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EXECUTIVE SUMMARY

This deliverable D3.4 “Final report on the translation of new EU policies into concrete actions for the EERA members and SET Plan community” presents the final results of the activities carried out in Task 3.2 “Translating new EU policies into concrete actions for the EERA and SET Plan community”. It follows the first interim report (D3.3), due in M18, and a second interim report (D3.5), including the additional activities performed over the following 6 months.

The report is an essential update of the D3.5 report, as to cover the last 24 months of activity. The first chapter takes much from the previous interim reports, as the methodology was not largely updated over the course of the project. The activities performed experienced a development, nonetheless, following the suggestions received during a meeting with representatives from the European Commission. In this context, the latest Policy Briefs (on the Energy Efficiency Directive (recast), REPowerEU, EU Biodiversity Strategy, Sustainable Carbon Cycles, ReFuelEU and Critical Raw Materials Act) actively tried to better address the topics most relevant for the project’s key audiences which, inter alia, required additional recourses from all projects partners.

The report then includes an assessment on the latest SUPEERA policy webinars on green hydrogen, critical raw materials and the reform of the electricity market design, organised respectively on 20 May 2022, 01 December 2022 and 26 April 2023. The webinars gathered EU and national policymakers, researchers and industry representatives to discuss the main developments and the future actions concerning highly debated issues, in which clean energy research could play a vital role. The webinars provided insightful discussions among speakers and participants, showcasing the potential of such gatherings for creating more inclusive policies and innovation.

LIST OF ACRONYMS

CDE	Communication and dissemination
CET	Clean Energy Transition
EC	European Commission
EERA	European Energy Research Alliance
EU	European Union
IP(s)	Implementation Plan(s)
IWG(s)	Implementation Working Group(s)
JP(s)	Joint Programme(s)
NECPs	National energy and climate plans
PB	Policy Briefs
R&I	Research and Innovation
SETIS	Strategy Energy Technology Plan Information System
SET Plan	Strategy Energy Technology Plan
SUPEERA	Support to the coordination of national research and innovation programmes in areas of activities of the European Energy Research Alliance

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I INTRODUCTION

In 2008, the European Commission launched the Strategic Energy Technology (SET) Plan, as an instrument to boost R&I in the field of low carbon technologies. Building on the SET Plan 10 priorities and 14 Implementation Plans (IPs) were written in order to cover all the Energy Union R&I priority areas, and Implementation Working Groups put in charge of executing the R&I activities listed under the IPs. The SET Plan is supported by the open-access SET Plan Information System (SETIS – Joint Research Centre, European Commission) that provides up-to-date information on its activities covering all R&I priorities of the Energy Union.

Within this context, the SUPEERA project - SUPport to the coordination of national research and innovation programmes in areas of activities of the European Energy Research Alliance - was launched on January 1st, 2020, and aimed at reaching four high-level objectives:

1) Facilitating the coordination of the research community in support of the execution of the SET Plan towards the Clean Energy Transition;
2) Accelerating innovation and uptake by industry;
3) Providing recommendations on R&I priorities and policy frameworks through the development and analysis of the energy and macroeconomic indicators;
4) Supporting and promoting the connection of the SET Plan and the Clean Energy Transition with all stakeholders.

In order to realise the third high objective and as described in Task 3.2, the project stipulates for the realisation of a series of webinars, the holding of a presentation session at each annual EERA Summer Strategy Meeting, now Annual Strategy Meeting, as well as the publication of a series of Policy Briefs on selected European policies applicable to the climate and energy fields. These actions have continuously been carried out under the scrutiny and quality assurance provided by the EERA Policy Working Group, which gathers senior researchers and policy workers active in the energy policy landscape and which meets with a monthly frequency.

This final report details precisely the actions above-mentioned from M25 until M42 with a view to providing a comprehensive overview of the activities and outcomes achieved during this specific timeframe.

II OBJECTIVES

The European Union's commitment to reach climate neutrality by 2050 and meet the objectives of the Paris Agreement entails no less than a complete redefinition of the European energy system. To achieve this ambitious but necessary goal, new policies are in the process of being drafted and existing ones reassessed in order to comply and inform this rapidly changing environment.

Based on the continuous analysis of the above-mentioned policy landscape, the fulfilment of Task 3.2 provided the EERA community with tailored recommendations on concrete research areas and industrial challenges. This final report therefore presents how this is has been concretely achieved from M25 until M42 by detailing the actions undertaken, their uptake and reach among the parties involved.

III REPORT ON HOW EU SELECTED POLICIES TRANSLATE INTO RESEARCH CHALLENGES AND INDUSTRIAL OPPORTUNITIES

3.1 Methodology

The task provided the EERA community with tailored recommendations on specific research areas and industrial processes to contribute to the implementation of selected new European policies applicable to the climate and energy sectors. Based on the initial discussion on relevance and capacity, it was decided between M25 and M42 to focus on the broader perspective of the European Green Deal and the policies aligning with its objectives.

The recommendations were based on a 'mission definition' approach, inspired by a methodology used by the Research Council of Norway[1] to detail research challenges and industrial opportunities related to subsets of the overall challenge of climate change. The method is in line with the EC's mission-oriented R&I policy framework, aimed at maximising the impact of investments by setting more precise targets and expected impact when addressing global challenges. This approach is illustrated in Figure 1, where the Mission "World leading supplier of zero-emission transport" is split into a set of solutions needed to realise it. Then each solution is analysed to identify research and innovation challenges employing a qualitative expert gap analysis.

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[1] https://www.forskningsradet.no/en/

From the analysis of the selected Green Deal policies and priorities, EERA experts defined concrete missions that translated into a set of interdisciplinary solutions. These solutions have been split into a list of R&I challenges and industrial opportunities, responding to specific European R&I needs.

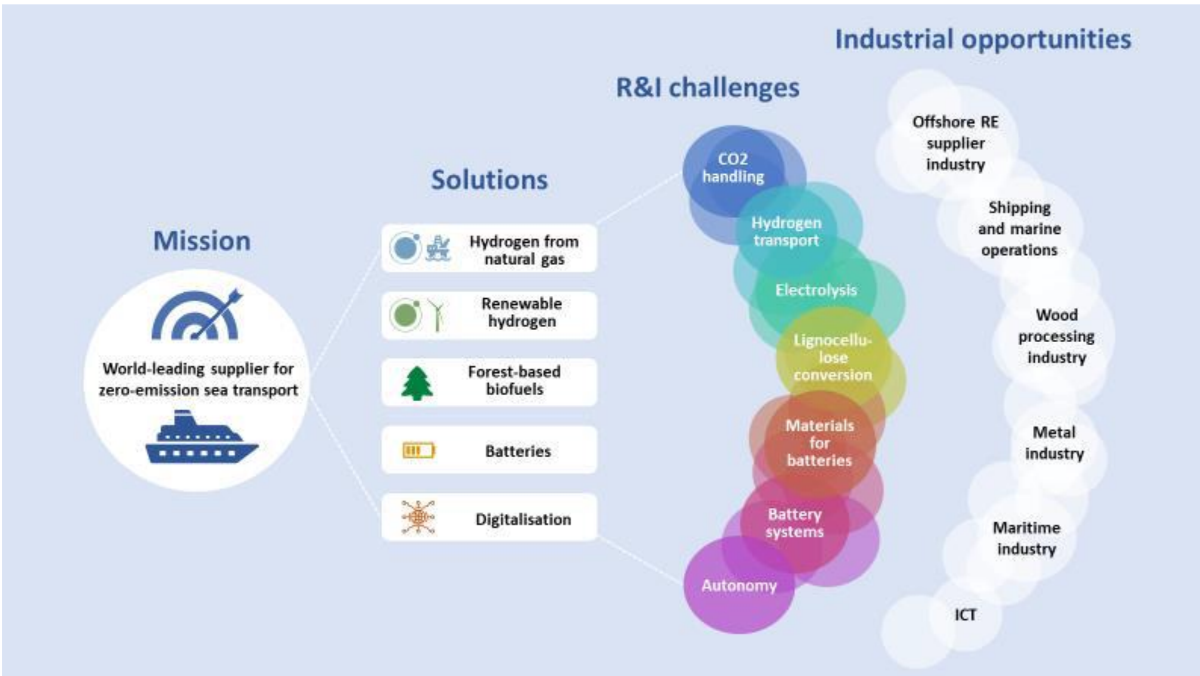

Figure 1. Mission definition approach: Translating policies into research challenges

Since the European Green Deal aims to solve the challenges posed by climate change and at the same time build a new Green Industry, the research challenges are held up against fields where Europe has solid competencies and industry to identify industrial opportunities with significant potential.

The method translates policy objectives into identifiable research challenges and firm actions for EERA members. In the EERA context, the Missions from the Norwegian model is the topic of the policy paper. The structured approach to the Green Deal policy papers is shown in Figure 2.

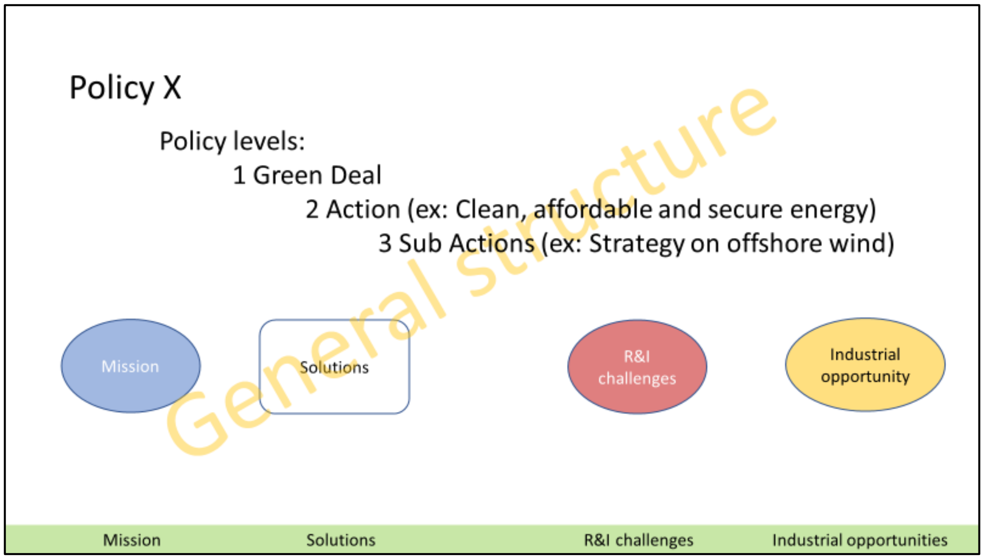

Figure 2. The hierarchical structure of policies to be analysed

At the top level, the Green Deal is divided into high-level areas to be addressed by policy papers, shown in Figure 3.

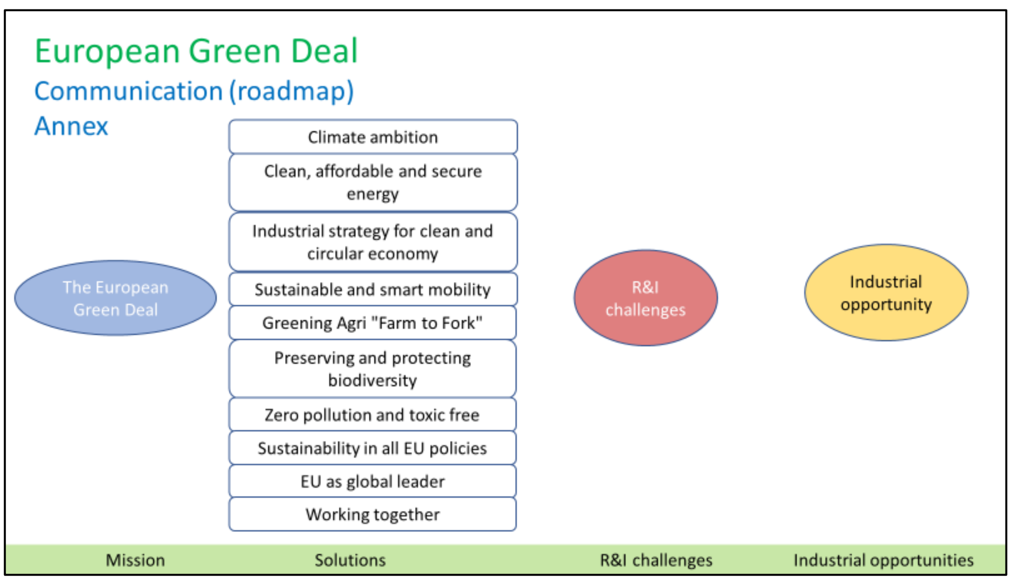

Figure 3. Policy paper areas addressed under the Green Deal

The analysis benefitted from the involvement of the EERA Policy Working Group. Active inside the EERA structure, this group gathers senior researchers and policy workers from a broad set of Member States and Associated Countries who are engaged in the national and European energy policy landscape. The group members provided intelligence on the latest developments at the EU level and the scientific base to translate the missions identified into concrete research challenges and industrial opportunities for the EERA community.

An example is the Energy System Integration Strategy shown in Figure 4. The critical issues underlined in the document are:

1) Creating a more efficient and circular energy system
2) Accelerating the use of electricity produced from renewable sources
3) Promoting renewable and low-carbon fuels, including hydrogen, for sectors that are hard to decarbonise
4) Adapting energy markets and infrastructure to a more complex, integrated energy system

These identified issues are translated into the need for five solutions within defined areas, which are again structured into concrete research challenges.

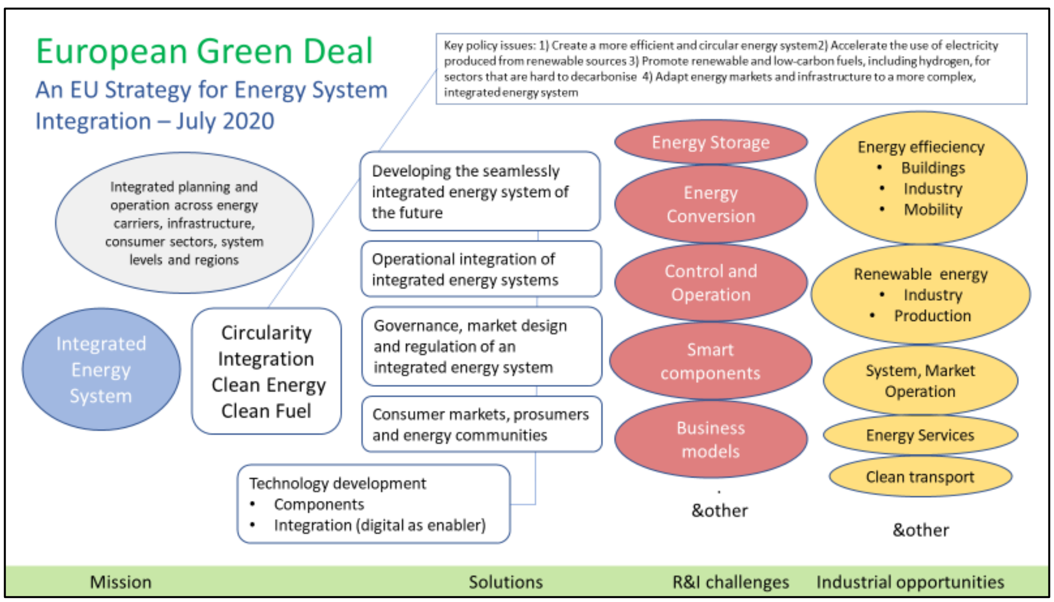

Figure 4. Analysis of EU strategy for Energy System Integration

For each policy document selected, a compact summary in text format of 4 to 5 pages documents the analysis. The results have been widely disseminated and discussed with the EERA membership to align and engage them in realising the policies both at the EU and national level.

3.1 Policy Briefs

The process identified in the previous section provided the basis for producing a series of documents named "Policy Briefs" (PBs). The ultimate goal of the Briefs is to analyse the policies of the European Union and identify concrete research questions relevant to the energy research community. The analysis of the policies identified has the primary objective of supporting recommendations towards the EERA membership and the SET Plan ecosystem at large. It is also intended to provide an insightful input for EU policymakers on which are the potential areas for investments in energy R&I.

The identification of the documents was conducted inside the SUPEERA consortium and involved the Secretariat of EERA as the project's main beneficiary. In addition, the EERA Policy Working Group (POL WG) was consulted in the decision process, given the expertise its members can bring to the discussion. Finally, the documents were selected among those published under the scope of the European Green Deal after ensuring that the associated research and innovation challenges would be of interest to the EERA community. This section outlines the policy context in which each of the six Policy Briefs published between M25 and M42 – The Energy Efficiency Directive (recast), REPowerEU, EU Biodiversity Strategy, Sustainable Carbon Cycles, ReFuelEU, Critical Raw Materials Act - proposes specific challenges to the energy research community. The full versions of the PBs with detailed recommendations (in the following sections only examples of recommendations are reported) can be accessed in Annex 1 to the report by clicking this link.

3.1.1 The Energy Efficiency Directive (recast)

The proposed energy efficiency recast Directive lays down rules designed to implement the "energy efficiency first" principle across all sectors, remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy. It also advocates for the establishment of indicative national energy efficiency targets between 2020 and 2030. The Brief presents the main provisions of the EU Commission's communication, followed by a broader analysis of the main challenges for energy research in the coming years.

Some of the key challenges identified are:

- Stimulate more investments in energy efficiency in the industrial sector. A reduction of 15% in the global energy demand in 2040 could be possible by implementing efficiency opportunities
- Promote R&D efforts towards specific technology developments that can reduce specific energy consumption needs in industrial processes
- Create greater demand for energy efficiency solutions in the industry

- Engage all parts of the value chain by, for example, promoting energy efficiency partnerships with all businesses' branches and sectoral plans for energy reduction towards 2050.
- Deploy energy flexibility solutions (microgrid, smart energy tariffs, etc.).

3.1.2 REPowerEU

The REPowerEU Communication discusses the ways the European Union can take to detach itself from dependence on Russian fossil fuels, in order to both help the green transition in the EU and to provide a response to the current Russian invasion of Ukraine. The official document focuses mainly on short term solutions to the problem of reducing EU dependence on Russian fossil fuels, mainly looking at wind and solar energy and heat pumps. Nonetheless, the paper tries to go further and explore the role of other energy sources in the coming future.

Some of the key challenges identified are:

- Develop further integrated photovoltaics and bring back to the EU the solar supply chain;
- Explore systems integration for larger wind projects, including floating wind;
- Continue developing next-generation nuclear reactors focused on fuel recycling;
- Explore energy system modelling for measures such as transmission capacity increasing;
- Promote solar hybrid projects combining concentrated solar power and PV panels;
- Empower geothermal energy research to further develop ground-based heat pumps.

