**.

ICF's extensive resources and effective management can absorb staffing variances, providing DG RTD with the flexibility to expand or decrease required services as necessary and assurance that project deliverables will be on time and to high quality. **This is critical to ensure we can adequately respond to the questions / requests that emerge over the course of the project.** We foresee no circumstance that would jeopardise our ability to complete this assignment to the highest standards. We have proposed experienced team members, all with significant expertise in the areas required to successfully complete this project. All have sufficient uncommitted time to meet the contract requirements.

The apportionment of time across the team is based on our current understanding of the Commission's requirements and priorities. Based on actual requirements and priorities, which will be discussed at the kick-off meeting, we can adjust the balance of resources across our team if necessary, re-assigning time to individuals and companies within the team if that would provide greater added value to the Commission. We have a large enough team with the depth of expertise to be flexible enough and can provide rapid responses to ad-hoc questions that we anticipate over the course of the project.

Table 3.4 shows days per person per task for all resources proposed. We have proposed **448.5 team days** for the successful delivery of this project, with the necessary senior oversight and direction and technical support.

- 13% of this time has been allocated to senior experts (i.e., category I staff members: staff with over 15 years of professional experience) and 53% to experts (i.e., category II staff members: staff with between 5 and 10 years of professional experience).
- Approximately 17% of our effort is targeted to Task 1, 25% for Task 2, 17% to Task 3, 11% to Task 4, 12% to Task 5, and 9% to Task 6.
- The rest of the allocated days are reserved for project inception, project management, and report preparation. This will ensure the team has enough resources to fully respond to DG RTD's needs over the course of the project.

Table 3.4 Global allocation of time and resources for the project

	Cat I	Cat II	Cat III	Total Days
Task 0 - Inception	6.25	16.25	3.00	25.50
Task 1 – Identification and selection of key R&I areas	12.25	31.75	30.00	74.00
Task 2 – Expert and stakeholder consultation	18.00	57.50	37.50	113.00
Task 3 – In-depth analysis of 10-15 R&I intervention areas	9.00	35.00	30.50	74.50
Task 4 – In-depth analysis of carbon dioxide removal approaches R&I intervention areas	8.25	25.50	17.50	51.25
Task 5 – In-depth analysis of disruptive general-purpose technologies	5.25	26.50	22.00	53.75

	Cat I	Cat II	Cat III	Total Days
Task 6 – International cooperation on key R&I intervention areas	0.50	30.00	10.00	40.50
Project management	-	16.00	-	16.00
Total number of days	**59.5**	**238.5**	**150.5**	**448.5**

Taking on board feedback from previous European Commission assignments, we are implementing a "best in front" staffing approach in which we assign tasks to the best-qualified individuals, regardless of corporate affiliation.

3.2.3 Rationale for allocation of time

Our approach to resourcing this project builds on prior experience in supporting related studies on this topic. Consequently, our team is built around a group of core experts with considerable experience in climate mitigation and innovation technologies, and across different topic areas.

The global allocation of time for this assignment has been developed by a bottom-up estimate of the time and resource required for the delivery of each sub-task. Further detail on the rationale for the time allocation for each main sub-task is provided in the table below.

Table 3.5 Summary of the rationale for each task

	Rationale
Task 0	Represents 5.7% of the man-days, which is deemed sufficient as it will be a short inception phase and a lot of the methodologies are already detailed in this proposal, allowing a smooth start.
Task 1	Represents 16.5% of the man-days as this is a key building block of the project. This task includes not only the literature review but also the horizon scanning, stakeholder survey, foresight dialogues and the design and deployment of the evaluation framework to identify the most promising high-risk high-impact solutions.
Task 2	Represents 25.2% of the man-days as the stakeholder engagement is at the core of this project. The key added value of the project will be to successfully gather insights from stakeholders that are not typically involved in these types of studies. This will form the backbone for the deployment of task 3, 4, 5 and 6.
Task 3	Represents 16.6% of the man-days as it is the largest thematic task with a broad scope.
Task 4	Represents 11.4% of the man-days.
Task 5	Represents 12% of the man-days.
Task 6	Represents 9% of the man-days.

