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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This deliverable D3.5 “Second Interim report on the translation of new EU policies into concrete actions for EERA members and SET-Plan community” presents the intermediate 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), covering the first 18 months of the projects. A final report will be prepared at the end of the project.

The report presents an essential update of D3.3, including the additional activities performed over the last 6 months. The first chapter takes much from the first interim report, as the methodology was not largely updated over the last six months. 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 European Climate Law, European Industrial Strategy and Adaptation Strategy) actively tried to better address the topics most relevant for the project’s key audiences.

The report then includes an assessment on the latest SUPEERA policy webinar, organised on the 16th of December 2021. The webinar gathered EU and national policymakers, researchers and industry representatives to discuss the main developments and the future actions in the context of energy efficiency and energy sufficiency, a concept not yet fully embedded in the EU narrative but highly debated in other arenas. The webinar provided insightful discussions both among speakers and participants, showcasing the potential of such gatherings for the creation of more inclusive policies and innovation.

The report concludes with a description of future activities, which will cover the project’s duration until its end (M42). The document is complemented by an annex (Annex I) which includes in full length the latest Policy Briefs.

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

LIST OF FIGURES

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, 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 aims 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 are continuously 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 interim report details precisely on the actions above-mentioned from M18 until M24 and provides a perspective on upcoming actions based on current policy assessment and priority setting.

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 aims at providing the EERA community with tailored recommendations on concrete research areas and industrial challenges. This interim report therefore presents how this is has been concretely achieved from M18 until M24 by detailing the actions undertaken, their uptake and reach and outlines the basis for future work.

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

3.1 Methodology

The task aims to provide the EERA community with tailored recommendations on concrete research areas and industrial challenges to contribute to implementing selected new European policies applicable to the climate and energy fields. Based on the initial discussion on relevance and capacity, between M18 and M24 it was decided to focus on the European Green Deal and the policy files that followed this initiative. Currently, policy papers on the New EU Industrial Strategy, the European Climate Law, and the Adaptation Strategy have been analysed. Additional new policies to be examined will be selected yearly depending on the priorities of the European Commission (EC).

The recommendations will be based on a 'mission definition' approach. The approach is 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

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

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.

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

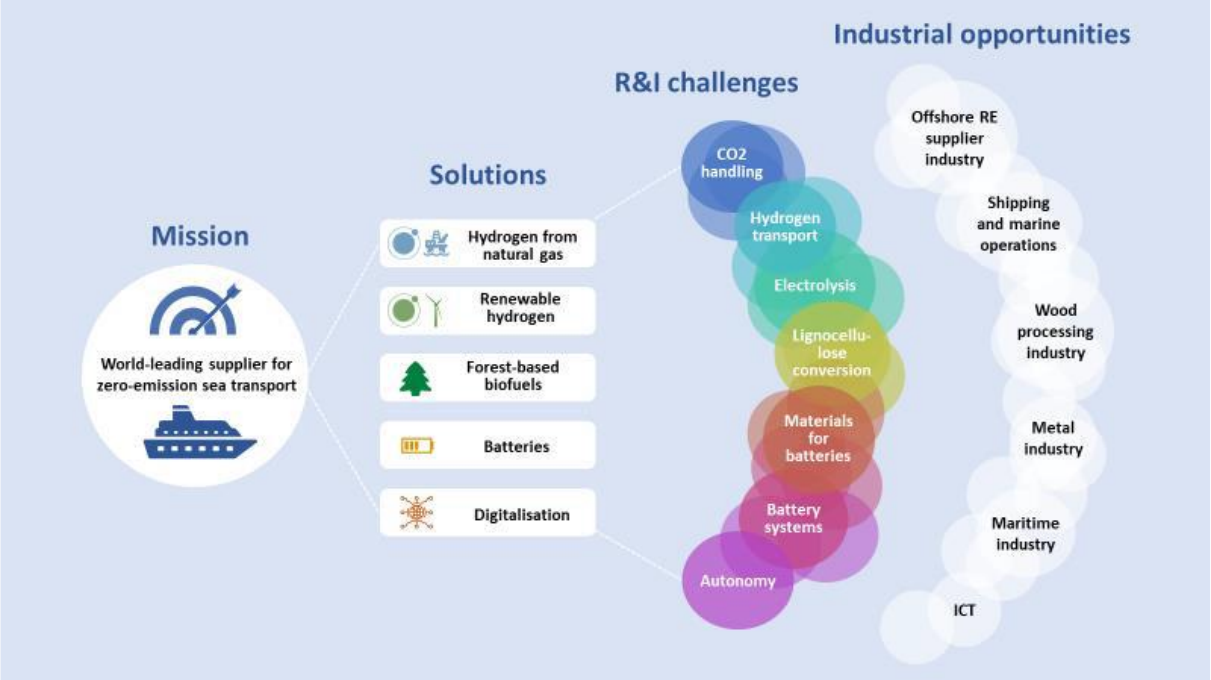

Figure 1. Mission definition approach: Translating policies into research challenges

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.