3.1.3 EU Biodiversity Strategy

The Policy Brief on the EC Communication on a new Biodiversity Strategy explores the key points relevant to the research community related to this comprehensive, ambitious and long-term plan to protect nature and reverse the degradation of ecosystems launched in May 2020. The Policy Brief highlights and suggests recommendations to minimise energy impacts on the ecosystems and actively support nature preservation and restoration. R&I&D will be key to ensuring the availability of the latest state-of-the-art environmental protection measures to minimise the negative impacts on biodiversity in the EU and their repercussions on a global scale.

Some of the key challenges identified are:

- Investing in the deployment of more sustainably sourced renewable energy with a priority on ocean energy, offshore wind, solar-panel farms, sustainable bioenergy;
- Fostering and increasing research and innovation on biodiversity and investing in the respective solutions;
- Incentivising local, regional, national and European-level partnerships and cooperation in the research and innovation community.

3.1.4 Sustainable Carbon Cycles

The EC Communication on Sustainable Carbon Cycles was released in December 2021, aiming to create resilient and sustainable carbon capture, storage, and use practices in the EU. The Policy Brief looks primarily at the perspectives brought forward by the carbon removal technologies of Carbon Capture, Use and Storage (CCUS), Direct Air Carbon Capture and Storage (DACCS) and Bioenergy with Carbon Capture and Storage (BECCS) in their research and innovation implications. These include the need to advance knowledge on the development of transport and storage infrastructures, data collection systems and social acceptance: all key elements for the above-mentioned technologies to be exploited at their full potential. The Policy Brief points out that whilst progress in those areas requires, first and foremost,t a firm funding commitment to R&I, concerted action from industry, policymakers, and other stakeholders in the field will be equally important for carbon removals to represent a successful option when it comes to achieving EU climate neutrality by 2050 and net-negative emissions after 2050, as mandated under the EU Climate Law.

Some of the key challenges identified are:

- Establish a proper and functioning system of incentives for land managers to increase carbon removals and protect carbon stocks;
- Enhance the potential for carbon farming practices to provide co-benefits on biodiversity and ecosystem services;
- Develop scientifically sound methodologies with the objective of acknowledging carbon storage in all European frameworks related to the climate performance of products.

3.1.5 ReFuelEU

The Commission's Proposal for a Regulation on ensuring a level playing field for sustainable air transport (ReFuelEU) aims to create a competitive and fair aviation fuels market in the EU. The document analyses various aspects of Sustainable Aviation Fuels (SAFs), including feedstock availability, production costs, sustainability, and the policy framework, which are crucial for promoting their uptake and decarbonising the aviation sector. The Policy Brief emphasises that progress in these areas necessitates a firm funding commitment to R&I, as most production technologies are not yet commercially available. Research efforts will have to focus on, among others, diversifying feedstock, increasing process efficiency and reducing production costs. All these elements will be key to developing a sustainable European SAF production industry.

Some of the key challenges identified are:

- Develop innovative feedstock production technologies for biomass included in Annex IX Part A 2. Develop methods for feedstock traceability all the way to the feedstock origin;
- Demonstrate and commercialise e-SAF and SAF produced from Annex IX Part A

(lignocellulosic and marine feedstock), particularly on reducing production costs and increasing efficiencies;

- Explore the policy needs for a possible shift of the feedstock used for production of biofuels from the road to the aviation sector;
- Explore the policy needs to support the production of both SAF and e-SAF.

3.1.6 Critical Raw Materials Act

The Commission's Proposal for a Regulation establishing a framework for ensuring a secure and sustainable supply of critical raw materials (CRMs) aims to lessen the EU's dependence on concentrated supply chains of strategic metals and minerals. The Policy Brief analyses the different pathways to diversify the EU's supply of CRMs, including upscaling domestic mining, recycling capacities, and forming new trade partnerships, which will be crucial to meet the needs of the Clean Energy Transition. The Policy Brief emphasises that progress in these areas necessitates faster permitting, more incentives to encourage circularity, and a firm funding commitment to R&I, to develop new technologies that are not yet commercially available and improve efficiency in using CRMs. Research efforts will have to focus on, among others, identifying new materials, improving their circularity, and expanding their lifespans. All these elements will be key to developing a sustainable and secure European Critical Raw Materials strategy.

Some of the key challenges identified are:

- Increase material efficiency (durability, reusability, reparability, resource use or resource efficiency);
- Increase material circularity (possibility of remanufacturing and recycling, recycled content and the possibility of recovery of materials);
- Increase the technological maturity of recycling technologies for critical raw materials;
- Promote the substitution of critical raw materials wherever possible.

IV SUMMARY OF WEBINARS AND DISCUSSIONS HELD WITH EERA MEMBERS

4.1 Webinars

Alongside the drafting and publication of the aforementioned Policy Briefs, the task entailed a series of webinars aiming to discuss the most recent and relevant policy developments in the EU climate and energy arena. The SUPEERA consortium identified the topics covered by such webinars, and their relevance was discussed by the POL WG members during the group's monthly meetings. The EERA Secretariat, as the project's main beneficiary, was involved in identifying relevant topics to be covered, as well as in the process of producing a concept note and an agenda for each webinar.

Within the considered period (M25 - M42), three webinars were organised, gathering speakers from the main four arenas relevant to the EERA community (EU and national policymakers, research and industry). The official invitation to the event was sent out to the whole SUPEERA community and was disseminated through the SUPEERA's website[2], as well as the EERA's main website[3], and social media channels (LinkedIn, Twitter).

Targeting the entire SUPEERA and EERA research communities, the webinars were organised to present the main policy developments and stimulate a discussion among speakers representing different interests in the fields of green hydrogen, raw materials and the reform of the electricity market design.

The first one, on Green Hydrogen & Clean Energy Research, took place on 20 May 2022. The webinar was joined by Luca Polizzi, Policy Officer at the European Commission, Senior Research scientist Gunhild Reigstad from SINTEF and Stephen McPhail, former coordinator of the Joint Programme (JP) Fuels Cells and Hydrogen.

The second one, “Paving the way for strategic autonomy: The role of R&I on materials for the clean energy transition” took place on 1 December 2022. The webinar was attended by Daniel Cios, Policy Officer at the European Commission, Dumitru Fornea, Rapporteur “Opinion on Critical Raw Materials” for the European Economic and Social Committee (EESC), Amada Montesdeoca, Director of Open Innovation at UMICORE, and Sawako Nakamae, Coordinator of EERA’s JP on Advanced Materials and Processes for Energy Applications (AMPEA).

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[2] https://supeera.eu/
[3] https://www.eera-set.eu/

Lastly, on 26 April 2023, SUPEERA's policy webinar "A future-proof EU electricity market: the role of R&I in taking up the challenge" took place online. The event featured Mathilde Lallemand-Dupuy, Policy Officer at the European Commission, Vilislava Ivanova, Research Manager at E3G, Charlotte Renaud, Head of Unit, Wholesale and Retail Market Issues at Eurelectric and Laurens de Vries, Coordinator of the EERA Joint Programme on Energy Systems Integration (ESI).

4.1.1 Green Hydrogen & Clean Energy Research: Issues at Stake, Ways Forward

The session was introduced by EERA Senior Policy Officer Rosita Zilli with a series of ice-breaking questions aiming at getting to know the audience's background and expectations. The majority of the attending participants that answered the questions had a background in either Research or Academia and was interested in gathering in-depth R&I challenges and industrial opportunities connected to the topic of the webinar.

The following Panel Discussion was moderated by EERA Secretary-General Adel El Gammal. The first guest, Luca Polizzi from the European Commission, also started its presentation with a series of introductory questions, with the goal of understanding the audience's perception of hydrogen. It was interestingly noticed, for example, that more than half of the participants that answered the questions did not think hydrogen was a truly green solution. Consequently, biomethane, biofuels and ammonia were indicated as viable alternatives to hydrogen by the attendees.

The expert then proceeded to illustrate the European hydrogen ecosystem strategy, clarifying that the Commission's intention is to focus solely on renewable hydrogen, thus green hydrogen. Polizzi shared that the Commission's long-term vision is to have renewable hydrogen deployed at a large scale across all sectors starting from 2030. After that, he involved participants once again, spurring a reflection on the financial side of hydrogen deployment and in which ways the needed infrastructure could be funded.

Polizzi also gave a brief presentation on the hydrogen transition, focusing on the just-launched REPowerEU Plan and the current and future role of hydrogen valleys in Europe. Finally, he was asked specific questions on the international framing for this initiative and how to keep EU leadership in this sector. Polizzi finally highlighted that the EU is committed to maintaining its hydrogen production leadership role.

The second speaker, Stephen McPhail, gave a presentation focusing on the EERA Joint Programme Fuel Cells and Hydrogen (JP FCH), indicating its scope, missions and key targets. In his presentation, he highlighted that the biggest challenge in exploring the role of hydrogen in our society is to preserve research freedom while maintaining scientific acumen and upholding unbiased investigation. He also shared that the JP FCH ambition is to continue as an independent group of scientists, fostering interaction with other EERA Joint Programmes, providing ad-hoc contributions to research strategies and work programmes. McPhail concluded his presentation by confronting the audience with a question regarding the obstacles for the achievement of the EU Hydrogen strategic targets. The participants mostly confirmed that they see the production of hydrogen as the main bottleneck for the achievement of these goals.

The last guest, Gunhild A. Reigstad, shared with the audience the results and experience of Hydrogen4EU, a cross-sectoral research project started in 2020 aiming to concretely assess the potential contribution of low-carbon and renewable hydrogen in reaching the European energy transition goals. The expert explained that the main findings of the project identified transport and industry as triggering the largest hydrogen demand in the future. The research on hydrogen production showed that production from renewable sources and natural gas are complementary in building up and expanding the market. Finally, she stressed the importance of more efficient tools for integrated assessment.

On a final note, a brief Q&A session was held with the experts to answer the questions from the audience. Some areas that were addressed related to the challenges to the transport of hydrogen, the competition between generating green power and generating green hydrogen, and the role of solar energy in kerosene production.

The recording and presentations can be accessed here.[4]

4.1.2 Paving the way for strategic autonomy: The role of R&I on materials for the clean energy transition

The session was introduced by EERA Senior Policy Officer Rosita Zilli, who opened the floor with a series of ice-breaking questions aiming at getting to know the audience's background and expectations. The majority of the attending participants revealed to have a background in either Research or Academia and expressed an interest in gathering in-depth R&I challenges and industrial opportunities connected to the topic of the webinar.

The panel discussion was moderated by EERA Secretary General Adel El Gammal, who initially emphasized the growing importance of materials as a topic. The first introduction statement was given by Daniel Cios, an officer from the European Commission, who provided the context for the subject by explaining the critical role raw materials play in renewable technologies and the energy transition. He highlighted the significance of research and innovation, particularly in relation to the

[4] https://www.supeera.eu/news-and-resources/3358-outcomes-of-the-supeera-s-webinar-on-green-hydrogen-clean-energy-research-30.html

Horizon Europe programme, which has received an increased budget for 2021-27 and covers the entire raw materials value chain in its research topics.

The second speaker, Dumitru Fornea from the European Economic and Social Committee, highlighted the external costs of the green economy and the energy transition, particularly as the demand for green energy is increasing while Europe does not currently have the capabilities and technology to provide the supply to that demand. Thus, the expert pointed out that a different approach to strategic interdependence is required, as Europe currently has a huge dependency on raw materials that are mostly existent in other regions of the world. Additionally, the mining projects for these materials have environmental and local social consequences in the respective areas. Subsequently, Mr Fornea emphasised the need for the EU to be present on the areas in which these raw materials are produced, and build trustful relationships with the respective projects and communities. Such strategies have not been adopted yet, even though countries like China have been marking their presence in such sites for a long time. Moreover, he pointed out how this context is an opportunity for research and innovation in Europe in order to find alternatives and solutions.

Dr Amada Montesdeoca provided an industry perspective, mainly from the view of UMICORE, and explained how the cooperation between industry and R&I actors is fundamental in delivering new technologies and solutions, as well as alternative materials. This process requires the reskilling of the workforce and the strengthening of intellectual property in Europe. In that context, Dr Montesdeoca added that circularity and the recyclability of technologies and products are important to reduce the industry's carbon footprint, particularly with respect to the waste that is generated.

The last speaker, Sawako Nakamae, expanded on Santana's emphasis on the discovery and development of new functional materials and underscored the importance of research and innovation in facilitating the clean energy transition. The transition poses significant challenges, particularly concerning the availability and sustainability of critical materials, as well as the requirement to ensure that these materials do not compromise application performance. Regarding the strengthening of raw material mining in Europe, Dr. Nakamae emphasised the necessity of reskilling the workforce while also considering sustainability standards and protocols.

The follow-up discussion explored the aforementioned topics in more depth. One of the focus was on the "fairness" of the clean energy transition and the importance of cooperation, in which Mr Fornea mentioned the EU's responsibility in cooperating with other countries and partners, and pointed out that the costs of this transition have to be shared in order to avoid unfairness and the emergence of conflicts. Mr El Gammal added that this point was discussed at COP27 regarding the "loss and damage" negotiations. Mr Cios joined the discussion, explaining that the EU is working with international partners and third countries in order to secure access to raw materials and that there is a need to expand that cooperation to businesses to foster matchmaking and facilitate investments.

On the challenge of the green transition and the demand for renewable energies, he confirmed that the Commission is looking at the increasing importance of raw materials in that context. Dr Montesdeoca highlighted the research that is currently being developed in Europe regarding the development of new materials, although she explained that Europe is more focused on the applications of existing materials. Thus, she noted that more support needs to be provided to the research community in developing the next generation of raw materials.

The importance of data, particularly on the access to it in an open and fair way, was also highlighted by Dr Nakamae as a crucial component for research modelling and policy-making. Mr Fornea added that data sharing is an issue regarding raw materials as it is mostly owned by international corporations. In that sense, he emphasised how important cooperation is and how vital that data is for governments in the policy-making process.

Finally, on the question of how this situation can be approached efficiently and in a fair way, Mr Fornea commented that the legislation established today will impact the outcome in ten years, thus investment in research and solutions are crucial to shield the EU against the effects of a potential future crisis in raw materials. Additionally, he stated, the international dynamics on environmental concerns in the extraction module of these materials needs to be combined with the protection of the rights and necessities of the local populations. Mr El Gammal concluded that including and getting the citizens to understand the necessary trade-offs is a crucial step forward, and that the unequal distribution of raw materials between the EU Member States requires a solidarity and compensation mechanism for the benefit of the whole union.

The recording and presentations can be accessed here.[5]

4.1.3 A future-proof EU electricity market: the role of R&I in taking up the challenge

The session was introduced by EERA Senior Policy Officer Rosita Zilli, who presented EERA and the SUPEERA project. Then, Ms Zilli opened the floor with a series of ice-breaking questions aimed at getting to know the audience's background and expectations. The majority of the attending participants revealed to have a background in Research and Academia or Industry and expressed an interest in gathering in-depth R&I challenges and industrial opportunities connected to the topic of the webinar and in obtaining intelligence and insights on the evolving legislative file.

The panel discussion was moderated by EERA Secretary-General Adel El Gammal, who introduced the first speaker, the officer from the European Commission Ms. Mathilde Lallemand-Dupuy, who provided a general overview of the main elements of the Electricity Market Design (EMD) reform. In particular, she highlighted that European Commission's proposal is built on three pillars: protecting

[5] https://www.supeera.eu/news-and-resources/511-news/3870-outcomes-of-the-supeera-policy-webinar-on-critical-raw-materials-in-the-context-of-the-clean-energy-transition.html

consumers, enhancing price stability and predictability, and accelerating the roll-out of renewables with flexibility services. The Policy Officer went through the measures proposed to address each of these issues, explaining how they would contribute to the strengthening of the future electricity market.

The second speaker, Vilislava Ivanova from the think-tank E3G, addressed the needs in terms of R&I by energy systems: basic research; feasibility; development; demonstration; and test, launch and operation. However, Ms Ivanova pointed out also that research should concern not only new technologies but also new business models and social innovation research (energy sharing, energy communities). The Research Manager from E3G also outlined the R&I challenges ahead as well as the opportunities that arise from this reform, such as the flexibility assessment and the national flexibility target, moving trade closer to real-time and energy sharing. Digitalisation, she added, may represent both a challenge and an opportunity, as either way, the transition is partly dependent on it. Lastly, Ms Ivanova focused on the synergies between research and industry, including delivery challenges; the move from testing to commercialisation; the development of the required skills; and socio-economic research, including an analysis of the imperfections of the policy instruments and their consequences.

Charlotte Renaud presented the work of Eurelectric and explained why this reform is needed. Indeed, considering the necessity for more investments in power generation (which will double by 2030) and grids to decarbonise, it is essential to ensure an adequate framework. Ms Renaud pointed out that electrification will be the driver for decarbonising other sectors, including heating, transport and energy-intensive industries. Thus, the energy market, which nevertheless proved itself strong during the recent crisis, will have to be further improved. In particular, the crisis made explicit that the price of fossil fuel generation excessively impacts short-term markets. Eurelectric's position, explained Ms Renaud, is based on two principles: preserving the elements that work, as the marginal price method, and developing long-term markets to protect consumers against excessive price vulnerability and foster investments. After having listed some suggestions for her organisation to improve the electricity market, she made a brief assessment of the Commission's proposal. The fact that this reform represents an evolution of the existing market, not a revolution, and that the emergency measures were not institutionalised was particularly appreciated by Eurelectric.

The last speaker, Laurens de Vries, provided a view from the research community. While he recognised that the current design works, he stressed the need to improve investment security and consumer protection. After having outlined what is needed to achieve a low-carbon electricity market, Mr de Vries explained the key research challenges ahead. These include the need to proceed to the development and deployment of new technologies simultaneously, a better understanding of imperfect markets to de-risk investments, a system in transition and system integration. De Vries explained that, so far, all research approaches have shown some deficiencies and further research is needed to develop an infrastructure vision. Lastly, he went through the market design challenges, explaining the modelling requirements that each would entail.

The follow-up discussion explored the aforementioned topics in more depth.

On the possibility of regulating the electricity market, Laurens de Vries insisted on the necessity of designing a robust market fit for future challenges. Providing consumers with a hedge and giving them more agency could contribute. Alternatives include, for instance, passive subscription and reliability options.

Speakers then discussed the role of governments and municipal authorities in developing R&I priorities for the electricity market of the future. In this context, Vilislava Ivanova, clarified the need to link the R&I actions to the solution of concrete clean energy transition challenges. Then, the debate concerned how to translate new measures into clear, simple guidance for consumers. Charlotte Renaud presented the results of a study by Eurelectric, which shows that most customers are unwilling or unable to embark on the energy transition. According to her, suppliers will have to be engaged in the communication challenge to explain the opportunity.