4 Quality control measures

4.1 Introduction

A robust quality management system and a team of experienced professionals ensure that quality is built into all phases of the project, from the use of research tools to the production of outputs and deliverables, so that:

- Outputs and deliverables meet DG RTD's expectations in terms of objectives and quality, including being drafted in clear, plain English whilst avoiding mistakes; and,
- Delays or failure to deliver the agreed tasks are avoided.

We intend to use the same quality management system as in our previous projects for other European Commission services. For all our previous projects, our quality management system proved its flexibility and robustness by addressing all the key challenges that we can expect under this project:

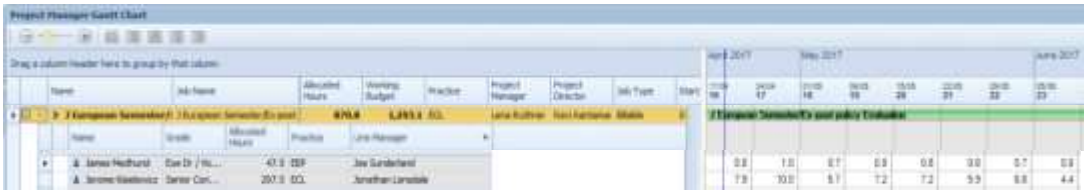
- Accommodating changes in project scope due to stakeholders' feedback and potential change in the political agenda;
- Delivering all required outputs on schedule as many of them will be crucial in the development of the R&I agenda towards long-term carbon neutrality; and
- Ensuring the development of reporting methods and supporting material at the expected quality levels (despite any disruptions that may have been caused by external events, such as potential further new waves of COVID-19).

4.1.1 Our reputation for delivery quality products in backed by certified quality management systems

The systematic approach that we propose for delivering quality products under this contract is secured by an ISO9001:2015 certified quality management system. This system includes stringent data protection mechanisms and well-established procedures for data validation, and it is reinforced by our ISO14001-compliant process for managing environmental issues.

Furthermore, DG RTD will benefit from the use of ICF's internal project management tools that facilitate forecasting of the team's capacity as well as budget usage. Some of the tools that will be used in this contract are:

- **People Planner and Maconomy** enable resources and projects to be managed most effectively. These two tools provide project managers (PMs) with a more accurate picture of the expected allocation of the staff during the project, available capacity and historical labour allocation to each task.



- **Project Tracker** is a proprietary system for PMs to alert senior management at ICF to issues and risks by giving key performance indicators a “traffic light rating”. ICF senior management then arrange suitable timely support to resolve problems and thus ensure the successful completion of the project.

- **iThenticate** is a plagiarism testing tool that checks our draft reports against a database in order to identify inadequate referencing and graphics unattributed to their original source.

Using these tools and continually monitoring the risks to quality will ensure that all the risks are promptly mitigated and that the project meets DG RTD’s standards.

4.2 Identifying risk which compromise the quality of the project

The success of each task of the project is dependent on the quality of previous task

4.2.1 Definition of the quality criteria

We have assessed risks to **nine key quality criteria**, in a **tailored assessment grid** (Table 4.2). Our focus is on ensuring that we maintain agreed standards of quality across each of the project tasks, resulting in a comprehensive approach to delivering high-quality outputs and deliverables, from the inception report to the final report via the outputs and deliverables of all six tasks.

1. Relevance to meeting the study needs. *Do the outcomes respond to the needs of all the project stakeholders, and are they in line with the terms of reference?* This will require the team to gain from the outset a clear understanding of the scope and level of detail of expected methods and supporting material precisely.

2. Appropriate design of methodology. *Is the methodology adequately designed for obtaining the results needed to answer the project objectives (i.e., to put strategic foresight at the heart of EU policymaking)?* This criterion requires us to design the methodology to identify relevant references (particularly by means of Task 1 and Task 2) and sources (both people – such as experts and stakeholders, as well as information – gathered through Tasks 3-6) and to obtain good-quality inputs and data from them.