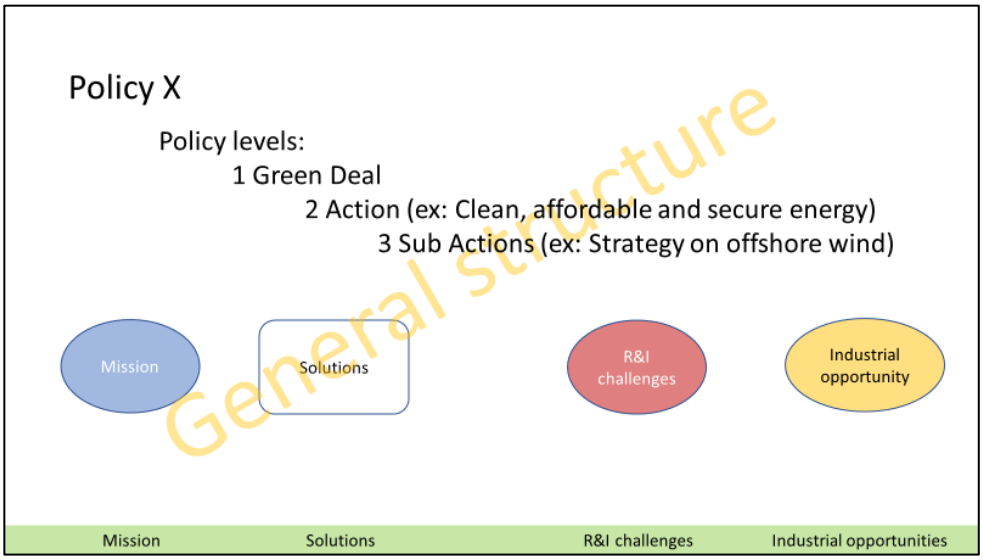

Figure 2. The hierarchical structure of policies to be analysed

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

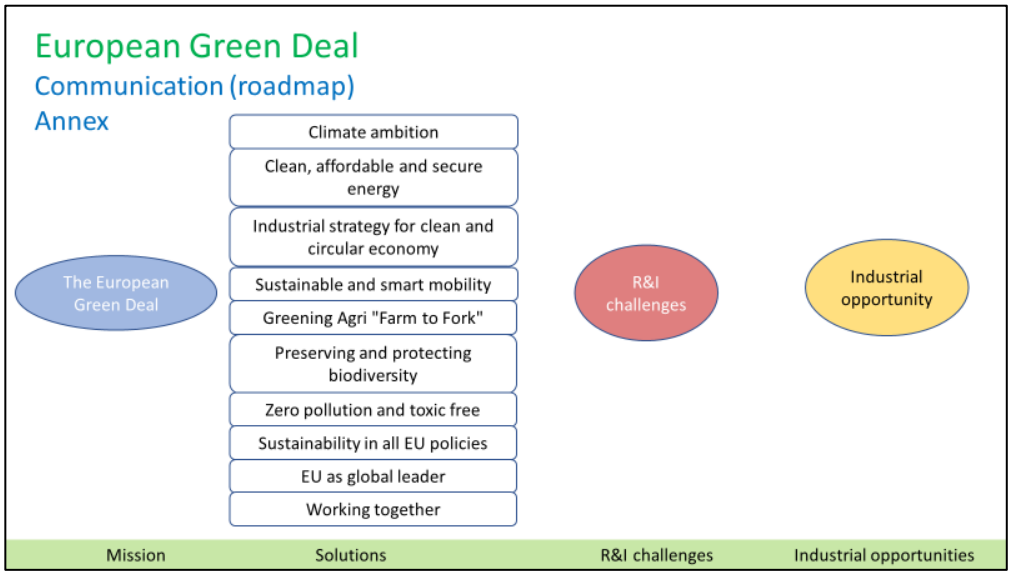

Figure 3. Policy paper areas addressed under the Green Deal

The analysis will benefit 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 will provide 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.