EERA Secretary-General Adel El Gammal brought up the issue of the resilience of the electricity market in the long run by stating that policymakers should refrain from making assumptions over the stability of certain conditions, for instance, the continued relatively low costs of renewable energy. Mr El Gammal thus asked the panel to what extent these assumptions are taken into consideration when designing the model. Mathilde Lallemand-Dupuy agreed on the pressing need to react to this crisis but, at the same time, of taking into consideration the fact that the reform of the electricity market will last more than the present emergency and that only solutions that will make it also fit for other future challenges should be incorporated. Lastly, the Commission’s Policy Officer outlined the next steps in the act’s legislative process by saying that trialogues are expected to take place already in the summer.

The recording and presentations can be accessed here.[6]

4.2 Annual Strategy Meeting (former Summer Strategy Meeting) Discussions

The EERA Annual Strategy Meeting (ASM) 2022 was held in Prague on the 22 and 23 of June. SUPEERA activities dominated the whole agenda and ensuing discussions. The ASM was the first physical event after Covid restrictions were lifted that gathered the EERA Secretariat, its Executive Committee, and its JP coordinators. The first day featured two external sessions focused on

[6] https://www.supeera.eu/news-and-resources/4177-r-i-policy-and-industry-unite-to-discuss-eu-electricity-market-design-reform-in-last-supeera-webinar.html

REPowerEU and the SET Plan Revamp, and how to best involve the research and innovation communities across Europe in the effort to handle the short-term challenge of becoming independent on Russian gas while at the same time ensuring that the EU Green Deal goals are met. The sessions welcomed interventions by Head of Units from DG RTD and ENER, and the JRC as well as ministerial representatives from the Czech Republic, followed by discussions. SUPEERA findings based on questionnaires on REPowerEU and the SET Plan Revamp, to which JPs and ETIPs responded, together with SUPEERA policy analyses and the specific project's Policy Brief on REPowerEU were part of the background for the discussions. The second day consisted of seven presentations from EERA Joint Programmes, who presented their initiatives for addressing REPowerEU and EU Green Deal target challenges according to the EERA's European Centre of Excellence (EUCoE) framework. The discussions focused on sharing experiences and how to move forward.

The EERA Annual Strategy Meeting (ASM) 2023 took place in Madrid on 14 and 15 June 2023. The first day of the meeting featured the SUPEERA Final Event, which comprised sessions presenting the final outcomes of the project, the cooperation between clean energy research and industry, the uptake of R&I in EU13 countries as well as the synergies among policy, research and industry in the context of the Net Zero Industry Act (NZIA). Representatives from the European Commission, industry, and the research community provided insights into the Commission's proposal and outlined the needs of both the industry and research community. Notably, Pieter Vingerhoets, Expert Energy & Climate Strategy at EnergyVille/VITO and member of the EERA Joint Programme Energy Systems Integration, emphasised the manufacturing capacity challenges faced by certain sectors and called for a comprehensive risk assessment and mitigation analysis, as well as increased funding and reduced investment uncertainty. The exchanges of views and the main conclusions reached in the panels provided a crucial base for the reply to the EC consultation on the Net Zero Industry Act.

ANNEX 1 – SUPEERA Policy Briefs

SUPEERA

Policy Brief

DIRECTIVE ON ENERGY EFFICIENCY (RECAST)

CHALLENGES AND OPPORTUNITIES AHEAD

Setting the scene

Two years after the launch of the European Green Deal, the European Union has taken substantial steps in its effort to promote the green transition. Since the announcement, a string of policy measures detailing the Green Deal ambitions have followed. The Fit for 55 package is the most telling example of this endavour and the finalisation and roll out of the legislative proposals contained in it will be crucial to attain the 2030 and 2050 EU climate goals.

The year 2022 also marks a crucial moment for the EU in general and European research in particular. It will not only signal the halfway of the current European Commission and European Parliament terms, but it will also see the Horizon Europe Missions, a new and innovative instrument, at work after being launched in 2021,

The result of these efforts will depend on the active participation and support of the research community. Only by combining state of the art research with careful policymaking the EU will be able to reach its ambitious goal of becoming climate neutral by 2050. The research community has a pivotal role to play in this process by supporting identified political priorities with empirical findings and developments. It can also advise policymakers on the way forward through fundamental research, particularly focused on low TRLs, to advance breakthrough technologies and materials, while also giving prominence to systemic approaches.

In the context of the SUPEERA project, a series of policy briefs are currently being developed to identify concrete R&I challenges in EU policies relevant to the energy research community. The final goal is to support the achievement of the Clean Energy Transition (CET). This Policy Brief will focus on the Proposal for a Directive on Energy Efficiency (recast). This directive will set the stage for a leap in the energy efficiency performance of the EU, including but not limited to buildings and industry. It will have a significant impact on the EU's energy system and set the bloc on the path to a more sustainable building environment.

As this brief was in preparation, the Russian invasion in Ukraine prompted the EU to put forward the REPowerEU communication, spelling out short term actions to substantially decrease Europe's dependency on Russian gas. Energy efficiency is essential given its short-term impact. However, it also calls to strengthen the urgency and volume of energy efficiency efforts, while emphasises the need to quickly address energy poverty issues to

The EC proposal for a recast of the Energy Efficiency Directive

The proposed energy efficiency recast Directive lays down rules designed to implement the "energy efficiency first" principle across all sectors, remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy. It also advocates for the establishment of indicative national energy efficiency targets between 2020 and 2030.

The text is built around six chapters outlining the European Commission's revised priorities for implementing energy efficiency measures at national, regional and local levels. The 2021 recast introduces a new chapter that considers energy justice and empowerment of citizens as a key priority for Member States.

Key priorities	Main elements in the priorities
Energy efficiency first principle	1. Member States shall ensure that energy efficiency solutions are taken into account in the planning, policy and major investment decisions related to the following sectors: energy systems and non-energy sectors, where those sectors have an impact on energy consumption and energy efficiency. 2. Member States shall collectively ensure a reduction of energy consumption of at least 9 % in 2030 compared to the projections of the 2020 Reference Scenario 3. Member States shall also provide the shares of energy consumption of energy end-use sectors, including industry, residential, services and transport, in their national energy efficiency contributions. Projections for energy consumption in information and communications technology (ICT) shall also be indicated.
Exemplary role of public sector	1. Member States shall ensure that the total final energy consumption of all public bodies combined is reduced by at least 1,7% each year, when compared to the year X-2 (with X as the year when the Directive enters into force). 2. Member States shall include, in their national energy and climate plans and updates thereof, a list of public bodies which shall contribute to the fulfilment of energy efficiency obligations, the reduction of energy consumption and the measures they plan to achieve it by each of them 3. Member States shall ensure that regional and local authorities establish specific energy efficiency measures in their decarbonisation plans after consulting stakeholders and the public. They should include particular groups at risk of energy poverty or more susceptible to its effects. 4. Member States shall support public bodies in the uptake of energy efficiency improvement measures, including at regional and local levels, by providing guidelines, promoting competence building and training opportunities and encouraging cooperation amongst public bodies.
Consumer information and empowerment	1. Member States shall ensure that information on available energy efficiency improvement measures, individual actions, and financial and legal frameworks is transparent and widely disseminated to all relevant market actors. 2. Member States shall take appropriate measures to empower and protect people affected by energy poverty, vulnerable customers and, where applicable, people living in social housing. 3. Member States shall take appropriate measures to empower and protect people affected by energy poverty.
Efficiency in energy supply	1. As part of its integrated national energy and climate plans, and respective progress reports, each Member States shall notify to the Commission a comprehensive heating and cooling assessment.

	2. Member States shall ensure that the public is allowed to participate in preparing heating and cooling plans, the comprehensive assessment and the policies and measures. 3. To increase primary energy efficiency and the share of renewable energy in heating and cooling supply, an efficient district heating and cooling system is a system that meets a set of criteria. The criterieas specify the development of the share of renewable energy, waste heat and the share of renewable energy in the waste heat in the period 2025 to 2050.

The transition to a more energy efficient Europe goes beyond technology

The concept of Energy Efficiency is one of the main pillars of the New European Bauhaus and the Fit for 55 package. A prominent reason is financial: **it is cheaper to save one unit of energy than to pay for the same amount of electricity**[7]. But this is not the only reason: **energy efficiency will be crucial for reaching the declared objective of a carbon-neutral Europe by 2050**. Its scope spans from industry to public buildings and private homes.

Despite the attention given to the topic, **the level of investments linked to improvements in energy efficiency, especially in businesses, does not reflect its importance**[8]. The recently proposed Energy Efficiency Directive (EED) recast will be deployed to spur more investment in energy efficiency activities to address this situation. The main aim of the proposed text is to increase the level of commitment, both at EU and Member State levels. Although still under discussion by the European Parliament and Member States, an informed analysis of the provisions currently on the table complemented by the viewpoint of the low carbon research community is presented. The objective is to suggest pathways that could be explored to maximise the directive's impact.

Supporting businesses to sort out their energy efficiency performance

The main objective of the recast directive is to reach a 9% energy efficiency target by 2030, equivalent to a 36% reduction of energy consumption for final energy[9]. This will impact all sectors, with a particular focus on businesses. For that, enterprises will have to develop technology related to infrastructure and processes, implement a circular economy and draw on digitalisation to align to the new rules and increase their performance in energy efficiency.

To start with, **investments in infrastructure are highly needed**. Under current circumstances, the industrial sector in the EU is responsible for around 16.4% of total energy consumption. The revised EED mainly addresses industry-related points concerning the insulation of buildings and heating

[7] European Court of Auditors, 17 January 2022, "EU's contribution to energy efficiency in businesses is unclear", https://www.eca.europa.eu/Lists/ECADocuments/INSR22_02/INSR_Energy-effic-enterpr_EN.pdf
[8] European Court of Auditors, 17 January 2022, "EU's contribution to energy efficiency in businesses is unclear", https://www.eca.europa.eu/Lists/ECADocuments/INSR22_02/INSR_Energy-effic-enterpr_EN.pdf
[9] The total energy consumed by end users, such as households, industry and agriculture

and cooling technologies. However, it falls short of mentioning any details on making industrial processes more energy efficient. **Technological aspects linked to *reducing the specific energy consumption in production processes* will be key to unlocking energy efficiency developments in the sector in the coming years.**

Crucial in many industries[10] will be the development of processes employing innovative materials and production methods. Electrification from renewable energy resources available today is a fundamental tool. Still**,** it currently supports only low-temperature industrial processes, while most barriers are met in high-temperature applications. Digitalisation and process automation are critical enabling technologies towards higher energy efficiency, providing new ways to improve flexibility in plants, optimise consumption and reduce GHG emissions.

Energy efficiency will also be crucial for making circularity possible in industrial processes. Today, 50% of the power consumption in Europe goes to heating and cooling, i.e. thermal energy. All industrial processes are affected by losses, mainly through heat not being utilised, which means that new alternatives should be developed to recover energy after the end of the cycle. In order to increase efficiency, **a substantial effort should be made to understand where the main opportunities lie regarding the life cycle of industrial production**. A leading example is the utilisation of waste heat. In this case, circularity is not limited to waste reuse but entails a broader scope of planning the design, production, construction and renovation processes in the industry and building sectors[11].

For its part, the built environment faces enormous challenges, with 75% of the EU building stock with low energy performance and responsible for about 40% of the EU's energy consumption and 36% of the GHG emissions. With clear targets for Nearly Zero Energy Building (NZEB) renovation, energy efficient measures are increasingly srecognised as the first step to achieving better performance and consistently reducing energy demand. Moreover, using **nature-based building materials** could be an emerging integrative solution in **circular and green construction**. **Bioclimatic strategies** such as optimising the passive solar, natural ventilation, and natural light use complement the cost-effective solutions set for future NZEBs.

The second step towards NZEB renovation is the smaximisation of renewable energy generation on-site. An efficient building operation and optimal use of renewables could be achieved through energy flexibility solutions and strategies such as effective monitoring, ICT, and smart technologies, providing direct interaction with building occupants and the buildings' environment.

Building the bridge between technology and implementation

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[10] European Parliament, 2021, "Study/In-depth Analysis: The Road to Energy Efficiency", https://www.europarl.europa.eu/RegData/etudes/STUD/2021/695480/IPOL_STU(2021)695480_EN.pdf

[11] European Parliament, 2021, "Study/In-depth Analysis: The Road to Energy Efficiency", https://www.europarl.europa.eu/RegData/etudes/STUD/2021/695480/IPOL_STU(2021)695480_EN.pdf

Any development on the technology side will not be of much use if it cannot reach the market. Barriers like the uncertainty of energy efficiency return on investments constitute a significant factor in understanding the shortage in capital flows in the sector. One reason to explain this dynamic is the private sector's lack of modelling and data readability. A possible missing piece is the still **low level of interaction between research organisations and enterprises.** In this regard, **a closer relationship would benefit both the researchers and the industrial partners**.

Moreover, there is a lack of knowledge regarding the best available technology. A closer communication between all parties in the value chain could address this challenge. However, it will be crucial to **introduce a definition for "energy sufficiency" in the EU**. This concept entails a deliberate reduction of energy consumption, best exemplified in actions such as establishing lower maximum heating standards in private houses, and it is not yet contemplated in EU legislation.

Conclusions

The potential for energy efficiency gains in the industrial sector is not given the place it deserves in the recast directive. The suggested provisions to remediate this shortcoming include:

- Stimulate more investments in energy efficiency in the industrial sector. A reduction of 15% in the global energy demand in 2040 could be possible by implementing efficiency opportunities. For example:
    - Showing benefits via industry demonstrations by developing more lighthouse projects;
    - Limiting dependency of the sector on natural gas reserves outside Europe;
    - Promoting cross-sectorial collaboration among energy-intensive industries and power companies. The surplus heat from energy-intensive industries will be a vital resource for the energy system.
- Promote R&D efforts towards specific technology developments that can reduce specific energy consumption needs in industrial processes. For example:
    - More efficient separation technologies;
    - Process intensification, including reactor design concepts and equipment and new catalyst development for resource and energy efficiency;
    - Energy-efficient solutions for drying & dewatering;
    - Heat to power technologies;
    - Thermal energy storage solutions for peak shaving and better sutilisation of fluctuating heat losses (sstabilising waste heat supply).
- Create greater demand for energy efficiency solutions in the industry. For example:
    - Energy management systems for analysis and control of a company's energy consumption and identifying opportunities for efficiency gains;
    - Energy efficiency regulations and control, levelling the playing field for industries. E.g., introducing import taxes for products with high carbon footprint/high energy consumption.
- Engage all parts of the value chain by, for example, promoting energy efficiency partnerships with all businesses' branches and sectoral plans for energy reduction towards 2050.

Additional research challenges concerning the building sector encompass:

- For building and district level:
    - Increase the use of nature-based solutions for the built environment;
    - Solutions for renewable integration;
    - Increase the use of ICT and smart technologies for buildings operations;
- Increase the implementation of bioclimatic strategies;
- Deploy energy flexibility solutions (microgrid, smart energy tariffs, etc.);
- Develop policies and strategies to address people affected by energy poverty, and assess and compare the impact of different energy efficiency measures implemented at Members States level to improve them;

- Promote the public sector to lead by example by implementing green criteria in procurement practices for the public building sector.

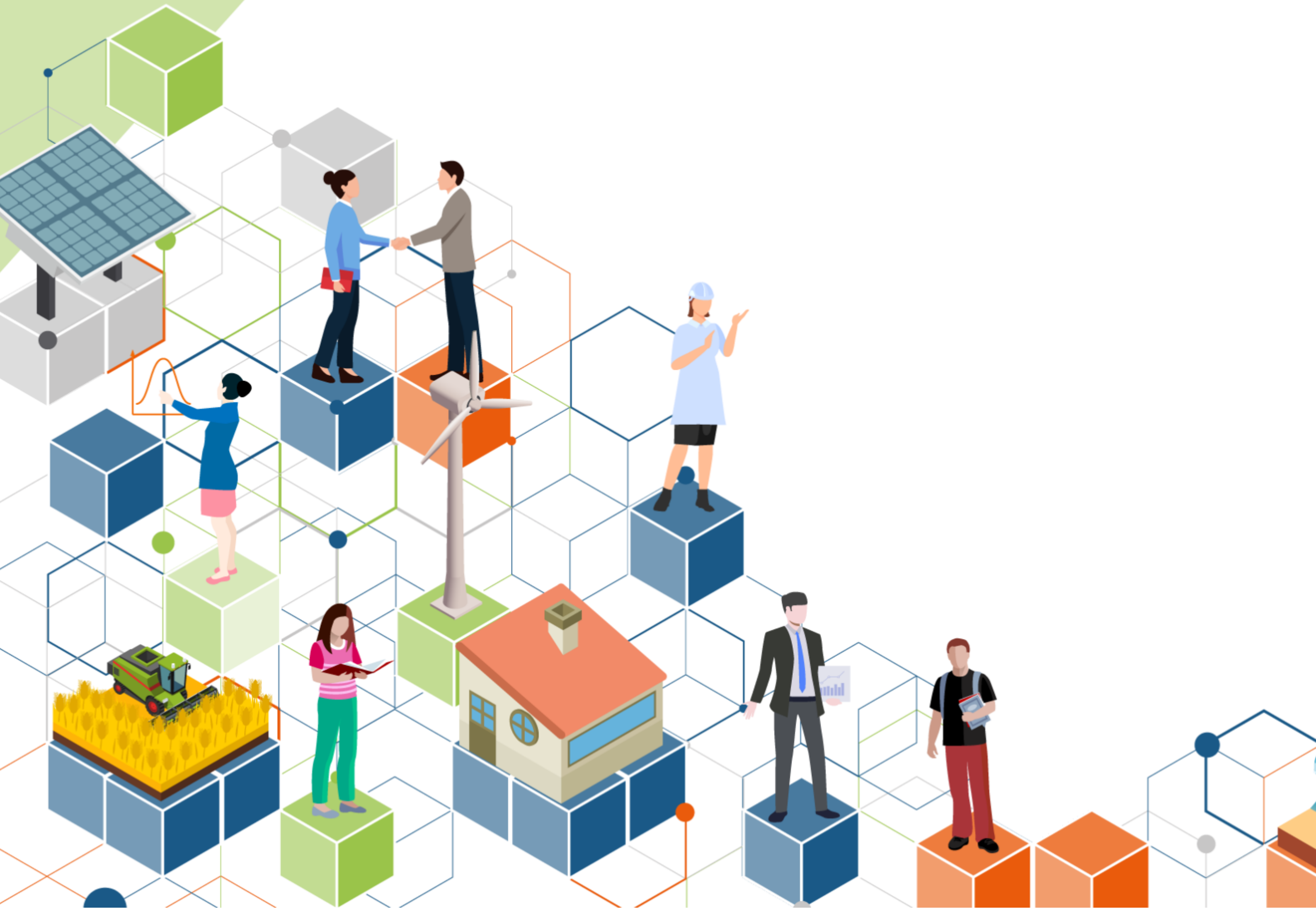
Support to the coordination of national research and innovation programmes in areas of activity of the European Energy Research Alliance

SUPEERA

Policy Brief

REPowerEU

- CHALLENGES AND OPPORTUNITIES AHEAD



Setting the scene

Two years after the launch of the European Green Deal, the European Union has made substantial steps forward in its efforts to promote the green transition. The publishing of the Fit for 55 package in 2021 is the most telling example of this endavour and the finalisation and roll out of the legislative proposals therein contained in the next years will be crucial to attain the 2030 and 2050 EU climate goals.