Quality of results is not only contingent on robust inputs but also on the successful collection and understanding of stakeholders' feedback.

3. Reliable sources and data. *Are the sources and data collected adequate for their intended use and has their reliability been ascertained?* In short, have sources and data been gathered of dependable quality and in sufficient quantity?

4. Sound analysis. *Are inputs systematically analysed to answer the four study questions and objectives for the project and cover other information needs in a valid manner?* In particular, are inputs (experts or stakeholders' comments alike) used within their limitations?

Quality in reporting is contingent not only on the robustness of the analysis, but also on the capacity to identify the relevant findings and to determine salient recommendations

5. Credible findings. *Do the findings (i.e., high-risk and high-impact areas and recommendations) follow logically from, and are they justified by, the analysis deriving from the data collection and consultation exercise and are and interpretations based on pre-established criteria and rationale?* The findings will require both validation with all experts involved in the study, and then with the Steering Group. The role of the QA team will be to challenge findings and reinforce their robustness.

6. Valid conclusions. *Are conclusions non-biased and fully based on evidence from findings?* See above.

7. Helpful recommendations. *Are areas needing improvements identified in coherence with the conclusions? Are the suggested high-risk and high-impact areas and policy options realistic and impartial?* See above.

8. Robustness and clarity of deliverables. *Are the literature and final reports well structured, balanced and written in an understandable manner?* The ICF team will review deliverables, and summaries of deliverables, to ensure that they are complete, accurate, and clear. This includes the inputs from experts (survey answers, questionnaires, interview notes, workshop and conference proceedings etc) as well as reports and the PowerPoint presentation of the final report.

9. Adequate organisation of work and of resources. *Are the roles and responsibilities of the team clear? Can the Project Manager handle a sudden loss of team members or eventual delays? Are the resources proposed sufficient to carry out the tasks within the timeframe? Will the proposed communication be sufficient and its means appropriate?*

4.2.2 Management actions to ensure quality

For all six tasks, we propose to review the key outputs and reports against the key quality criteria. This will ensure both readability and delivery to agreed standards of quality across main phases of the methodology, resulting in a comprehensive approach to delivering a high-quality draft and final reports within this overall quality framework.

The quality review will be performed by Jonathan Lonsdale, a native English speaker, acting in a capacity as Project Director - QA. Jonathan will apply a judgement / rating scale comprising of five elements to each of the phases of the methodology, as set out below:

- Unacceptable
- Poor
- Satisfactory
- Good
- Excellent

Feedback will then be provided to the team (both task leads and paid external reviewers), and remedial action taken promptly by the team, to ensure that any

scores below the scale rated 'Good' are addressed before progression to the next stage. For ad-hoc outputs requested by DG RTD at short notice – for example, emails, memos, or notes – there might not be time to use the quality review process described above. In such instances, we will make sure that only the Project Manager, Task Leads or, *in extremis*, other senior team members issue such outputs to DG RTD.

4.2.3 Availability of resources and independence of the project team members

The extensiveness of ICF's staff, its partners and of experts deployed in this study, in combination with the robustness of our approach for risk management, will ensure that any staffing challenges that might arise (e.g., through illness, resignations or lack of commitment from high-level experts) would be resolved easily. Such challenges could be resolved through substitution from existing staff, while providing DG RTD with the assurance that project outputs will be delivered on time and to high quality, with the flexibility to expand or decrease required services as necessary. We foresee no circumstance that would prevent us from completing this assignment to DG RTD's standards. We have proposed experienced team members, all with enough uncommitted time to meet the contract requirements.

The apportionment of time across the team is based on our current understanding of DG RTD's requirements and priorities and can be adjusted based on considerations from the client during the inception phase.

As shown in Section 3 (Organisation of work), many of the team members cover a broad range of knowledge areas relevant to this study (as highlighted in Annex 1 Project Experience). This gives us flexibility to substitute staff in key roles with other team members if necessary (e.g. in the case of sickness). For key roles, back-up staff are presented in Table 4.1 below.