The year 2022 also marks a crucial moment for European research, and the EU in general. It will not only signal the halfway of the current European Commission and European Parliament terms, but it will also see the Horizon Europe Missions – new instruments designed to reduce the distance between citizens, researchers, policymakers and local government - at work, after being launched in 2021,

These efforts will be invalidated without the active participation and support of the research community as only by combining state of the art research with careful policymaking the EU will be able to reach its ambitious goal of becoming climate neutral by 2050. The research community has a pivotal role to play in this process, supporting identified political priorities with empirical findings and developments. It can also advise policymakers on the way forward through fundamental research, particularly focused on low TRLs, to advance breakthrough technologies, materials, and systemic approaches. Crucial in this effort will be the participation of the industrial sector, without which developments will be unattainable. In particular with the new objectives posed by REPowerEU, a close interaction between research, industry and Member States will be more fundamental than ever.

In the context of the SUPEERA project, a series of policy briefs are currently being developed to identify concrete R&I challenges in EU policies relevant to the energy research community. The final goal is to support the achievement of the Clean Energy Transition (CET). This Policy Brief will focus on the REPowerEU Communication, published by the European Commission as a reaction to the Russian aggression of Ukraine and the consequences the conflict will have on the EU energy system. The document is also intended to provide further responses to enduring high energy prices and the need to proceed to a swifter emancipation from fossil fuels in line with the goals of the European Green Deal.

The EC Communication for a Joint European action for more affordable, secure and sustainable energy

The European Commission has published in March 2022 the Communication "**REPowerEU: Joint European Action for more affordable, secure and sustainable energy**"[12]. The document lays down indications to attain a twofold objective: diversifying gas supplies, via higher Liquefied Natural Gas (LNG) and pipeline imports from non-Russian suppliers, and larger volumes of biomethane and renewable hydrogen production and imports; and, reducing faster the use of fossil fuels in houses, buildings, industry, and power system, by boosting energy efficiency, increasing renewables and electrification, and addressing infrastructure bottlenecks.

The table below summarises the main actions and features of each objective, divided following the structure of the document. The measures are categorised by short (ST), medium (MT), and long term (LT).

Key priorities	Identified R&I challenges
Mitigating retail prices and supporting heavily exposed companies	1. The combination of higher energy, transport and higher food prices is likely to increase poverty and affect business competitiveness. Therefore, the Commission will investigate all possible options to address the emergency. 2. Price regulation and transfer mechanisms are available to help protect consumers and the economy. Examples of such mechanisms include: • Member States setting retail prices for households and micro-enterprises; [MT] • Commission's incentives for energy efficiency and savings; [MT] • Member States offering temporary relief for companies facing liquidity needs, based on the guidelines on rescue and restructuring; [ST] • Member states supporting the companies and sectors mostly impacted by the energy crisis being facilitated by the full flexibility of the Commission's State aid toolbox. [ST] 3. The Commission will shortly be consulting Member States on the needs for and scope of a new, self-standing Temporary Crisis Framework. [ST] 4. Member States will be able to keep on taking exceptional measures with the support of the Stability and Growth Pact (SGP) all throughout 2022. [ST]
Preparing for next winter by ensuring sufficient gas storage	1. Gas supplies are sufficient until the end of this winter even in case of full disruption of supplies from Russia. Nonetheless, to be prepared for the next winter, filling of gas storage across the EU should start now. [S/MT] 2. A legal proposal will help ensuring the fairness and smart use of the existing infrastructure, as not all Member States have underground storage facilities in their territories. The aim is to ensure the uninterrupted energy flow within the whole EU. [LT] 2.1. Such legal proposal will identify gas storage as a critical infrastructure and introduce provisions to tackle ownership risks for gas infrastructure. 2.2. Solidarity arrangements are expected to be concluded in between the Member States. 3. The Commission will be in charge of coordinating the refilling operations through various joint actions, while Member States can incentivize such operations by providing aid to suppliers, for example in the form of guarantees. [S/MT] 4. The Commission is currently investigating all allegations of potential anti-competitive commercial conduct by Gazprom. [MT] 5. The EU stands ready to support Ukraine, Moldova and Georgia to ensure reliable and sustainable energy as necessary. [MT]
Eliminating EU dependence on Russian fossil fuels	1. Phasing out our dependence on fossil fuels from Russia can be done well before 2030. To do so, the Commission proposes a REPowerEU plan based on two pillars: diversifying gas supplies and reducing faster EU dependence on fossil fuels. [M/LT]

[12] Official Communication Text

	2. The energy efficiency first principle is more relevant than ever and should be applied across all sectors and policies. [ST] 3. Projects completing internal market in energy and those with a strong cross-border dimension should be privileged. Such projects will improve the interconnection of the European gas and electricity networks and other infrastructure and fully synchronise our power grids. [M/LT] 4. Financing needs will be assessed based on a comprehensive mapping of the needs of Member States as well as of cross-border investment needs. [LT]
Diversify gas supplies	1. The Commission will continue discussing within G7 and with major global purchasers of gas (Japan, South Korea, China, India) medium-term market developments to diversify LNG and pipe imports and to foster international partnerships. [MT] 2. The Commission aims at increasing the EU production of biomethane, doubling the objective of Fit for 55. [M/LT] 3. The Commission will further develop the regulatory framework to promote a European market for hydrogen and support the development of an integrated gas and hydrogen infrastructure, hydrogen storage facilities and port infrastructure. [LT]
Reducing faster our dependence on fossil fuels	1. Rolling out solar, wind and heat pumps • The Commission will present in June a communication with the aim of helping unlock solar energy's potential as a major renewable energy source in the EU [ST] • The Commission will help further develop the value chain for solar and wind energy and for heat pumps, also boosting the EU's competitiveness and tackle strategic dependencies [LT] 2. The REPower EU aims at decarbonising industry through the deployment of innovative hydrogen-based solutions and cost-competitive renewable electricity. [LT] 3. The necessary condition to realize all REPowerEU acceleration goals is to simplify and shorten permitting. The Commission calls on Member States to ensure that the planning, construction and operation of plants for the production of energy from renewable sources as being in the overriding public interest, and thus qualify for the most favourable procedure available. [LT]

REPowerEU brings promises to change the EU energy system, opening the door to innovation

The REPowerEU communication bears a **unique chance** to reformulate energy policies in a way which is conducive to emancipate the EU from Russian fossil fuels, tackle high prices and reach 2030 and 2050 climate goals. To attain these objectives, it is important for further legislative steps stemming from it to have at the core the vision for a **sustainable, fair and just transition to the benefit of all EU citizens and businesses** and embed at the same time the **principles of EU security of supply and Stategic Autonomy**. On a global scale, it will be critical to promote **EU leadership in climate diplomacy** and **technology transfer**, **integrate climate adaptation considerations** (e.g., IPCC AR6 WG2[13]) and actively support the achievement of the **United Nations Sustainable Development Goals**[14]. Now more than ever, the transition needs in fact to be addressed from a **holistic** and **systemic** perspective, and driven by **societal objectives**. In this respect, the REPowerEU Communication represents a golden opportunity to translate these aspirations into concrete proposals which will be able to deliver impact within a short time frame while at the same time laying the foundations for the future EU energy system.

Against this backdrop and diving into the specificities of the document, a first historical measure contained in the Communication foresees a mechanisms for **common purchase of gas for**

[13] https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/
[14] https://sdgs.un.org/goals

all EU Member States, to be coordinated at EU level by the European Commission. This represents a change from common practice, but it is not the only remarkable point therein contained. Here below follows an analysis of the research and innovation challenges deriving from a number of measures identified in the REPowerEU proposal with the view of harnessing its potential and drive significant impact both in the short and medium to long term.

Eliminating EU dependence on Russian fossil fuels

Although the Communication is divided into two parts, the most relevant section for the energy R&I community is the one dedicated to cutting ties with Russia on fossil fuel imports. Phasing out this dependence will be difficult, as Russia exports to the EU 155 bcm (billion cubic metres) of gas alone every year. The EU has decided to tackle this issue with a three-folded strategy: **Gas Diversification**, **Electrify Europe**, and **Transform Industry**.

Each of these "chapters" aims at reducing the current dependence on Russian fossil fuels, ranging from LNG diversification, to heat pumps installations, to the deployment of additional wind and solar capacity. The "Gas Diversification" chapter gives high importance to **hydrogen**, but this opens up a series of potential issues. First, **the current technology does not allow for fast production and transmission of green hydrogen**, diminishing its role in the short run. Secondly, the Communication expects additional renewable hydrogen production to substitute 25 to 50 bcm of Russian gas by 2030. The EU is aiming high with this objective, as green hydrogen production still has a long way to go in the energy mix. The current EU hydrogen strategy foresees the production of 10 million tonnes of green hydrogen per year in 2030. Not only the feasibility of full domestic production is challenged, but the objective in general will require **massive investments in renewable electricity**.

Electrification is one of the main focus of the REPowerEU discussion, as it holds the potential of greening up a large part of the energy sector. However, there are many directions that electrification can go to deliver on its objective. The document dedicates great attention to **wind and solar energy**. To capitalise on this important role, there are some key steps that the EU will need to take.

In regards to solar energy, for the EU to become energy-independent it would need to **bring back the production value chain to Europe**. Relying on PV panels produced elsewhere in the world is no option as proven by the events of 2021, where PV factories in China were unable to produce for some time and, as a result, there was a shortage of PV panels in Europe and very long waiting times. In this field, initiatives like the **Important Projects of Common European Interest (IPCEI)**[15] **on PV** should be supported immediately by substantial investments from the EU and the Member States. In this way, research and industry would be able to collaborate to swiftly bring back the complete value chain to Europe.

Furthermore, because of space constraints the EU should capitalise on its technological leadership in the field of "**integrated photovoltaics**" and boost funding to research and development in this technology. PV is particularly suited for integration in a broad variety of environments because of the absence of rotating parts resulting in the absence of noise and a limited need for maintenance. Integrated PV refers to the integration of solar cell technology in the built environment, infrastructure, agricultural environments, on water and on vehicles. This

[15] https://ec.europa.eu/competition-policy/state-aid/legislation/modernisation/ipcei_en

requires a close and strong interaction between producer, designer, installer and customer and represents an opportunity for the development of a local industrial eco-system that is distinct from and not in competition with the giants that now dominate the PV market for standardized PV systems.

As far as **wind energy** is concerned, the research community can first and foremost play a vital role in **developing a revised assessment of resources onland and offshore**. This assessment should be carried out according to the latest technology developments and the latest existing wind conditions data (wind resources and site suitablity data). Subsequently, another important step consists in providing innovations to accelerate the **implementation of larger wind energy projects**. In terms of technological barriers to overcome, **system integration innovations can be implemented relatively fast**, while **impact on ecology and society should be minimised**. Innovations and guidelines for this process should be addressed by different partners in the various countries to account for existing heterogeneous geographical conditions. **Administrative barriers**, for example those related to **permitting procedures**, should also be tackled.

Two will be the main realms of interest for wind energy research: **system integration** and **floating wind**. In both cases, the experience learnt from EU projects will prove to be crucial when executed, as the insights can quickly be implemented in offshore wind developments and system integration. The potential held by floating wind technology opens up completely new areas of research, while system integration is essential to absorb the large amount of energy injected in the energy system. Both areas of study can provide short and long term results, advancing wind energy fast enough to achieve the goals set for 2030.

Making the transition as technology-inclusive as possible

While certainly fundamental in the short term due to the nature of their technological advancement and deployment, wind and solar energy are part of a more complex system of energy sources.

Nuclear energy, although still a controversial point in EU policy also in relation to the debate over the EU taxonomy, can be a part of the solution as it currently represents a large section of the EU's generated electricity. Delaying the planned shutdowns of nuclear power plants could be a short term answer, but in the long run the support to small and medium sized nuclear reactors can prove to be effective, in pair with licensing and construction of next generation reactors focused on fuel recycling rather than new materials sourcing.

Other technologies can prove powerful tools to transition away from Russian fossil fuels, tackle high energy prices and attain climate objectives. **Concentrating Solar Thermal technologies** can play a decisive role in delivering electricity overnight, thus complementing PV plants and partially replacing currents combined cicle and coal-fired power plants. To capitalise on the technology's potential, there is a need among other actions to promote **solar hybrid projects** combining concentrated solar power and PV panels, to couple existing coal and gas plants to CSP plants with Thermal Storage, and to apply high TRL technology solutions to integrate solar energy in upgrading fuels and biomass.

Similarly, **geothermal energy** will be crucial to substitute gas in district heating systems, with and without the contribution of ground-based heat pumps. Researchers can provide regional concepts to combine seasonal heat storage for cooling and heating, based on the different geological conditions and demand structure. This would help balance the fluctuating supply from other renewables, as is the case of the power-to-heat application which exploits the vast amount of excess power provided by PV, mainly in the summer period.

Energy efficiency and sufficiency, then, will need to span through and go beyond all the mentioned technologies for their high potential to attain large volumes of energy savings, tackle energy poverty and foster a culture of energy sobriety and moderation. One of the most recent initiatives in this regard is the collaboration between the EU Commission and the International Energy Agency on a set of actions[16] aimed at reducing energy use among EU citizens. Crucial in this field will be nonetheless the achievement of energy consumption reductions at industrial and company levels, where larger volumes of energy savings can be reached.

Energy system modelling will also eventually have an important impact on the EU energy systems. As there is no common EU model, analyses would need to be performed by running the models of a number of institutions that evaluate the results jointly. **Modelling can support policymaking in many aspects**, including deciding how to best use existing resources, showing the consequences of gas imports, presenting an EU-wide outlook and planning further steps such as transmission capacity increase. Nonetheless, a common energy modelling strategy does not exist at European level, leaving the EU trailing behind in policy planning.

Potential R&I challenges connected to REPowerEU include:

- Develop further integrated photovoltaics and bring back to the EU the solar supply chain
- Explore systems integration for larger wind projects, including floating wind
- Continue developing next generation nuclear reactors focused on fuel recycling
- Explore energy system modelling for measures such as transmission capacity increasing
- Promote solar hybrid projects combining concentrated solar power and PV panels
- Empower geothermal energy research to further develop ground-based heat pumps

16 https://ec.europa.eu/info/news/european-commission-and-iea-outline-key-energy-saving-actions-2022-apr-21_en

Conclusions

The REPowerEU Communication is a bold reply to the consequences that the Russian invasion of Ukraine has on the EU energy system, the enduring high energy prices and the need to pursue the EU climate goals for 2030 and 2050. Squaring the circle proves to be a complex task, as many short term goals risk being conficting with medium to long term priorities.

In this context, it will be of the utmost importance to base any legislative action stemming from the REPowerEU Communication on the vision for a **sustainable, fair and just transition to the benefit of all EU citizens and businesses**, the principles of **EU security of supply and Stategic Autonomy** as well as on the promotion **of EU leadership in climate diplomacy and technology transfer**. The integration of **climate adaptation** considerations and the active support the achievement of the **United Nations Sustainable Development Goals** will be equally crucial to the success of the initiative.

Hydrogen was recently defined by EU climate chief Frans Timmermans as the '[pivotal element]' in Europe's future economy, stating he strongly believes green hydrogen will be the driving force of energy systems of the future.

On a more concrete level, several are the low-hanging fruits to which REPower can look at to unlock suitable solutions to the challenges it aims to tackle. Among these, the **accelerated permitting procedure for renewable energy projects** will be key for all Member States and will be a transveral boost for many different energy applications. In addition, the **focus on hydrogen** will be beneficial to all EU member states in driving the clean enery transition, by eliminating the necessity for dependence on foreign gas and helping national economies by creating jobs and fostering innovation.

The measures proposed will also importantly have an underpinning goal: **increasing the energy efficiency of all processes**, mainly in industry and buildings. This goal, in line with EU legislation, will have the effect of making the EU more independent and cleaner in the long run, reaching both EU objectives and obtaining a transition that is clean, fair and future proof for all citizens. This is a goal in line with SUPEERA and EERA's mission and objectives, and through the research on clean energy technologies the EERA community will be a fundamental actor in all developments to come.

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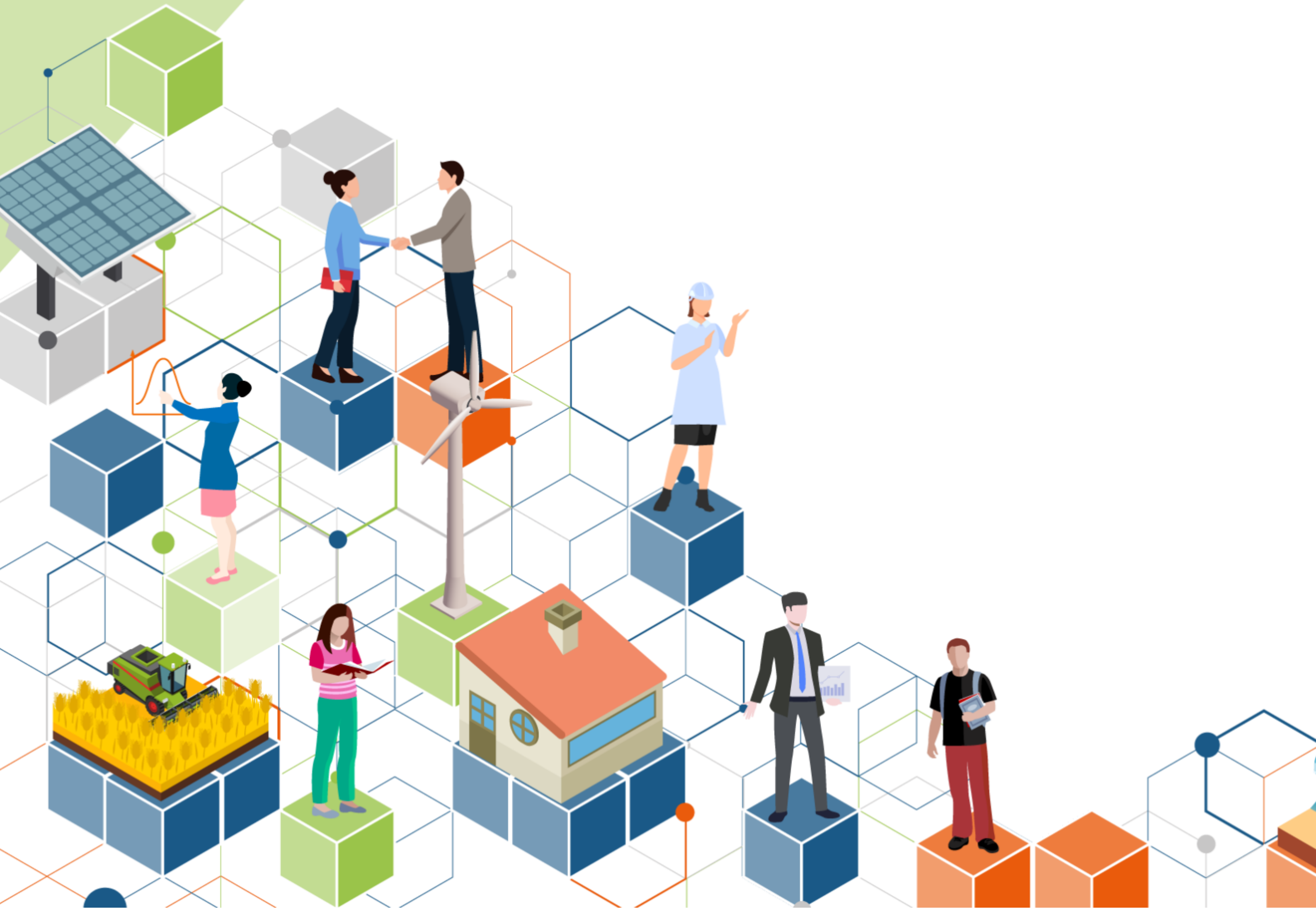
Support to the coordination of national research and innovation programmes in areas of activity of the European Energy Research Alliance

SUPEERA

Policy Brief

EU BIODIVERSITY STRATEGY

- CHALLENGES AND OPPORTUNITIES AHEAD



Setting the scene

Two years after the launch of the European Green Deal, the European Union has made substantial steps forward in its efforts to promote the green transition. The publishing of the Fit for 55 package in 2021 is the most telling example of this endavour and the finalisation and roll out of the legislative proposals therein contained in the next years will be crucial to attain the 2030 and 2050 EU climate goals.

The year 2022 initally marked a crucial moment for European research, and the EU in general, signalling the halfway point of the current European Commission and European Parliament terms, but also the start of the Horizon Europe Missions. Nonetheless, it has already become a watershed point in energy research and management in the EU due to the unfolding of two major crises: the rise in energy prices and the war in Ukraine led by Russia. The two are highly intertwined and pose serious challenges to energy security in Europe.

Efforts to increase the autonomy of the EU in energy terms will be undermined without the active participation and support of the research community. Only by combining state of the art research with careful policymaking the EU will be able to reach its ambitious goal of detaching from Russian fossil fuels by 2030 and becoming climate neutral by 2050. The research community has a pivotal role to play in this process, supporting identified political priorities with empirical findings and developments. It can also advise policymakers on the way forward through fundamental research, particularly focused on low TRLs, to advance breakthrough technologies, materials, and systemic approaches. Crucial in this effort will be the participation of the industrial sector, without which developments will be unattainable. In particular with the new objectives posed by REPowerEU, a close interaction between research, industry and Member States will be more fundamental than ever.

In the context of the SUPEERA project, a series of policy briefs are currently being developed to identify concrete R&I challenges in EU policies relevant to the energy research community. The final goal is to support the achievement of the Clean Energy Transition (CET). This policy brief focuses on the EU Biodiversity Strategy for 2030, published by the European Commission in May 2020 as a key document to ensure that the defense of Europe's biosphere will remain at the top of the policy agenda.

The EC Communication for a EU Biodiversity Strategy for 2030

The European Commission published on 20 May 2020 the "**EU Biodiversity Strategy for 2030**"[17], a comprehensive, ambitious and long-term plan to protect nature and reverse the degradation of ecosystems. The strategy aims to put Europe's biodiversity on a path to recovery by 2030 and contains specific actions and commitments.

The table below summarises each objective's main actions and features by following the document's structure.

Key priorities	Identified R&I challenges
Decarbonisation of the energy system and decreasing pollution	6. In light of the EU Green Deal and the efforts to decarbonise the energy system: 6.1. Invest in the deployment of more sustainably sourced renewable energy with a priority on ocean energy, offshore wind, solar-panel farms, sustainable bioenergy. 6.2. Increase energy efficiency to reduce energy consumption and reducing consumption from sources and energy technologies that damage the environment or don't contribute to the reduction of GHG emissions. 6.3. Further pressure to minimize the use of whole trees, food and feed crops as biofuels for energy production – increasing the sustainability criteria as highlighted in the Renewable Energy Directive
Compatibility of renewable energy infrastructure and biodiversity restoration	7. The restoration of biodiversity should take into account the deployment of renewable energy and vice-versa: 7.1. Member States shall assess and ensure if suitable land and sea areas are available for renewable energy projects, considering their national energy and climate plans, the availability of resources, grid infrastructure and the targets of EU Biodiversity Strategy – as outlined in REPowerEU. 7.2. Promoting energy performance and efficiency of buildings, in addition to accelerating the permitting for renewable energy projects, while providing identification of renewable go-to areas, either on land or sea. 7.3. Ensuring compatibility of the designation of these renewable go-to areas while maintaining and fostering the Member States' respective national restoration plans. 7.4. Encouraging Member States to foster synergies between their restoration plans and the designation of renewable go-to areas in, for instance, managing the permitting procedures applicable to both endeavours. 8. Ensuring that the deployment or use of renewable energy technologies does not harm green/blue areas and the biodiversity within them: 8.1. Mitigating the harmful local environmental effects that the deployment of certain technologies may have, such as the possible negative impact of Marine energy technologies on Marine biodiversity 8.2. The EU is thus prioritising options such as: offshore wind, which also allows for fish stock regeneration; solar-panel farms that provide biodiversity-friendly soil cover; amongst other options. 8.3. Increasing need to assess and consider such risks as the Clean Energy Transition and the subsequent deployment of additional renewable energy infrastructure
Increasing the sustainability and management of biomass and biofuels-based energy sources	6. Ensuring that the future supply of woody biomass won't hamper the efforts made to increase the forest area in the EU, which will substantially increase if the GHG emissions are indeed drastically reduced by 2050 6.1. Fostering compatibility between the climate neutrality goals (and their subsequent benefits for biodiversity) and the use of biomass and biofuels energy – as indicated in the Renewable Energy Directive. 6.2. Establishment of thresholds that allow for a win-win scenario in forest management and woody biomass for energy production, in a way that reduces pressures on forest and agro-ecosystems, while allowing for the continuation of bioenergy production in a sustainable way.

[17] Official Strategy Overview

	7. Increasing the sustainability criteria of bioenergy and the use of biofuels
Building an integrated and sustainable whole-of-society approach	8. Ensuring that environmental and social interests are fully embedded into business strategies in order to increase sustainable corporate governance: 8.1. The European Commission will incentivise nature-based solutions and businesses, which will lead to a significant increase in employment opportunities in various sectors that are key for innovation in biodiversity-friendly businesses. 8.2. Measuring the environmental footprint of products and organisations through life-cycle analysis and natural capital accounting. 9. Develop a trade policy that actively contributes to the ecological transition by fostering trade and imports of products into the EU that are environmentally friendly and sustainable and do not harm the environment through, for instance, contributing to deforestation or undesirable CO2 emissions.
Improving knowledge, education and skills	10. Fostering and increasing research and innovation on biodiversity and investing in the respective solutions. 11. Training and reskilling the workforce across a wide range of sectors. 12. Incentivising local, regional, national and European level partnerships and cooperation in the research and innovation community. 13. The Horizon Europe Programme will include a long-term strategic research agenda for biodiversity, including a science policy mechanism for research-based options.

Biodiversity and energy have the potential to be mutually beneficial instead of clashing forces

Biodiversity has become a **crucial theme in current policy planning.** From a tipping point[18] perspective, looking at the physical limits of planet Earth in terms of nature preservation, **the protection of biodiversity is an absolute priority**. It reduces the speed at which humanity is approaching the boundaries of an irreversible modification of all species' living environment. Many forms of energy result from a service provided by ecosystems (e.g., agroecosystems, forest ecosystems, grassland ecosystems, and aquatic ecosystems). Conversely, society's growing requirements for energy are resulting in significant changes in the same ecosystems, both in the search for energy sources and due to energy use patterns. Given that energy is a fundamental requirement for supporting development in all economies, the challenge is to sustainably provide it without driving further loss of biodiversity.

The **exploitation of fossil fuel sources along the entire supply chain** is arguably the activity which usually leads to the biggest damage to biodiversity[19]. A driver of climate change, it is also associated with air pollution, including acid rain[20]. Punctual phenomena like oil spills are reported to be extremely harmful to aquatic and marine ecosystems[21]. Shale oil and gas can

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[18] https://www.stockholmresilience.org/research/research-news/2013-11-06-avoid-tipping-over.html

[19] Harfoot, MBJ, Tittensor, DP, Knight, S, et al. Present and future biodiversity risks from fossil fuel exploitation. Conservation Letters. 2018; 11:e12448. https://doi.org/10.1111/conl.12448; Butt, Nathalie & Beyer, Hawthorne & Bennett, Joseph & Biggs, Duan & Maggini, Ramona & Mills, Morena & Renwick, A & Seabrook, Leonie & Possingham, Hugh. (2013). Biodiversity Risks from Fossil Fuel Extraction. Science (New York, N.Y.). 342. 425-6. 10.1126/science.1237261.

[20] Grennfelt, P., Engleryd, A., Forsius, M. et al. Acid rain and air pollution: 50 years of progress in environmental science and policy. Ambio 49, 849–864 (2020). https://doi.org/10.1007/s13280-019-01244-4

[21] Eklund, R. L., Knapp, L. C., Sandifer, P. A., & Colwell, R. C. (2019). Oil Spills and Human Health: Contributions of the Gulf of Mexico Research Initiative. GeoHealth, 3, 391– 406. https://doi.org/10.1029/2019GH000217

also severely impact ground waters and other natural ecosystems[22]. While **phasing out fossil fuels needs to stay as an urgent and overarching global priority**, it is critical to **include biodiversity considerations in all ongoing fossil-fuel-related activities** with the view to minimise damage and plan future reconversion and ecosystem restoration.

While impacts on biodiversity are more evident in the case of fossil fuels, those tend to be less apparent for renewable energy sources (RES). The environmental performance of renewable energy solutions is now at the centre of the stage. Given the recent provisions in EU legislation, the deployment of RES should be strongly increased to face the issues created by the energy crisis in the EU. To counter the decrease in Russian gas supply, the EU plans to use RES as the primary tool to secure energy supply.

One of the challenges linked to RES uptake is related to permitting procedures for renewable energy projects, which are now deemed to be far too long. To answer the matter, the EU has established that Member States will be encouraged to create **"go-to areas" for the installation of RES**, where permits will follow a faster approval process. While the measure answers investors' concerns, it raises doubts about the projects' ecosystem and biodiversity impact assessment.

Another issue connected to the fast deployment of several RES and which deserves particular attention from a biodiversity perspective is the **mining of Critical Raw Materials (CRM).** Policy steps in this direction should ensure that biodiversity considerations cover industrial development in Europe as well as the actual production process of clean energy technologies. In addition, it will be important to envisage biodiversity impact assessment frameworks for the technologies currently at a lower TRL level but that will become increasingly important in the future, such as hydrogen.

Against this background, research has a critical role to play by not only identifying **solutions that minimise RES impacts on the ecosystems** but also **actively supporting nature preservation and restoration**.

The section below looks at some key examples of energy sources, their impacts on biodiversity and how these can be best addressed.

Solar energy is today one of the major players in the renewable energy sector, not only because its price has increasingly dropped in the past years but also given the consistent push that REPowerEU gives to its deployment, especially in the case of solar PV. One of the major impacts is the one on land, as solar installations can modify and fragment considerable amounts of land. They might not only represent an obstacle to the movement of different animal species but increase deaths due to heliostat collisions and burning[23]. Impacts on biodiversity also include the damage to water-scarce ecosystems brought by concentrated solar power (CSP) plants, which need large amounts of water. Nonetheless, solar energy has ample margins for improvement. The **integration of PV installations with agricultural areas**, for example, will ensure that solar panels co-exist with the ecosystem instead of creating dangers

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[22] Margaret C. Brittingham, Kelly O. Maloney, Aïda M. Farag, David D. Harper, and Zachary H. Bowen Environmental Science & Technology 2014 48 (19), 11034-11047
DOI: 10.1021/es5020482

[23] A. Gasparatos et al., 2017, "Renewable energy and biodiversity: Implications for transitioning to a Green Economy"

to its existence and diversity. In general, **building solar installations in low-biodiversity areas** could already represent a step forward. Furthermore, **reducing the environmental footprint of PV equipment and installation procedure** could go a long way. Overarching will also be the **research on materials**, making the mining activities related to panel deployment more sustainable.

Wind energy must be discussed concerning the location of its production: offshore and onshore wind each carry their own opportunities and challenges. Both technologies present their unique issues, mainly impacting fauna offshore and onshore, with the former also affecting maritime flora. The main threat is the collision of birds and downdraught generated by turbine movement, and additional information is needed on the impacts of wind farms on insects, mammals and other fauna. Nonetheless, researchers are already working on addressing the main issues: not only **designating proper installation areas**, but also **improving biodiversity protection in processes and instruments** for wind operations. These actions will require thorough research, as the most suitable locations for wind deployment (e.g., unpopulated areas) also represent the greater risk for animal populations. Also, **aggregation of turbines** could be an option to reduce the impact on fauna, given the higher visibility that multiple turbines would have.

Hydropower is an additional technology posing serious challenges to biodiversity, but compared to the previous examples, is also much more influenced by environmental modifications. The construction of dams and structures in rivers impacts the water flow regimes of different environments, affecting fish communities needing to navigate water streams, plants, and the broader aquatic ecosystem. The fragmentation of water streams due to the construction of barriers is a powerful factor in this process. Nonetheless, changes in the surrounding environment threaten hydropower itself: reduced soil water retention, increase in debris from forests and water plants, and augmented or decreased precipitation are all features of a less healthy and diverse environment. This situation could be highly damaging for hydropower structures and impair the technology's potential for energy production. Hydropower needs to seriously factor in biodiversity issues, as its existence highly depends on ecosystem changes. The **development of pumped-hydro solutions** will be key for the long-term survival of the technology, especially in the case of prolonged droughts and low rainfall levels. But more broadly, research should aim to **create new solutions that look at nature for inspiration.** Some examples of sustainable management of soils include reforestation, reclaiming of land, and restoration of ecosystems: all of these can contribute to increasing water holding capacity in the soil and reducing surface runoff.

Another prominent example of the interrelation between energy and biodiversity is the use of **bioenergy**. The land use correlated with the increase of feedstock for energy solutions can substantially impact habitat and biodiversity loss, although this is context-specific according to research[24]. In addition, biomass energy operations have been documented to release harmful emissions into the environment, again with some exceptions. In this case, factors influencing emissions include feedstock, yields, conversion technologies and pollution control

[24] Núñez-Regueiro, M.M., Siddiqui, S.F. and Fletcher, R.J., Jr (2021), Effects of bioenergy on biodiversity arising from land-use change and crop type. Conservation Biology, 35: 77-87. https://doi.org/10.1111/cobi.13452

mechanisms[25]. Most of the same risks apply to feedstock for biofuels too. However, **side and waste streams for bioenergy production typically impact biodiversity much less.** Research for improved biodiversity protection can look **to mitigation measures like the reduction of monocultures** and the **adoption of more environmentally-friendly processes**, including the development of impact assessment tools to effectively mitigate risks connected with the practice.

In addition to these examples, many more are the dynamics at play between RES and biodiversity. The impacts of the European energy systems on biodiversity can be direct on land, waters, forest and other natural ecosystems but also indirect when considering repercussions on developing countries and regions. When thinking of solutions for a better future, research is a key area to invest in. **R&D investment will therefore be needed** if the EU plans aim to be effective, as the increase in renewable energy deployment foreseen by the EU institutions will not be sustainable in the long run if environmental protection is not factored into the equation.

Finally, **nuclear energy** should also be given careful attention. Currently, there is little research on the impacts of nuclear energy on the surrounding ecosystem. This is mainly because compared to the previously mentioned energy sources, nuclear has much less impact on the environment, given its small land footprint. Nonetheless, the technology has remarkable effects on biodiversity, mainly related to operating risks, long-term radioactive wastes, thermal pollution or mining threats[26]. For example, releasing cooling water into water streams has a non-negligible impact on aquatic fauna and flora[27]. Researchers should therefore set their sights **on innovation in the management of nuclear energy operations,** ranging from the treatment of wastewater to the overall sustainability of the production process.

[25] A. Gasparatos et al., 2017, “Renewable energy and biodiversity: Implications for transitioning to a Green Economy”
[26] Patricia Mateo-Tomás, José Vicente López-Bao, A nuclear future for biodiversity conservation?, Biological Conservation, Volume 270, 2022, 109559, ISSN 0006-3207, https://doi.org/10.1016/j.biocon.2022.109559.
[27] Madden, N., Lewis, A., Davis, M., 2013. Thermal effluent from the power sector: an analysis of once-through cooling system impacts on surface water temperature. Environ. Res. Lett. 8, 035006.

Conclusions

Ensuring access to energy while maintaining biodiversity and vital ecosystem services will require an **integrated and practical multi-pronged approach**. In this regard, a **holistic perspective** to managing biodiversity and natural resources will be needed, together with a **shift in environmental governance** to incorporate policies and incentives promoting energy production and use. Besides**, increasing partnerships with the private sector** to promote energy programmes that internalise the total costs of biodiversity and livelihoods will also be critical. The EU Biodiversity Strategy for 2030 is undoubtedly a step in the right direction, although more decisive action is needed.

Research must play a critical role in this effort by identifying solutions that minimise the impacts of energy on the ecosystems and actively support nature preservation and restoration. In this respect, a **sustained R&I&D investment** will be key to ensuring the availability of the latest state-of-the-art environmental protection measures to minimise the negative impacts on biodiversity in the EU and their repercussions on a global scale.