Table 4.1 Back-up staff for key roles

Project role	Assigned staff member	Back-up staff
Project Manager	Jerome Kisielewicz (ICF)	Thibaud Lemercier (ICF)
Project Director - Technical	Wolfgang Eichhammer (FhISI)	Frank Sensfuss (FhISI)
Project Director - QA	Jonathan Lonsdale (ICF)	Mark Allington (ICF)
Task 1 Lead	Ralitsa Donkova (ICF)	Thibaud Lemercier (ICF)
Task 2 Lead	Irina Dobre (ICF)	Ralitsa Donkova (ICF)
Task 3 Lead	Jakob Wachsmuth (FhISI)	Johannes Eckstein (FhISI)
Task 4 Lead	Matthias Honegger (Perspectives)	Axel Michaelowa (Perspectives)
Task 5 Lead	Heike Brugger (FhISI)	Frank Sensfuss (FhISI)
Task 6 Lead	Arianna Griffa (ICF)	Laurent Petithuguenin (ICF)

We have checked with our core team of experts that they are independent and free from conflicts of interest in the responsibilities accorded to them.

4.2.4 Data collection and expert and stakeholder engagement

Information and data will be collected during Tasks 1 and 2 (literature review and expert and stakeholder consultations) and will be the basis for Tasks 3 to 6, where study questions will be explored in more depth to shape the research and innovation agenda towards reaching the 2050 climate neutrality goal. Those inputs play a key role for the quality and success of the study results.

It is critical that data gathered during the literature review are identified from **credible, reliable sources** and are then collated and **referenced suitably**. The Project Manager will be responsible for implementing procedures to review, validate, and assess the usability of inputs and data collected during Tasks 1 and 2 and prior to analysis. The ICF team will assess data in accordance with the client's direction and requirements and will document the results. The results of data quality assessments, including any identified limitations of the data, will be documented in reports and other work products in which the data are presented or used.

Data quality checks will include:

- A review of the quality of the original source, including its data collection approach, calculation approach, representativeness, transparency, extent of quality/peer review.
- Several completeness, robustness and plausibility checks, such as outlier corrections and comparison (whenever possible) to other publicly available data bases.

Originators of inputs and data will be responsible for documenting their quality. The ICF team will ensure that all information generated or used for the study are "of the type and quality needed and expected for their intended use." Each team member who participates in the processing, reduction, or conversion of the inputs and data has the responsibility to understand the limitations of the inputs and data and not to misuse them, to twist them from their original purpose, or stretch them beyond their applicability. Secondary data use must have data quality that is documented or that is established by indicators (such as precision, accuracy, representativeness, comparability, completeness, and sensitivity) and other data acquisition elements (including objectivity, utility, and integrity). The criteria used to review and validate—that is, accept, reject, or qualify—data will be described in an objective and consistent manner. All data quality limitations need to be documented in the resulting work products.

Expert and stakeholders alike have a central role to play in this project as their inputs will be critical to answer the four study questions and validate policy recommendations and conclusions. The ICF team has therefore already paid specific attention to the selection of relevant experts, ensuring professional diversity (e.g. technology leaders, innovators, investors and academics) with a level of experience able to ensure their views and inputs can shape the research and innovation agenda towards reaching the 2050 climate neutrality goal. The expert and stakeholders list, as well as the broader engagement process will be discussed and validated with DG RTD in the inception phase.

4.2.5 Deliverables

Completeness and accuracy of outputs generated, and deliverables submitted, by the ICF Team are paramount in this contract. All members of the ICF Team are responsible for conducting their work, generating outputs, and preparing deliverables in accordance with the quality requirements established for this project.

The Project Manager is responsible for ensuring that all ICF Team members (whether drawn from own staff or from subcontractors, including the high-level experts who are remunerated for their work) are informed of the quality requirements and that deliverables are reviewed for compliance with these requirements – and approved – prior to delivery to the DG RTD.