In the specifics of the various energy sources and their deployment, the case of **fossil fuels** is arguably the one having the most impact on biodiversity. While their urgent phasing-out remains the absolute priority, it will be nevertheless critical to include biodiversity considerations into all ongoing activities to lessen damage and plan future reconversion and ecosystem restoration.

As far as RES are concerned, research can develop in various directions to minimise biodiversity loss and install a virtuous circle of ecosystem restoration:

- **Solar energy** entails substantial land use issues but also a high potential for improvement regarding biodiversity. The research community can play a decisive role, e.g., in ensuring reduced ecosystem damage by solar panels, minimising the environmental footprint of PV equipment and installation procedures, and in promoting further research on materials.
- To enhance biodiversity performance of **wind energy**, researchers are designating proper installation areas and improving biodiversity protection in processes and instruments.
- Research should aim to develop solutions around **hydropower** that look at nature for inspiration**,** with sustainable management of soils, including reforestation, reclaiming of land, and restoration of ecosystems.
- In **bioenergy**, research should look at measures such as the reduction of monocultures and the adoption of more environmentally-friendly processes along with the development of impact assessment tools to effectively reduce related risks.

Finally, as far as **nuclear energy** is concerned, researchers should focus on the innovation of biodiversity-related practices in nuclear energy operations, including waste materials management.

Support to the coordination of national research and innovation programmes in areas of activity of the European Energy Research Alliance

SUPEERA

Policy Brief

Sustainable Carbon Cycles

- CHALLENGES AND OPPORTUNITIES AHEAD

Setting the scene

Three years after the launch of the European Green Deal, the European Union has made substantial steps forward in its efforts to promote the green transition. The publishing of the Fit for 55 package in 2021 is the most telling example of this endavour and the finalisation and roll out of the legislative proposals therein contained in the next years will be crucial to attaining the 2030 and 2050 EU climate goals.

The year 2022 also marks a crucial moment for European research, and the EU in general. It will not only signal the halfway of the current European Commission and European Parliament terms, but it will also see the Horizon Europe Missions – new instruments designed to reduce the distance between citizens, researchers, policymakers and local government - at work, after being launched in 2021.

These efforts will be invalidated without the active participation and support of the research community as only by combining state-of-the-art research with careful policymaking the EU will be able to reach its ambitious goal of becoming climate neutral by 2050. The research community has a pivotal role to play in this process, supporting identified political priorities with empirical findings and developments. It can also advise policymakers on the way forward through fundamental research, particularly focused on low TRLs, to advance breakthrough technologies, materials, and systemic approaches. Crucial in this effort will be the participation of the industrial sector, without which developments will be unattainable. In particular with the new objectives posed by REPowerEU, a close interaction between research, industry and Member States will be more fundamental than ever.

In the context of the SUPEERA project, a series of policy briefs are currently being developed to identify concrete R&I challenges in EU policies relevant to the energy research community. The final goal is to support the achievement of the Clean Energy Transition (CET). This Policy Brief will focus on the EC Communication on Sustainable Carbon Cycles launched in December 2021, having as a main goal to create resilient and sustainable carbon capture, storage and use practices in the EU.

The EC Communication on Sustainable Carbon Cycles

The EC Communication on Sustainable Carbon Cycles of last 15 December 2021 introduces the EU's objective to implement sustainable and resilient carbon cycles in Europe, in accordance with the indications given by the International Panel on Climate Change and its reports on the status of global climate[28]. As stated by the EU Commission, this could be achieved by reducing the EU's reliance on carbon (by improving efficiency of building, transport and industries), recycling carbon to be used in place of fossil carbon, and upscaling carbon removal solutions that capture and store CO2, either through nature-based or industrial solutions.

The table below summarises the main R&I challenges of the Communication, divided following the structure of the document:

Key priorities	Identified R&I challenges
Role of carbon farming	5. Reverse the decline in carbon removal by forests and return to above 300 MtCO2eq removed annually (pre-2013 levels) 6. Establish a proper and functioning system of incentives for land managers to increase carbon removals and protect carbon stocks 7. Enable key stakeholders in sustainable carbon management to deliver on recovery of biodiversity and nature protection 8. Enhance the potential for carbon farming practices to provide co-benefits on biodiversity and ecosystem services 9. Facilitate knowledge and access to carbon farming opportunities for land managers, by facilitating and tailoring training and advisory services 10. Standardise the methodologies and rules for monitoring, reporting and verifying (MRV) 11. Carbon farming initiatives should contribute to the increase by 42 Mt CO2eq of the land sink that is required to meet the objective of 310 Mt CO2eq net removals by 2030 12. Harmonise forest-related information across the EU 13. Facilitate the installment of a demonstration network on climate-smart farming 14. Fully exploit the potential of digital technologies and data technologies for more accurate, cost effective and efficient estimates of carbon emissions 15. Provide solutions to enhance resilience and protection of EU coastal areas 16. Increased knowledge and data on blue carbon quantification
Industrial capture, use and storage of carbon	9. Improve the climate performance of buildings, being able to reduce overall emissions of the construction sector while storing substantial amounts of carbon 10. Develop scientifically sound methodologies, with the objective of acknowledging carbon storage in all European frameworks related to the climate performance of products 11. Develop innovative projects that replace energy-intensive materials, such as cement and steel, with bio-based materials and products. 12. Improve solutions to turn the CO2 from a waste to a resource and use it as feedstock for the production of chemicals, plastics or fuels 13. Bring down the costs of producing methanol from CO2, opening the road to the production of a large range of chemicals such as ethylene or propylene 14. Study the potential of depleted oil and gas reservoirs and saline aquifers to store billion tonnes of CO2 in offshore sites 15. Ensure that at least 20% of the carbon used in the chemical and plastic products should be from sustainable non-fossil sources by 2030 16. Remove and permanently store 5Mt of CO2 annually from the atmosphere by 2030 17. Improve the infrastructure capacity for transport and storage of CO2

[28] April 2022 Working Group III report of the Intergovernmental Panel on Climate Change (IPCC) - https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf#page=48

	18. Develop an efficient system for the traceability of captured CO2 that can track how much fossil, biogenic or atmospheric CO2, respectively, is transported, processed, stored and potentially re-emitted to the atmosphere each year

Sustainable Carbon Cycles plans open the door to the future of emissions management

Planet Earth is heating up, there is no doubt about it and there is ever less doubt on the fact that humans have sped up the process leading to global warming, according to the latest reports from the IPCC[29]. In particular, the emissions of damaging gases like CO2 and CH4 (methane) have proved catastrophic in leading to higher average temperatures across the world. So much that, in order to prevent further degradation of the environment, and to support the larger efforts aiming at a clean energy transition[30], we will need not only to develop renewable energy systems as such, but also think about how to capture, store and use the excessive carbon emissions that we produce.

This is the aim of the EC's communication, which focuses on the sustainability of carbon cycles in the EU. Proper management of carbon cycles can answer Europe's need for carbon, particularly fossil-based, as a material or feedstock for products through reuse, reduce and recycle or substitution approach. The Communication mentions the need to increase the presence and use of natural carbon sinks, and discusses the position of carbon capture in the process. The link with energy technologies can be then directly made with CCUS (Carbon Capture, Use, and Storage) developments. The technology has made giant leaps forward in the past decades, and offers today a valuable contribution to the clean energy transition and the attainment of the Green Deal goals in the EU.

Capturing CO2 directly from the atmosphere using direct air capture with carbon storage (DACCS), and using biomass, which has sequestered CO2, to produce bioenergy with carbon capture and storage (BECCS) are the two best known methodologies of technology-based carbon capture.

Direct air capture with carbon storage is probably the most mainstream technology known to the public, when it comes to CCS developments. DACCS uses chemical solutions which bind the CO2 and release the air back into the atmosphere. The method involves either passing the captured air through filters with solid sorbents or using a liquid chemical solution. There are presently 19 DACCS plants operating worldwide, capturing more than 0.01 Mt CO2/year[31]. The number is expected to grow, as the hopes of many nations worldwide are ever more pointing to negative emissions technologies according to IPCC reports. However, increasing DACCS operations will create a new challenge: energy demands. According to recent studies, machinery absorbing CO2 from the air could grow to require as much as a quarter of the total

[29] https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/
[30] EERA (2021), White Paper on the Clean Energy Transition, European Energy Research Alliance, Brussels
[31] Mihrimah Ozkan, Saswat Priyadarshi Nayak, Anthony D. Ruiz, Wenmei Jiang, Current status and pillars of direct air capture technologies, iScience, Volume 25, Issue 4, 2022, 103990, ISSN 2589-0042, https://doi.org/10.1016/j.isci.2022.103990 (https://www.sciencedirect.com/science/article/pii/S2589004222002607)

energy supply by 2100[32]. Given the important potential of the technology, it will be therefore crucial for researchers to address how this could impact energy systems.

Bioenergy with carbon capture and storage (BECCS) is the other major sector in the field. Here, investment needs vary differently across the technology spectrum. According to the IEA[33], bioethanol is an up-and-coming leader in the field, but further BECCS applications lack the proper policy landscape to grow further. Among the developments most needed in the field, we can single out instruments to reduce high upfront costs, long payback periods, biomass supply sustainability and the further development of transport and storage infrastructures. R&D areas of interest for future technologies, in need of public and private investment, include advanced gasification for hydrogen production, low-energy-penalty capture technologies, and solid-adsorption capture through metal organic frameworks[34]. At the same time, the relationship between BECCS and land use must be further explored, as models show that relying heavily on BECCS could require land areas up to five times the size of India devoted to growing the biomass needed[35].

To boost the development of the technology, the availability of data will be fundamental. The collection of key data along the whole CCS value chains will give legislators, researchers and industry alike a better grasp of the real impact of carbon removals and environmental impact. Key areas of focus include accounting and verification of the feedstock biogenic carbon content in waste-to-energy and co-firing applications, the permanence of CO2 storage and reversal risk, and carbon dioxide removal (CDR) allocation across multi-stakeholder, cross-boundary BECCS value chains[36].

Infrastructure could prove to be one of the most crucial topics in the years to come. Decisions on the location of CCS operations bases are subject to multiple and complex factors, that need to consider carefully the historical problems of social acceptance of CCS processes in populated areas. The point on infrastructures is key if we consider that according to estimations, a single plant with an absorbing capacity of 1Mt CO2/year would require an area of 0.2 km2, equivalent to 28 soccer fields. In addition, for a liquid solvent DAC technology today to capture one ton of CO2 nearly 1–7 tons of water are used and, in some cases, this may reach 13 tons[37]. More research will be needed, as the need to make the technology more

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[32] Realmonte, G., Drouet, L., Gambhir, A. *et al.* An inter-model assessment of the role of direct air capture in deep mitigation pathways. *Nat Commun* 10, 3277 (2019). https://doi.org/10.1038/s41467-019-10842-5

[33] IEA (2022), *Bioenergy with Carbon Capture and Storage*, IEA, Paris https://www.iea.org/reports/bioenergy-with-carbon-capture-and-storage, License: CC BY 4.0

[34] IEA (2022), *Bioenergy with Carbon Capture and Storage*, IEA, Paris https://www.iea.org/reports/bioenergy-with-carbon-capture-and-storage, License: CC BY 4.0

[35] Alexander Popp, Katherine Calvin, Shinichiro Fujimori, Petr Havlik, Florian Humpenöder, Elke Stehfest, Benjamin Leon Bodirsky, Jan Philipp Dietrich, Jonathan C. Doelmann, Mykola Gusti, Tomoko Hasegawa, Page Kyle, Michael Obersteiner, Andrzej Tabeau, Kiyoshi Takahashi, Hugo Valin, Stephanie Waldhoff, Isabelle Weindl, Marshall Wise, Elmar Kriegler, Hermann Lotze-Campen, Oliver Fricko, Keywan Riahi, Detlef P. van Vuuren, Land-use futures in the shared socio-economic pathways, Global Environmental Change, Volume 42, 2017, Pages 331-345, ISSN 0959-3780, https://doi.org/10.1016/j.gloenvcha.2016.10.002.

[36] IEA (2022), *Bioenergy with Carbon Capture and Storage*, IEA, Paris https://www.iea.org/reports/bioenergy-with-carbon-capture-and-storage, License: CC BY 4.0

[37] Mihrimah Ozkan, Saswat Priyadarshi Nayak, Anthony D. Ruiz, Wenmei Jiang, Current status and pillars of direct air capture technologies, iScience, Volume 25, Issue 4, 2022, 103990, ISSN 2589-0042, https://doi.org/10.1016/j.isci.2022.103990.

appealing and reasonable to society will have a great impact on its potential for development. Still, there is also a technical side to the problem: building an interconnected network for emitters will be a major challenge for the EU as a whole. Different steps along the value chains also suffer from forced distance, including challenges in connecting different industrial complexes[38].

The future of CCS also includes the possible pathways related to using the captured CO2. As shown in an analysis by our SUPEERA Partners, Finnish research organization VTT, the carbon reuse economy can profoundly impact many different aspects of life. These range from chemicals and materials derived from CO2 and food products. Most interesting for the purposes of this document and community, however, are CO_2-derived energy carriers and fuels. The authors argue that, in a future where CO2 capture and fossil-free energy will be cheap processes, the value network for using CO2 to produce sustainable fuel production will be a strong component in the clean energy world. Still, they say, this value network can already start today by supporting innovative processes, such as modular decentralised production of hydrocarbon fuels from carbon dioxide and hydrogen, or boosting the biomass to liquids (BTL) process by low-carbon hydrogen[39].

To conclude, the proposal for a certification of carbon removals from the EU published last 30 November[40] is a significant push forward in the direction of CCUS developments. Improving the EU's capacity to quantify, monitor and verify carbon removals will create the conditions for stable classification of best practices and points of strength in carbon value chains. This higher transparency and accountability will strongly enhance the attractiveness of the sector for investors and stakeholders, therefore keeping the sector growing where it is needed and where it is most successful. However, important will be to continue encouraging research on lower TRLs for CCS, as many technologies of tomorrow risk otherwise remaining closed in a lab.

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[38] IEA (2022), *Bioenergy with Carbon Capture and Storage*, IEA, Paris https://www.iea.org/reports/bioenergy-with-carbon-capture-and-storage, License: CC BY 4.0

[39] Lehtonen, J. (Ed.), Järnefelt, V. (Ed.), Alakurtti, S., Arasto, A., Hannula, I., Harlin, A., Koljonen, T., Lantto, R.,
Lienemann, M., Onarheim, K., Pitkänen, J-P., & Tähtinen, M. (2019). The Carbon Reuse Economy: Transforming CO2 from a pollutant into a resource. VTT Technical Research Centre of Finland. https://doi.org/10.32040/2019.978-951-38-8709-4

[40] European Commission's Proposal for a Regulation on an EU certification for carbon removals. https://climate.ec.europa.eu/document/fad4a049-ff98-476f-b626-b46c6afdded3_en

Conclusions

The EC Communication on Sustainable Carbon Cycles is one of the cornerstones of the future legislation contributing to the objective of climate neutrality by 2050 in the EU. The potential of carbon removals to protect and regenerate biodiversity and the environment will be crucial for the EU in managing emissions, soils, and energy applications.

Still, the Communication opens up challenges and focus points for research and innovation, mainly regarding CCUS applications. Infrastructure, data and social impact will all need to be carefully assessed and developed to be exploited at full potential. The research performed in these areas will bring to light new capacities, new skills and new innovations that will bring us closer to making our environment more sustainable. Still, the imperative remains: research must be taken up, not only by industry but also by policymakers, as a serious player in the fight against global warming. Funding is a starting place, but it cannot be all. In particular, when it comes to CCS technologies, more is needed: permitting, market interventions and value chain-oriented strategies. All of these realms are beyond the reach of researchers, who need serious and targeted interventions from the other actors in the field.

Nonetheless, the promises are bright: CCUS is being developed at a faster pace than ever, and positive signals from the markets shall keep the technology up and running, giving the necessary momentum to build a stronger and more resilient conducive environment for the years to come. In connection with the REPower EU Plan, great expectations are being put on CCS to deliver on carbon removals, a cleaner atmosphere and new solutions for materials, soils and energy.

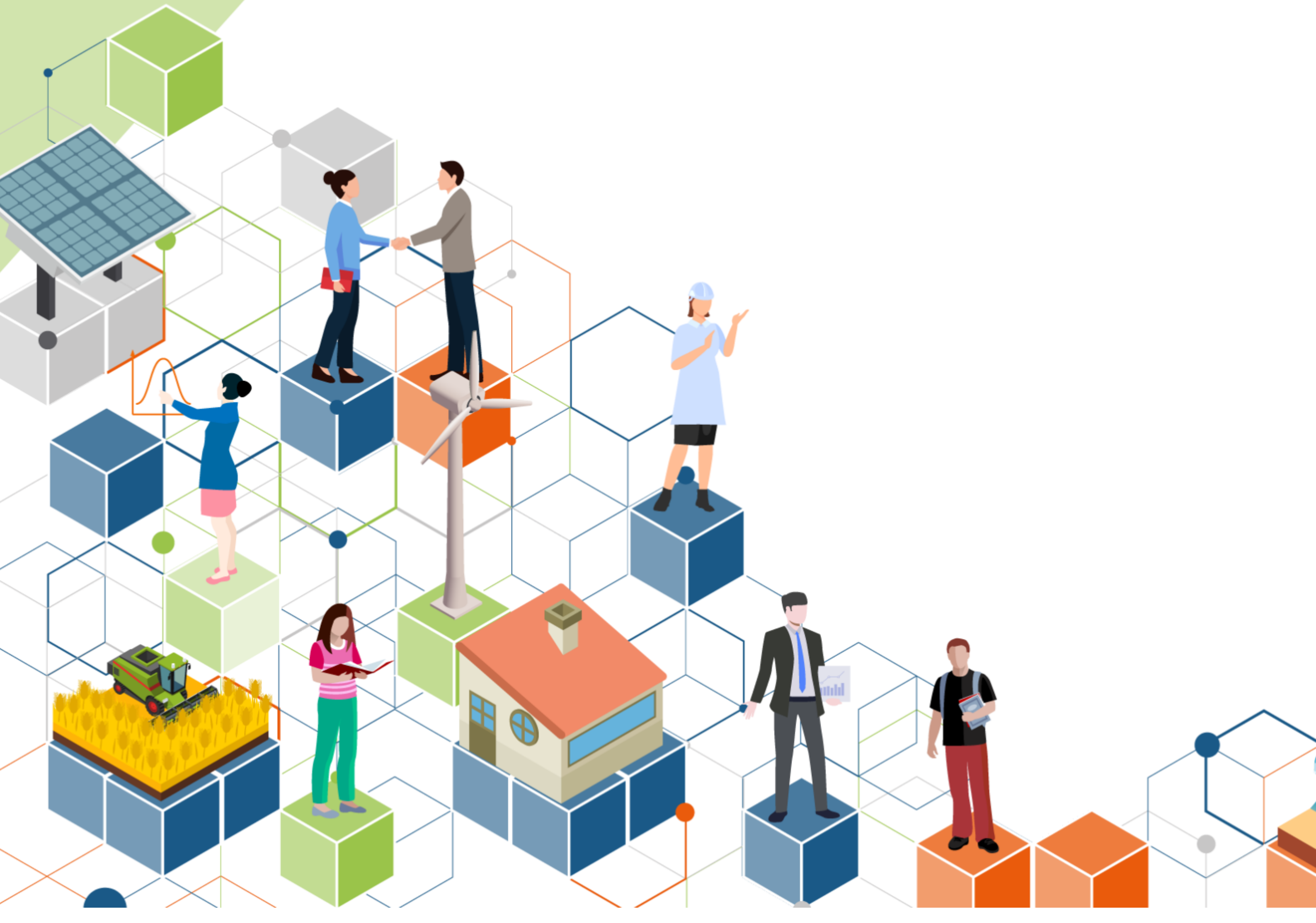
Support to the coordination of national research and innovation programmes in areas of activity of the European Energy Research Alliance

SUPEERA

Policy Brief

ReFuelEU

5 CHALLENGES AND OPPORTUNITIES AHEAD



Setting the scene

The year 2022 represented a watershed moment for the EU energy system. After a long period of high-volume trade with Russia, led by the conviction that commercial relations could ease the diplomatic ones, the invasion of Ukraine by the former has turned the tide on energy markets in the EU.