For the reports (literature report as well as inception, interim, final reports) produced for the purpose of answering the study questions, we will adopt a standard approach to deliverable preparation, which includes the following steps:

- **Outline** of the deliverable is prepared by the Task Lead, in line with the contents agreed with DG RTD;
- Report planning meeting (involving relevant staff / prospective authors] to discuss structure, issues, allocation of content;
- Content authors **prepare first internal draft** of deliverable;
- Task Lead **reviews first internal draft** for technical issues and English language;
- Content authors **prepare second internal draft** in line with Task Lead's review;
- Project Director **reviews second draft** for technical issues and English language;
- If necessary, **content authors revise internal draft** in line with PD's review;
- Project Director and QA (native English speaker) **reviews third internal draft** for technical issues and English language;
- If necessary, **content authors revise internal draft** in line with the review of Project Director and QA; and,
- Project Manager submits the draft deliverable to DG RTD.

Reviews will be conducted in a manner that is consistent with and aligned to the quality criteria need for this study.

Review of deliverables for English language will be a core element of the overall process for review of deliverables. Jonathan Lonsdale is a native English speaker and will take on the role of Project Director – QA, reviewing each final deliverable. He has previously performed a similar task for previous DG RTD projects. Together with Wolfgang Eichhammer who will be the Technical Project Director and Jerome Kisielewicz who will act as overall Project Manager, Jonathan will provide final 'gateway' checks on the spelling, punctuation, grammar, and overall quality of English in the reports.

4.2.6 Confidentiality and GDPR

ICF are committed to full compliance with the General Data Protection Regulation (GDPR). We recognise that the collection and processing of any personal data comes with significant responsibilities. Our policies and procedures ensure that the privacy and security of personal data are safeguarded.

When expert interviews will be conducted, ICF will ensure we request and receive verifiable, affirmative consent from the data subjects. This consent will be requested in a clear manner, and as easy to withdraw as it is to give. Any resulting data will be stored securely, and the details of any who do not consent to participate will be deleted from the contacts list.

Project data is stored on ICF central servers within a Brussels-based data centre. The data centre provider is ISO 27001 and ISO 9001 accredited. Security personnel are based onsite 24x7 to ensure no unauthorised access to the facility. Visitors are required to pre-book and photo-id is required for entry of all personnel.

As standard, all ICF data is backed-up once a day both on premises and to an alternate secure data centre. The data is explicitly tied to the data centre location and no transfers outside of the EU can/ will occur.

Access to project folders is restricted to a need-to-know basis and additionally encrypted at the file level using public key cryptographic processes (utilising Symantec Encryption Desktop). Our primary servers are audited for access and change events.

All staff are issued with laptops as their primary work device. These laptops are deployed with centrally managed full disk encryption (Microsoft BitLocker) and without administrative rights for the primary user. These devices are tied to the corporate network, requiring valid credentials to access and use. Use of removable media is allowed and training is provided to all staff on their correct usage.

Any documents transferred via **email are encrypted** using industry standard software. Files including sensitive information and personal data are transferred using **a web-based secure transfer service hosted on ICF infrastructure**.

4.2.7 Risk Management

ICF has established a systematic process to manage risk, overseen by the Project Manager. Relevant risks will be added to the Study Risk Register (Table 4.2) – a "Live" document, updated regularly as needed, used to discuss with DG RTD the likelihood, impact, severity, and appropriate mitigation strategies to meet study goals with minimal disruption. Discussion will cover the quality criteria (Section 4.2.1) and associated risks to client reputation, quality, schedule, and resources. For each risk, a risk owner will be assigned who will have appropriate authority to deal effectively with the impacts if mitigation methods fail. The Project Manager will track all risks, investigating without delay and overseeing actions from risk identification to resolution.

Figure 4.1 Managing risks on a rolling basis, identifying key decision points

The following risks for the project have been identified, using key criteria under ICF's quality control systems. These risks along with the likelihood and severity of the impacts, classified as "low" (green), "medium" (amber) and "high" (red), are presented in Table 4.2. Our approach to ensure that any issues rated "medium" or "high" are properly mitigated before progression to the next stage, is also described in the table.