The events have created the conditions for strong action on the EU side, marked first and foremost by the launching of one of the most ambitious policy packages to date, the REPower EU Plan. According to it, the EU should cut all ties with Russian-based fossil fuels by 2030, freeing Europe from burdening dependencies and boosting its renewable energy capacity at home.

In this context, the research community is called to be an integral part of the transformation of the EU energy system. EU policymaking will need to boost research efforts now more than ever, as the ambitious goals set in the REPowerEU Plan and in the legislations surrounding it will be vain if not accompanied by targeted efforts in investigating new solutions. The research community remains, therefore, a core piece of the EU policymaking puzzle, although sometimes not recognised as such. Its enormous contribution in aligning political priorities with empirical findings plays a crucial part in the creation of realistic and ambitious policies alike, opening the door to a greener future for the energy system.

The focus on low Technology Readiness Level (TRLs) is needed now more than ever, even though it might sound counterintuitive when the EU targets are set for a short timeframe such as 2030. But, as the International Energy Agency (IEA) has underlined, many of the technologies that will enable the clean energy transition have not been developed yet. The triple helix of research, industry and policy needs to come together quickly, if we are to safely bring the EU towards a bright and developed future.

In the context of the SUPEERA project, a series of policy briefs are currently being developed to identify concrete R&I challenges in EU policies relevant to the energy research community. The final goal is to support the achievement of the Clean Energy Transition (CET). This Policy Brief will focus on the EC's Proposal for a Regulation on ensuring a level playing field for sustainable air transport (ReFuelEU), proposed in 2021 to regulate the sustainability and competitiveness of the European aviation system. Shortly after the completion of the analysis, a provisional agreement on the text was found by the European Council and European Parliament on 25 April 2023, now awaiting formal approval by the two co-legislators.

The Proposal for a Regulation on ensuring a level playing field for sustainable air transport

The Proposal for a Regulation on ensuring a level playing field for sustainable air transport, part of the legislative package known as "Fit for 55", sets out the target to reach a competitive and fair aviation fuels market, introducing mandatory requirements for the use of sustainable aviation fuels (SAFs). According to the proposal, "*the aviation sector needs to reduce its current exclusive reliance on fossil jet fuel and accelerate its transition to innovative and sustainable types of fuels and technologies*". In the coming years, market readiness, production and operability of sustainable aviation fuels will need be ramped up to support the EU air transport sector.

The table below summarises the main R&I challenges related to the proposal:

Identified R&I challenges
17. Develop innovative feedstock production technologies for biomass included in Annex IX Part A 18. Develop methods for feedstock traceability all the way to feedstock origin 19. Demonstrate and commercialize e-SAF and SAF produced from Annex IX Part A (lignocellulosic and marine feedstock), particularly on reducing production costs and increasing efficiencies 20. Explore the policy needs for a possible shift of the feedstock use for production of biofuels from the road to the aviation sector 21. Explore the policy needs to support the production of both SAF and e-SAF

ReFuelEU, the accelerator for production and use of sustainable aviation fuel

There is no doubt that aviation will keep on growing rapidly in the coming decades[41] as a strong driver to connect citizens, businesses and regions, despite the two-year difficult period the sector had to face during the COVID-19 pandemic, with severe travel restrictions and dramatic economic consequences. Although aviation only contributes to 2.1% of the global carbon emissions and 12% of the CO_2 emissions from the transport sector[42], it is one of the most hard-to-abate sectors, which means that its share of emissions is expected to increase. A recent publication[43] (September 2022) by the International Energy Agency indicates that aviation emissions reached ~720 Mt in 2021, regaining about one-third of the emissions reduction reported in the previous year, and it is expected that emissions will surpass pre-pandemic levels fairly soon.

While waiting for advances in long-term net-zero solutions such as electricity or hydrogen-powered aircrafts, which still require significant time and effort for commercialization, **sustainable aviation liquid fuels will be key in reducing the air transport carbon footprint in the short to mid-term**. Sustainable aviation fuel, when certified and mixed up to the blending limits of the American Society for Testing and Materials (ASTM) certification, is a drop-

[41] https://www.icao.int/Meetings/FutureOfAviation/Pages/default.aspx
[42] https://www.atag.org/facts-figures/
[43] https://www.iea.org/reports/aviation

in fuel, i.e. it is allowed to be used in the current infrastructure and aeroplanes without any restrictions, thus contributing to an immediate GHG emission reduction.

To meet the expected activity growth while protecting the environment, **it will be imperative the increased production and use of SAFs**, and this is exactly what ReFuelEU aims at. Therefore, the proposed regulation focuses on advanced biofuels and synthetic aviation fuels (e-fuels). The EC's communication states the need for a SAF obligation to boost SAF production and uptake as well as lower production costs. Concretely, this policy supports the imposition of a SAF blending mandate on the fuel suppliers and a jet fuel uplift obligation on aircraft operators. The proposed targets would start with a minimum volume share of 2% of SAF by 2025, reaching a minimum volume share of 63% by 2050, of which a minimum share of 28% of synthetic aviation fuels. With such mandates, the EC wants to restore and preserve a level playing field, with equal opportunities for all aviation market actors across the EU and avoid fuel tankering practices which lead to larger fuel consumption and increased emissions. **Currently, only small amounts of SAF are available on the market with a price at least three times higher than Jet A-1**[44]. In order to accelerate the production and scale-up of SAF and e-SAF and bring larger volumes of these fuels into the market, there are four success factors to be considered, feedstock availability, production costs, sustainable SAF production and favourable policy landscape, with availability and costs being the main ones.

> Currently, only a small amount of SAF is available on the market, so production must increase immediately to meet ReFuelEU obligations. In order to boost European production, it is necessary to act on these four dimensions:
>
> - Feedstock availability
> - Production costs
> - Sustainability

Feedstock availability

According to a study[45] published last fall (September 2022) by the Royal Netherlands Aerospace Centre, the amount of available biomass feedstock to produce SAF in Europe will be so scarce in the long run that it will only be sufficient to meet the ReFuelEU aviation mandate until 2030. Thereafter, the study projects a SAF supply below the legislative mandates, with an increased gap towards 2050. Hence, **it will be crucial to develop innovative feedstock production technologies that allow increasing affordable, sustainable biomass availability and feedstock diversification**.

The same study also looked into e-fuels and their availability potential until 2050. The authors revealed that from 2035 onwards, the amount of e-SAF combined with SAF potentially produced in Europe would be insufficient to meet the overall ReFuelEU mandates due to the limited amount of green hydrogen available for e-SAF production. The study, therefore, underlines the importance of feedstock and SAF imports to meet the overall RefuelEU targets.

44 https://a4e.eu/publications/production-and-deployment-of-sustainable-aviation-fuels-in-europe-refuel-eu-aviation/

45 Novel propulsion and alternative fuels for aviation towards 2050 – Promising options and steps to take (TRANSCEND Deliverable D3.2). Royal NLR - Netherlands Aerospace Centre, September 2022. NLR-CR-2022-094.

In a freshly published report[46], SkyNRG describes the building blocks for e-SAF production and the success factors for the development of an e-SAF supply chain. The analysis concludes that 70% of the e-SAF production price originates from green hydrogen production. Around half of these costs are associated with renewable power production and the other half with the electrolysers needed to convert water into hydrogen and oxygen. Thus, **research is needed to further reduce the costs of both renewable power production and electrolysers. Besides, research efforts are required to deploy larger electrolyser capacities**[47].

Production costs

Seven neat SAF production routes[48] and two coprocessing pathways are ASTM certified, but only one of the neat routes, the hydroprocessed esters and fatty acids (HEFA-SPK) one, is developed at a commercial scale. Other important production value chains with high deployment potential are syngas-FT (FT-SPK), alcohols to jet (ATJ-SPK) and SAF via direct thermochemical liquefaction routes (not yet ASTM certified). Besides the currently produced and new planned production initiatives, additional production volumes can be unlocked by existing refinery conversion or coprocessing of bio-based materials, as well as by switching the production from Hydrotreated Vegetable Oil (HVO) to HEFA (in the US, the former is favoured). In order to reach the net-zero aviation goals in 2050, the annual SAF production capacity needs to be increased to 449 billion litres. The announced investment plans indicate that SAF annual production could expand from 125 million litres to 5 billion by 2025 and 30 billion litres by 2030 if efficient government incentives are in place[49].

There are two HEFA production plants in operation globally (2022), providing 0.1-0.2% of the global aviation fuel supply[50]: Neste in Porvoo, Finland and World Energy in Paramount, California. There are several initiatives to accelerate production; both Neste and World Energy are planning new facilities in addition to new stakeholders (SkyNRG). The production technology of HEFA is based on hydrotreating oils and fats into sustainable fuels. As mentioned earlier, **the feedstock resource, i.e. the availability of sustainably sourced oils and fats, is limited, and more efforts are needed to access or produce sustainable oils and fats for this pathway**.

As for syngas-FT to SAF, Fulcrum Bioenergy started operating its first commercial plant in 2022[51]. It converts household garbage to syngas and further to SAF. Total Energies has also demonstrated SAF production from waste and residues in France[52]. The main bottlenecks attributed to the syngas-FT technology are the high capital costs and to the need to develop and demonstrate new catalysts to selectively convert syngas into liquid products, including SAF.

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46 Framework for the development of an e-SAF facility (TULIPS Deliverable 5.1). SkyNRG, February 2023

47 https://www.iea.org/reports/electrolysers

48 https://aviationbenefits.org/environmental-efficiency/climate-action/sustainable-aviation-fuel/producing-sustainable-aviation-fuel/

49 https://www.iata.org/en/pressroom/2022-releases/2022-06-21-02/

50 https://www.easa.europa.eu/eco/sites/default/files/2022-09/220723_EASA%20EAER%202022.pdf

51 https://www.fulcrum-bioenergy.com/sierra-biofuels

52 https://www.ifpenergiesnouvelles.com/article/biotfuelr-project-entry-industrialization-and-commercialization-phase

With regards to alcohol-to-jet (ATJ) conversion, the company Gevo operates a corn biorefinery in the US where ATJ-SPK is produced,[53] and LanzaJet is planning to start up its first ATJ-SPK production plant in the US[54]. When looking into this value chain, making ethanol from lignocellulosic biomass feedstock consists of pretreatment, hydrolysis and fermentation before the alcohol is converted to hydrocarbon fuels. One of the major bottlenecks is that the **enzymes needed in hydrolysis are very costly; therefore, research is needed to decrease operational costs.**

The pathways *via* direct thermochemical liquefaction are still under the ASTM certification process. Alder Fuels[55] aims to produce and certify 100% SAF by combining hydrocarbons achieved from direct thermochemical liquefaction and HEFA. In the direct liquefaction value chain, most of the research efforts at present are concentrated on the (advanced) upgrading of biocrudes originating from biomass feedstock which have been submitted to moderate temperatures – and, for some technologies, also to moderate pressures. Such biocrudes contain high concentrations of undesired components such as nitrogen and oxygen, which are detrimental to the quality of the SAF and challenging to remove.

Synthetic or e-SAF produced using green hydrogen from water electrolysis using renewable power and CO_2 from point sources or direct air capture are separately mandated in ReFuelEU and ASTM-certified if produced through Fischer–Tropsch (FT) but not through methanol. **When considering e-SAF, the main barrier for upscaling production today is the sky-high production costs**[56] associated first and foremost with the generation of and access to green hydrogen, as described above. **Substantial research work is currently ongoing on catalyst technologies in those aspects**[57,58]. **Access to CO_2 is a second major barrier for e-SAF production, requiring better understanding and investigation. The desired technology,** in the long run, **is known as Direct Air Capture (DACCS), but it is still immature, and it is first necessary to better understand the scientific, engineering, economic and socio-political challenges surrounding it**[59].

Sustainability

ReFuelEU clearly underlines that all aviation fuels defined within the EC's communication must comply with the sustainability criteria regulated through the Renewable Energy Directive (RED) currently under revision (version II is the one in force at the time of writing). The eligible feedstock for biobased SAFs is listed in RED II Annex IX part A and B. Part B includes most feedstock (used cooking oil and animal fat) for HEFA and stipulates that its maximum energetic share in transport is restricted to 1.7%[60]. For ReFuelEU the eligible feedstock base is extended, including the Annex IX Part B feedstock as well as low-carbon fuels as long as they

[53] https://gevo.com/about-gevo/our-facilities/silsbee/
[54] https://www.lanzajet.com/where-we-operate/#georgia
[55] https://www.alderfuels.com/latest-news/alder-saf100-accelerating-development-for-next-generation-sustainable-fuelsnbspnbsp
[56] https://www.biofuelsdigest.com/bdigest/2022/03/14/what-is-esaf-why-the-buzz-and-whats-stopping-it-from-being-produced-at-scale-today/
[57] https://techxplore.com/news/2023-03-natural-catalysts-low-cost-green-hydrogen.html
[58] https://pubs.rsc.org/en/content/articlelanding/2023/gc/d2gc04205c
[59] https://pubs.rsc.org/en/content/articlehtml/2022/ee/d1ee03523a
[60] https://op.europa.eu/en/publication-detail/-/publication/46892bd0-0b95-11ec-adb1-01aa75ed71a1

comply with the 70% GHG emission reduction criteria[61]. The rules for calculating the GHG impact of biofuels, including SAF with the default values to be used, are described in RED II Annex V[62].

In order to be able to make all these emissions calculations rigorously, **it is essential to develop standardized methods for feedstock traceability all the way to feedstock origin, especially for feedstocks with very uncertain origins, as is the case today of lipid wastes.**

The eligibility criteria for synthetic (e-)SAF feedstock (hydrogen and carbon dioxide) are described in two delegated acts linked to RED II. The terminology used for the synthetic part of the mandate is Renewable Fuels from Non-Biological Origin (RFNBO), where the term renewable indicates that the hydrogen used for fuel production is renewable (green). The first delegated act[63] includes additionality criteria for renewable hydrogen, and the renewable power used for this hydrogen production must be obtained at the same time and in the proximity of the RFNBO in addition to existing renewable power production and use. The second delegated act[64] describes the rules of the GHG emission calculation method (the minimum GHG savings criteria is 70% compared to fossil equivalents) and adds that the CO_2 must come from renewable point sources or direct air capture (non-renewable point sources are allowed until 2041).

The aviation sector in Europe will be not only regulated by ReFuelEU but also by the international regulation Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), a tool establishing the goals to achieve carbon-neutral growth from 2020 onwards and reach net-zero CO_2 emissions from 2050. **The so-called CORSIA-eligible fuels are an option for offsetting emissions.** CORSIA is composed of twelve sustainability requirements[65], among which two need to be complied with, the ones on greenhouse gas emissions[66] and carbon stock. Under CORSIA, not only SAF but also low carbon non-renewable fuels are eligible, as long as their GHG emissions reduction is at least 10% compared to fossil fuel equivalent. The carbon stock criteria state that fuels should not be produced from land with high carbon stock. CORSIA defines a set of lands that are excluded from production, and it also indicates that land use change (both direct and indirect) needs to be accounted for in the calculations.

Policy landscape

A final success factor in accelerating market penetration of all kinds of sustainable aviation fuels is a **strong synergy between the scientific community and political decision-makers through tailored-made policies regarding SAF and e-SAF complementing**

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[61] https://www.consilium.europa.eu/en/press/press-releases/2023/04/25/council-and-parliament-agree-to-decarbonise-the-aviation-sector/
[62] ANNEX V Renewable Energy Directive - RULES FOR CALCULATING THE GREENHOUSE GAS IMPACT OF BIOFUELS, BIOLIQUIDS AND THEIR FOSSIL FUEL COMPARATORS (lexparency.org)
[63] https://energy.ec.europa.eu/publications/delegated-regulation-union-methodology-rfnbos_en
[64] https://energy.ec.europa.eu/publications/delegated-regulation-minimum-threshold-ghg-savings-recycled-carbon-fuels-and-annex_en
[65] https://www.iea-amf.org/app/webroot/files/file/Workshop_Task63/IEA%20AMF%20Talk%20Robert%20Malina%20Dec%201%202022.pdf
[66] https://www.icao.int/environmental-protection/pages/SAF_LifeCycle.aspx

ReFuelEU to be soon approved. In June 2022, ICAO published[67] an exhaustive guidance on potential long-term and stable policies for the deployment of sustainable aviation fuels and listed three main policy mechanisms: the first one aimed at supporting the growth of the SAF supply targeted to increase feedstock and fuel production capacities, the second one at creating SAF demand and the third one at enabling the SAF marketplace. For each of these mechanisms, the authors described several policy types, all summarized in a table at the end of the document. Focusing on the first one, which the International Air Transport Association (IATA) urges governments to set up incentives for[68] as production is the step in the value chain which needs the most stimulation, ICAO pinpoints four types of policies. The first type refers to governmental funding for research, development, demonstration and deployment of SAF. The second is meant to enlarge the infrastructure of SAF supply. Thirdly, ICAO indicates targeted incentives to assist the facility operation of SAF, and last but not least, a fourth type of policy needs to recognize and value the environmental benefits of SAF.