The Project Manager will monitor the identified risks throughout the project to anticipate circumstances where their likelihood or severity increased. Other imminent risks that have not been previously mapped will be included in the risk management plan and mitigation actions will be suggested.

Table 4.2 Potential risks to project quality and proposed actions to mitigate them

Risk	Likelihood (High/Med/ Low)	Severity (High/Med/ Low)	Mitigation measures
1. Relevance to meeting the study needs			
Lack of clarity on the scope and focus of the analysis to be provided under the contract	Low	High	■ This is a risk that can arise at different moments in the project, but that can be mitigated during the Inception phase of the project by ensuring a clear and common understanding of the project objective between the Commission, the project team and high-level experts acting as subcontractors to the study. Therefore, during the kick-off meeting with DG RTD, we will ensure we agree on the detailed approach (both methodology and tools employed) and outputs for each task, including the contents of all key deliverables.
Outputs do not meet European Commission's needs	Low	High	■ The team will update the proposed methodology and outputs in line with each of the objectives set out (or revised) by DG RTD at the kick-off meeting. The Project Manager, Project Director and Project Director & QA will continue to verify the alignment of methodology and outputs throughout all tasks with DG RTD particularly so during progress meetings.
Conflicting views between experts' findings and those of stakeholders	Low	Med	■ These different groups might have different views on the project and the expected outcomes. As such, having the stakeholder workshop organised around the same time as the online expert conference should be able to accommodate different views in the process of validating the conclusions and policy recommendations. In other words, our approach will maximise the chances of securing buy-in from stakeholders.
2. Appropriate design of methodology			
Experts and Task Leads do not achieve effective exchange of information.	Low	High	■ The success of the project will depend on an effective engagement with various experts (including the 50+ high-level experts) to inform the different deliverables and ensure they are able to answer the four study questions. We are confident that based on our engagement strategy and the different information exchange tools we have at hand, we will manage this process very effectively. Given the level of interest of experts in the policy development linked to R&I activities for climate neutrality, we also expect very substantial engagement and interest particularly from stakeholders.
Uncertainty regarding future technologies and non-technological solutions alters scoring	Low	Med	■ Scoring will be only as granular as makes sense, given the prevailing level of uncertainty. Scores will be based on evidence, literature, and input from experts. Scores will be sense-checked relative to the scores given to other technologies and non-technological solutions.
Weighting scores (Task 1.3) reduces transparency	Low	Med	■ Weighting will only be used where there is clear justification for doing so, it is clearly explained, and there is sufficient information to inform weighting.

Risk	Likelihood (High/Med/ Low)	Severity (High/Med/ Low)	Mitigation measures
Deadlines cannot be met	Low	Med	■ We understand that DG RTD has high expectations for the outcomes of this project and that the policy development timeline is very tight. The team will draw up a detailed schedule for all work steps. At the beginning of the project, this schedule is refined and coordinated with DG RTD. The Project Manager, Jerome Kisielewicz, will closely monitor progress and report back to DG RTD in case of any challenges where action could be taken. A proactive approach will maximise the chances that each work step is completed within the allotted time and with the expected quality. ■ ICF has built up a track record and reputation for timely delivery of complex studies for the Commission. Recent, high profile successes for ICF include the successful launch of the Innovation Fund in July 2020, despite the onset of COVID-19 pandemic. This was an achievement made possible only by the expertise of ICF and Fraunhofer ISI in producing on time the necessary methodologies and guidance underpinning the overall competition. We also completed a 16-month contract in December 2021 for DG REFORM, on schedule, despite the challenges of remote working throughout, providing Italy with a Sustainable Finance Action Plan and a Sovereign Green Bond Framework that in total has enabled Italy to raise EUR 13 billion from the market during 2021.
3. Reliable sources and data			
Some of the high-level experts fail to participate in the study	Med	High	■ Strong engagement from the initial phases will ensure experts remain engaged and committed throughout the whole study. We recognise, however, that it is not unlikely that some of the expert can drop out and become unresponsive at any stage of the study. We will ensure that a back-up list is kept and alternative candidates with similar expertise are swiftly brough on board.
4. Sound analysis			
The study does not bring to light the breakthrough / transformative low / zero carbon solutions towards climate neutrality	Low	High	■ The study team has developed a strong methodology made up of four sub-tasks for the purpose of identifying and selecting key R&I intervention areas (Task 1) and has selected world-class experts with excellent professional experience in cutting edge of R&I areas (Task 2). The approach will be complemented by a strong core team working on Tasks 3-6, all in all ensuring the study will bring to light the next generation disruptive technologies and non-technological solutions.
Conclusions and policy recommendations are disputed by stakeholders	Low	Med	■ The study team has developed a strong methodology to involve expert from within and outside the study team in the delivery or project outputs which ensures high-quality delivery underpinned by robust factual (and hard to dispute) data.

Risk	Likelihood (High/Med/ Low)	Severity (High/Med/ Low)	Mitigation measures
The 95% response rate to expert survey and interviews under is not achieved (Task 2)	Low	High	■ The study team will draw on the long list of experts (over 160 developed at the proposal stage) and contact additional high-level experts and stakeholders to ensure surveys, interviews and questionnaires employed in the study deliver an almost 100% response rate.
Disagreement over the interpretation of findings or lack of credibility of results.	Low	High	■ The research and analysis carried out in all Tasks will be fully documented and so contain the references to the original sources which provided the information that the findings were built upon. The Project Manager and QA Directors will, with the relevant Task Leads, critically assess the gathered data for robustness and the analysis for accuracy and comprehensiveness. They will then turn to the conclusions drawn on the findings developed. The long experience of Wolgang Eichhammer and Jonathan Lonsdale as Study Directors for the Commission will be of great importance here, not least in understanding DG RTD's needs for this study and how it relates to wider Commission policy needs. We will work collaboratively with DG RTD to proactively address any differences in the interpretation of the findings.
Conclusions are not coherent with the findings.	Low	Med	■ DG RTD's feedback on the conclusions and policy recommendations, as well as on the coherence of the findings and quality of the analysis, will also be considered and integrated where possible. ICF will ensure that there are consistent interactions with DG RTD and the other key Commission services including DG CLIMA and JRC. There will be multiple opportunities for study stakeholders to interact, and help shape study findings and key study conclusions. The addition of five external peer reviewers will also play a vital role in ensuring that there is coherence across the study.
5. Robustness and clarity of the deliverables			
Reports do not meet language standards (i.e., in clear, plain English, avoiding technical / specialised language).	Low	Med	■ Our standard approach in this study involves three rounds of review by PM, PD and PD QA checking that the reports are written in clear, plain, correct English, avoiding jargon. The Project Manager and all Task Leads are fluent English speakers who have drafted numerous reports for European Commission clients.
6. Adequate organisation of work and of resources			
Lack of communication between contractor and Commission.	Low	High	■ Good communication among team members located in different offices is integral to our project delivery. Our commitment to communication is supported by steps we take in the design of the project, the methods we use, and the tools that we have available to support our work. ■ Clear and timely communication will be supported by digital tools allowing rapid dissemination and regular updates. We will hold regular reviews between the Project Manager and the team to discuss progress and any technical, operational or methodological issues that arise, and to plan the next phase of activities. We will send progress reports to DG RTD that contain information on