Conclusions

There is no doubt that aviation will continue growing, and being one of the most hard-to-abate sectors, emissions from aviation are also expected to increase. In order to reach the net-zero aviation goals in 2050, it is imperative to apply immediate solutions to reduce emissions already now. **SAF is the key solution in the short to mid-term**. The aviation industry is aware of this challenge and is eager to reduce its emissions. However, SAF availability on the market is very limited, and the prices are still too high.

ReFuelEU is a remarkable step forward to accelerate the production and use of SAF, and with it, contribute to stabilising the market. **Most of the production technologies are still not commercially available. Demonstration and deployment of viable SAF production routes are urgently needed.** Therefore, **significant research efforts are required**, particularly to **diversify feedstock, increase process efficiency and reduce production costs**. These research efforts will depend on the type and maturity of the technology. On the other hand, **it is expected that both feedstock and SAF will be imported** to fulfil ReFuelEU's obligation due to the limitations of feedstock availability and production facilities in Europe. **To produce SAF sustainably**, which is crucial for success, **not only standardized methods for feedstock traceability but also stronger policy support for European SAF production must be developed**.

Sustainable aviation fuels will play a key role in decarbonizing aviation. To increase their production and use, the following R&I actions are needed:

- Development of new and improved sustainable feedstock production methods to increase the available feedstock base
- Improvement of energy-efficient processes to enhance cost-competitive SAF production routes
- Formulation of standardized methods for feedstock traceability
- Exploration of how science can contribute to a policy framework enabling European SAF production

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67 https://www.icao.int/environmental-protection/Documents/SAF/Guidance%20on%20SAF%20policies%20-%20Version%201.pdf
68 https://www.iata.org/en/pressroom/2022-releases/2022-06-21-02/

Support to the coordination of national research and innovation programmes in areas of activity of the European Energy Research Alliance

SUPEERA

Policy Brief

Critical Raw Materials Act

- CHALLENGES AND OPPORTUNITIES AHEAD

Setting the scene

The year 2022 represented a watershed moment for the EU energy system. After a long period of high-volume trade with Russia, led by the conviction that commercial relations could ease the diplomatic ones, the invasion of Ukraine by the former has turned the tide on energy markets in the EU.

The events have created the conditions for strong action on the EU side, marked first and foremost by the launching of one of the most ambitious policy packages to date, the REPowerEU Plan. According to it, the EU should cut all ties with Russian-based fossil fuels by 2030, freeing Europe from burdening dependencies and boosting its renewable energy capacity at home.

The past year also saw the launching of the Inflation Reduction Act (IRA) by the Biden administration in the US, a package of $369 billion worth of incentives to support green energy innovation, manufacturing, and usage. This bold move prompted the reaction from the European Commission, which unveiled on the 1st of February 2023 the European Green Deal Industrial Plan, an initiative aimed at preserving and boosting the EU's industrial competitiveness by bolstering clean-tech investments while keeping climate goals on track.

Under this plan, the European Commission has so far presented three key initiatives: the Net Zero Industry Act to promote the scale-up of clean energy technologies, the Electricity Market Design reform to prepare the electricity market for an increasing share of renewables, and the Critical Raw Materials Act, to ensure sufficient access to materials crucial for manufacturing key technologies.

In this context, the research community is called to be an integral part of the transformation of the EU energy system. EU policymaking will need to boost research efforts now more than ever, as the ambitious goals set in the REPower EU Plan and in the legislation surrounding it will be in vain if not accompanied by targeted efforts in investigating new solutions. The research community remains, therefore, a core piece of the EU policymaking puzzle, although it is sometimes not recognised as such. Its enormous contribution in aligning political priorities with empirical findings plays a crucial part in creating realistic and ambitious policies, opening the door to a greener future for the energy system.

The focus on low TRLs is needed now more than ever, although it might sound counterintuitive when the EU targets are set for a short timeframe, such as 2030. But, as the International Energy Agency (IEA) has underlined, many of the technologies that will enable the clean energy transition have not been developed yet. Therefore, the triple helix of research, industry and policy needs to come together quickly to safely attain the EU climate neutrality goals.

As part of the SUPEERA project, a series of Policy Briefs is being developed to identify R&I challenges in EU policies relevant to the clean energy research community. The ultimate objective is to accelerate the development and implementation of innovative solutions that can foster a sustainable and resilient energy system in Europe. This Policy Brief focuses on the Proposal for a Regulation establishing a framework for ensuring a secure and sustainable supply of critical raw materials, also known as the Critical Raw Materials Act, published by the European Commission on March 16th and aimed at establishing a framework that ensures the secure and sustainable supply of critical raw materials required for the clean energy transition.

The Proposal for a Regulation establishing a framework for ensuring a secure and sustainable supply of critical raw materials

The **Proposal for a Regulation establishing a framework for ensuring a secure and sustainable supply of critical raw materials**[69], also known as the **Critical Raw Materials Act** (CRMA), was introduced in 2022 during the European Commission President's State of the Union speech and then launched on 16 March 2023 as a part of the Green Deal Industrial Plan. The Act aims to address the challenges posed by highly-concentrated raw materials value chains and the over-reliance on certain countries, driven by various geological, economic, and political determinants. The initiative sets out a regulatory framework to **increase and diversify the supply of critical raw materials (CRMs) in the EU**, **promote circularity**, and **support research and innovation (R&I)** in the area.

The table below summarises the main R&I challenges of the proposal:

Identified R&I challenges
22. Increase material efficiency (durability, reusability, reparability, resource use or resource efficiency) 23. Increase material circularity (possibility of remanufacturing and recycling, recycled content and the possibility of recovery of materials) 24. Increase the technological maturity of recycling technologies for critical raw materials 25. Promote the substitution of critical raw materials wherever possible 26. Develop technologies that make CRMs more easily retrievable in the EU or partner countries 27. Ensure that the workforce is equipped with the skills needed and, in case, develop plans for upskilling and reskilling the workforce 28. Increase the state of knowledge on the technology for recycling permanent magnets which contain critical raw materials, such as neodymium, praseodymium, dysprosium and terbium, boron, samarium, nickel or cobalt 29. Assess the EU’s potential to increase its extraction, processing or recycling capacities 30. Develop strategic manufacturing technologies such as semiconductors

[69] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023PC0160

A key tool to strengthen supply chains and accomplish the clean energy transition

In the Critical Raw Materials Act, critical raw materials are defined as **specific raw materials that are essential for the European Union's industry and have high economic importance for the EU economy**. These materials, including antimony, arsenic, barite, bauxite, and beryllium, play a significant role in various strategic sectors such as green technology, digital industries, defence, aviation, microelectronics, medical devices, and everyday devices like smartphones. The CRMA also categorises certain raw materials as **strategic raw materials** (SRMs). This subset of CRMs is deemed highly significant for specific sectors and applications that are vital to the EU's transition objectives. SRMs are eligible for greater support and play a key role in elements like microchips or batteries, which are susceptible to global demand, supply imbalances, and trade barriers imposed by producing countries. The proposed legislation's list of SRMs includes lithium, as well as base metals such as aluminium, copper, and zinc.

In a European Commission's document[70] accompanying the 2021 update of the new industrial strategy, CRMs were identified as an area of strategic dependency for the EU. The present proposal would be the first EU act to regulate the EU's supply of CRMs specifically and would contribute to strengthening the EU's open strategic autonomy. It introduces a monitoring system, stockpiling measures, and risk preparedness strategies to secure the EU's CRMs' supply and enhance capacities along the value chain.

Increasing needs for CRMs

Critical raw materials are subject to a projected steep rise in demand that could potentially outpace supply. A foresight study from the European Commission's Joint Research Centre (JRC)[71] provides a systematic and detailed overview of fifteen key technologies' complete value chains across the five strategic sectors (renewable energy, electro-mobility, industrial, digital) responsible for delivering on the EU's climate and energy neutrality targets. According to the report, the consumption of lithium, a crucial element of batteries in electric vehicles and devices, is expected to increase by 9 to 12 times by 2030 and up to almost 21 times by 2050, primarily due to the adoption of e-mobility solutions. However, **Europe is highly dependent on importing critical materials, especially for manufacturing batteries.** China controls 50% of the battery materials supply chains and produces 90% of the permanent magnets required for production. By 2030, Europe needs to establish 600 to 800 GWh capacity for electric vehicles, and although it

The need for CRMs will increase so sharply that Europe will struggle to address this growing demand while reducing its dependency on highly concentrated supply chains. To cope with this challenge, it is necessary to act on:

- Upscaling domestic mining
- Developing recycling
- Reinforcing trade partnerships to diversify imports

[70] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021SC0352
[71] https://publications.jrc.ec.europa.eu/repository/handle/JRC132889

has some of the critical materials required for this transition, the demand for metals and minerals will rise too sharply to meet it. The demand for rare earth metals for wind turbines – also classified as CRMs – is, for example, expected to increase more than fourfold by 2030. In the case of graphite, overall EU consumption is anticipated to rise to 14 times its current levels by 2030 and 26 times by 2050. A recent study from KU Leuven on the clean-energy metals needed to reach the EU's 2050 climate-neutral target stressed that **metals will play a central role in successfully building Europe's clean technology value chains and meeting the EU's 2050 climate-neutrality goal**[72]. Besides, CRMs are also used in other sectors beyond energy, such as health, defence and space. The European Parliament's think tank (EPRS) pointed out that "a number of still unknown new key technologies may emerge in the future, using specific CRMs"[73], affecting the expected demand trajectories and rendering the need to secure the supplies of CRMs even greater.

The CRMA proposes two main ways to enhance the EU's strategic autonomy when it comes to raw materials. The first approach is to **explore potentially untapped domestic resources**, such as scaling up mining activities in Europe and promoting the development of technologies that rely on CRMs easily retrievable in the EU or partner countries. The second approach involves **increasing recycling capacities in Europe**. The Act establishes benchmarks for both pathways, requiring a 10% increase in European CRMs and a minimum of 15% of strategic raw materials to be produced from recycled materials[74].

Upscaling domestic mining

Europe has some domestic resources of lithium, especially in France and Portugal. However, upscaling mining capacities in the EU poses several challenges. Apart from technical and economic feasibility questions, **permitting procedures regarding mining are lengthy and complex**. With a timeframe of 10 to 15 years from the decision to implementation, new EU mining production cannot contribute significantly to the EU's raw materials requirements by 2030. Moreover, mining regulations fall under the Member States' responsibility. The CRMA proposes to address this challenge by identifying Strategic Projects. This status, granted by the EU to projects that meet certain terms of technical feasibility and sustainability, will allow to speed up the process of obtaining necessary permits – even within two years when it comes to mining for SRMs – and will simplify access to financing.

It is important to point out as well that mining has low public acceptance and is often subject to local resistance from communities living close to the mining sites, especially in regard to the impact of mining on nature and climate. For instance, it consumes a substantial amount of water and generates hazardous waste, while also posing health and safety risks to workers[75]. Therefore, although the CRMA sets a target of only 10% of strategic raw materials to be mined in the EU, it is unlikely that this requirement will be met by 2030. While not the most obvious, this represents nevertheless an area where the role of the R&I community needs to be better recognised. Beyond industrial policy, **increasing domestic mining will indeed require the upskilling or reskilling of a part of the workforce, as well as assessing thoroughly the resources available in Europe and how to exploit them in a way that mitigates risks**. Of

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[72] https://eurometaux.eu/media/jmxf2qm0/metals-for-clean-energy.pdf
[73] Securing Europe's supply of critical raw materials (europa.eu)
[74] These benchmarks refer to the 2030 time horizon, in alignment with the Union's climate and energy targets set under Regulation (EU) 2021/1119 of the European Parliament and of the Council
[75] See Reference 6

course, **research will also allow the further use of domestic resources outside of mining by fostering demand reduction and increasing resource and product efficiency.**

Improving recycling capacities

Compared to expanding mining production, scaling up the EU's recycling capacity may have a faster time horizon. While recycling cannot realistically cover the needs of a sharply growing market where demand keeps increasing, it can participate in alleviating some of the pressure on primary production supply chains. The CRMA sets a target for the EU's recycling capacities to cover at least 15% of the annual consumption of each SRM by 2030. Rather than solely relying on new domestic sources to retrieve critically needed materials, **increasing knowledge of recycling technologies could be beneficial, especially in sectors heavily dependent on external sources** such as batteries, hydrogen, and semiconductors. The European Commission's Directorate General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) released a report on Critical Raw Materials and the Circular Economy, which highlights that several CRMs have a high potential for technical and real economic recycling. However, despite government encouragement to move towards a circular economy, the recycling rate of critical raw materials remains generally low[76].

Scaling up the EU's recycling capacity may have a faster time horizon than expanding mining production. However, it cannot realistically cover the needs of a sharply growing market where demand keeps increasing.
To this day, very few CRMs are recycled and reused. To address this challenge, the EU needs to:

- Further incentivise recycling and provide preferential treatment for repurposed CRMs
- Work on eliminating bottlenecks in the recycling process
- Recognise the crucial role of R&I in making recycling processes more efficient and effective

This issue may be principally attributed to bottlenecks in the recycling chain. The availability of products to be recycled is a primary consideration in meeting the future demand for CRMs for electric mobility and renewable energy. Yet, the ability to process large volumes of recycled products is equally important. **To upscale recycling capacities, the efficiency of the entire recycling system and the European recycling industry must be improved.** The circular use of CRMs is highly dependent on the sectors in which they are used as well as on various other parameters, including the nature of end-of-life products or different take-back schemes implemented in different sectors. Therefore, **parallel EU regulations could accelerate the transition to a circular economy.** For example, the proposed new Battery Regulation aims to speed up the recovery of batteries from electric vehicles in the EU by requiring minimum levels of recovered cobalt (16%), lead (85%), lithium (6%), and nickel (6%)[77]. The EPRS highlights that for lithium-ion batteries, recycling end-of-life batteries could help meet 52% of the 2040 demand for lithium for new battery production, 58% of the demand for cobalt, and 49% for nickel in the most optimistic scenarios[78].

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[76] https://weee4future.eitrawmaterials.eu/wp-content/uploads/2020/09/09_report-of-CRM-and-CE.pdf

[77] https://data.consilium.europa.eu/doc/document/ST-5469-2023-INIT/en/pdf

[78] See 6

While it is evident that secondary resources alone cannot meet the growing demand for CRMs as today's amount of resources that can be recycled is lower than tomorrow's needs, **the importance of circularity should not be underestimated in the current regulation**. However, it is noteworthy that **the regulation, in its present form, does not address the issue of circular product design. R&I will play a pivotal role in reducing the reliance on primary CRM sources by promoting recyclability, exploring alternatives to mining, developing innovative extraction methods for CRMs, and identifying non-critical materials as substitutes when feasible**. However, **numerous technologies are still in the developmental stage and require scaling up**, highlighting the need for **greater emphasis on piloting and advancing the necessary technologies (TRLs 5-7).** Additionally, **fostering collaboration with key stakeholders engaged in the R&I agenda is essential.**

Diversifying imports

While increased mining and recycling efforts constitute important steps in the right direction, they may still not be enough to meet Europe's ever-growing critical materials demand. As a result, the CRMA relies on a third pillar that focuses on diversifying imports to avoid reliance on single suppliers and address trade imbalances. The EU has indeed been prompted to deeply reevaluate its partnerships with third countries as well as its supply strategies in the wake of the Covid pandemic and the Ukraine war. The goal established within the Act is to ensure that no single country supplies more than 65% of a strategic raw material at any stage and that 40% of raw material processing occurs within the EU.

As it is quite certain that the EU will never achieve complete self-sufficiency in supplying CRMs, the European Commission acknowledges that international trade is essential to support global production and ensure supply diversification. Therefore, **the EU must strengthen its global engagement with reliable partners, promote stability in international trade, and enhance legal certainty for investors,** especially as access to CRMs is a concern shared with many other stakeholders. The Commission has published a Communication[79] alongside the CRM Act that emphasises the need to seek mutually beneficial partnerships with emerging markets and developing economies while adhering to Environmental Social and Governance standards (ESGs). It also insists on making good use of existing partnerships, such as bilateral and trade agreements, as well as the Global Gateway strategy[80]. Examples of such partnerships include Latin America for copper and lithium, the Democratic Republic of Congo (DRC) for cobalt and copper, and Indonesia for nickel and cobalt.

Conclusion

[79] https://circabc.europa.eu/rest/download/7ce37e41-1d9a-4f96-a24b-4f89207700bf

[80] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/stronger-europe-world/global-gateway_en

To achieve Europe's ambitious goals for the green and digital transition by 2030 and 2050, it is essential to **diversify supply chains and avoid reliance on a limited number of suppliers**.

The Critical Raw Materials Act presents multiple pathways that can complement each other in this endeavour. One such pathway involves **increasing domestic primary production**, which would grant the EU greater control over supply chains and ensure more reliable access to critical materials. However, this option faces various challenges, including regulatory obstacles, low public acceptance, local resistance, high carbon emissions, and insufficient investment in mining. Addressing these issues requires measures to expedite permitting processes, encourage European investment in mining and processing, and promote sustainable practices.

Critical Raw Materials will be key in achieving the clean energy transition. In order for the EU to obtain as much as it needs in that regard, the CRM Act plans to increase domestic mining and circularity and strengthen international partnerships.
Within and beyond these solutions, the role of R&I has to be better recognised, as it is essential for:

- Diversifying the supply mix
- Reducing CRM demand and usage
- Improving resource efficiency
- Advancing technology with reduced CRM requirements
- Enhancing sustainability in the CRM value chain.

To reduce the need for additional primary production, **recycling must also play a significant role**. Upscaling recycling capacities relies on enhancing material circularity, implementing circular design strategies, and advancing recycling technologies. Therefore, greater attention should be given to **circularity**, providing **preferential treatment and support for recycled, reused, or repurposed CRMs,** along with the adoption of **Circular Product Design principles**.

The third pathway outlined by the CRMA focuses on diversifying imported materials to mitigate overdependence on specific countries. Recognising that the EU will never achieve complete self-sufficiency in CRM supply, **the bloc must strengthen global engagement with reliable partners based on observance of ESG standards**. This approach facilitates investment diversification, promotes stability in international trade, and strengthens legal certainty for investors.

Against this backdrop, while the Commission's proposal emphasises the EU's industrial policy, **it is vital to acknowledge the crucial contribution of research and innovation in achieving the outlined goals**. They play a pivotal part in diversifying the supply mix, reducing CRM demand and usage, improving resource efficiency, advancing technologies with reduced CRM requirements, and enhancing sustainability and efficiency in the CRM value chain. Therefore, **strengthening the role of R&I in the Regulation and fostering collaboration between industry and the research community are vital steps toward ensuring a secure and sustainable supply of CRMs.**

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