Risk	Likelihood (High/Med/ Low)	Severity (High/Med/ Low)	Mitigation measures
	Low		the activities completed to date, the issues that have arisen, and the scheduled activities for the forthcoming reporting period.
Discontinuity of work due to absence of a member of the team		Med	■ Team capacity and planned staff absences (e.g. for annual leave, maternity) will be monitored throughout the project using ICF's proprietary tool, People Planner. ICF has low rates of staff turnover and has several other suitable staff capable of joining the project team. Although unlikely, circumstances may arise where it is necessary to replace members (e.g. illness). In the event this takes place, such members will be replaced by equivalent expert from ICF or partners, who are suitably qualified to carry out the tasks envisaged in the contract. Client approval will be sought for any replacement in the core team. If the proposed candidate is deemed not acceptable by DG RTD, alternatives will be suggested. Once confirmed, the formal replacement will take place, and the new member of the team will be fully briefed by the PM on the nature of the specific assignment and tasks envisaged. Given the breadth of experience and skills of the team, we are confident of our ability to respond to the unavailability of a team member, without any technical loss and with minimum disruption to the assignment.
Lack of clarity on roles and responsibilities, different quality standards and disconnected outputs due to the large team.	Low	Med	■ Jerome Kisielewicz is an experienced PM who will be proactive in liaising with task leads, and other team members to clearly set out their roles, project requirements and the timeline to deliver their outputs and to monitor the quality of their expected contributions. Through the regular reviews, the Project Manager will be updated on any eventual need for reallocation of resources. The information on the task leads and individual experts and researchers involved in each activity will be available to DG RTD upon request. For any quality issues that need to be escalated, Jonathan Lonsdale and Wolfgang Eichhammer are both highly experienced Study Directors (each with over 20 years of experience respectively), and they will liaise with the PM and Task leads to maintain quality standards throughout the project.
Hardware/ software failure: loss of reports saved in servers/ data/ computing failure.	Low	Med	■ Virtual servers store all data and information remotely, including for the collaboration tools via Microsoft Office applications. An additional remote backup is also maintained to ensure that work is not at risk if local hardware develops faults. ■ Regular backups are undertaken to avoid any loss of data and information. Automated backups are performed on a weekly basis and manual backups are performed once each major milestone is reached.

Risk	Likelihood (High/Med/ Low)	Severity (High/Med/ Low)	Mitigation measures
The complex analysis required as well as a demanding set of objectives for the study, mean that time and resources must be used very effectively	Low	Med	■ The team's deep collective knowledge overall of the needs of DG RTD, and the Commission more widely, with regard to the further development of the R&I agenda to underpin the European Green Deal, coupled with the team's broad and deep knowledge of specific R&I areas, and what constitutes beyond state-of-the-art provides us with a perfect reinforcing set of skills that will help us to be efficient and effective in not only our prioritisation of R&I areas but also our interaction with stakeholders and the Commission. We have the experience to know how to focus resources on the most important areas of interest to add value to this important study.
Current events			
The COVID-19 pandemic has created significant global disruption. This may lead to illnesses within the project team, the Commission's team, or others involved. It may also make it more challenging to interview and effectively gain feedback from stakeholders.	Med	Med	■ This is a risk we are acutely aware of, and we have taken extensive steps to ensure business continuity during the last two years. The safety, security and health of the team is at the forefront of our minds, and we have several layers of pastoral care in place to support each member as much as possible. We have ensured each team member is effectively equipped to continue working if restrictions would be (re-)established in any country of operation. We will be providing support in the case of any individual issues, for example IT failures. ■ Based on the current situation (ongoing COVID-19 pandemic, war in Ukraine) – and the fact that the expertise we require for this study is both extensive and widely dispersed geographically, we have foreseen all meetings to be virtual or hybrid and interviews to happen virtually. We have deployed similar approaches in all our projects since the beginning of the pandemic and have delivered successful virtual events and workshop across multiple projects, with very happy Commission clients that include DGs CLIMA, ENV, REFORM and GROW. ■ In the case of illnesses, we will evaluate possible remedial actions depending on the situation. The team has inbuilt redundancy in the case of short-term issues, with team members able to provide short-term cover. We have flexibility in our workforce, and with the agreement of the Commission could substitute team members with other employees to ensure the work is seamlessly delivered. If critical team members are impacted, then we would reinvestigate the timeline to see what other work could be brought forward to ensure progress continues in the interim. In all cases, we will remain dedicated to delivering this project to the highest quality and on-time.