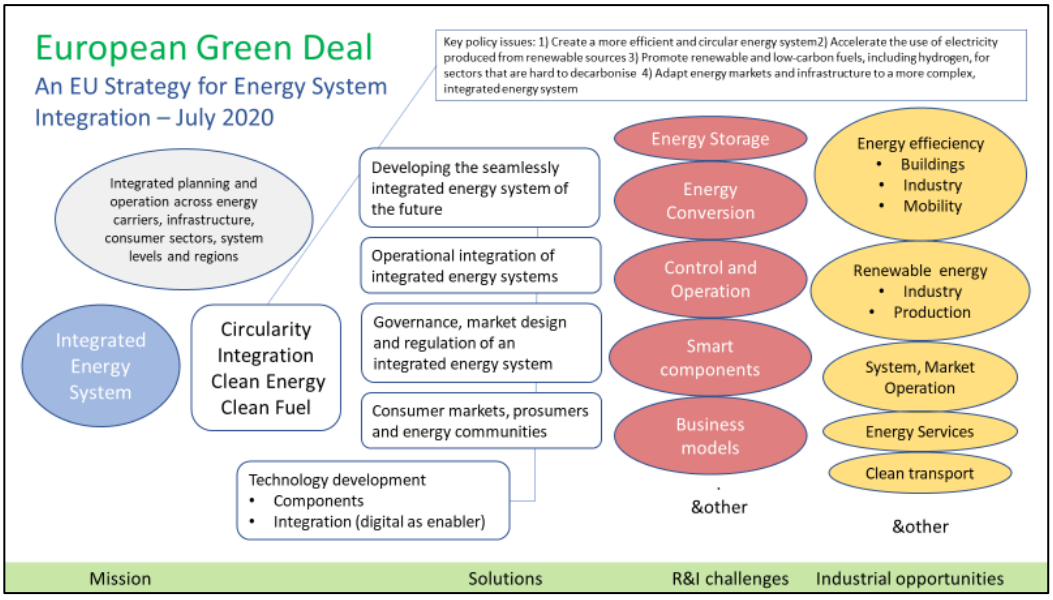

Figure 4. Analysis of EU strategy for Energy System Integration

For each policy document selected, a compact summary in text format of 4 to 5 pages documents the analysis. The results are 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 three Policy Brief published between M18 and M24 – the New EU Industrial Strategy, the European Climate Law, and the Adaptation Strategy- 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 the Annex 1 to the report by clicking at this link.

3.1.1 New EU Industrial Strategy

The European Commission's Communication “Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe’s recovery” puts forward a set of policies aimed at boosting the EU’s recovery and enhancing its open strategic autonomy. At the same time, it helps to drive the transformation towards a more sustainable, digital, resilient, and globally competitive economy. The Communication revolves around three strategic priorities that will guide the EU actions in the months and years ahead.

Among the challenges brought forward in the Policy Brief are:

- To facilitate a change of collaboration culture in Europe to allow stronger cooperation between research and industry
- To create an innovation funnel across the whole TRL range
- To initiate a strong acceleration and intensification of international collaboration

3.1.2 European Climate Law

The European Commission's Communication on the European Climate Law enshrines into law the EU's climate-neutrality objective, ensuring that all EU actions and policies contribute to it in a socially fair and cost-efficient manner, with all sectors of the economy and society playing their part. Also referred to as the "law of laws" due to its key importance for achieving the EU Green Deal's objectives, the European Climate Law provides the conditions to set out a trajectory leading the EU to climate-neutrality.

The Policy Brief's main challenges include:

- Desiloing most of the areas of energy research (with particular attention to energy systems integration)
- Studying methods to support new industrial sectors and instruments, in order to enable a crosscutting transition
- Keeping an open dialogue between the research community and the European institutions

3.1.3 Adaptation Strategy

In its Communication "Forging a climate-resilient Europe – the new EU Strategy on Adaptation to Climate Change", the European Commission outlines a long-term vision for the EU to become a climate-resilient society, fully adapted to the unavoidable impacts of climate change by 2050. The Communication revolves around four strategic priorities to build a climate-resilient society, by improving knowledge on adaptation, step up adaptation planning, speed-up adaptation actions, and help strengthening climate adaptation globally.

Various identified challenges for the R&I community can be identified, including:

- New assessments of plants stability and waterflow modelling, together with new environmental studies tackling the main impact of increased streamflow on river and dam ecosystems
- Modelling the impact of climate change on critical infrastructures, waterways and land use
- Designing integrated and stable energy networks throughout the continent

IV SUMMARY OF WEBINARS AND DISCUSSIONS HELD WITH EERA MEMBERS

4.1 Webinar

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

With specific regard to the webinar organised between M18 and M24, speakers from the main four arenas relevant to the EERA community (EU and national policymakers, research and industry) were gathered. 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 webinar was organised to present the main policy developments in the field and to stimulate a discussion within speakers representing different interests.

4.1.1 Energy Sufficiency and Efficiency in the Fit for 55 Context: Challenges & Opportunities for Clean Energy Research

The event was opened by Mr Radoš Horáček, representing the Directorate General for Energy in the European Commission. He presented the main features of the latest legislative proposals on energy efficiency, showing the Commission's plan to achieve a 9% reduction in energy consumption by 2030. Although the Member States should take up the goal, the current ambitions do not seem to coincide with the measures indicated in the countries' National Energy and Climate Plans (NECPs).

In this respect, Article 8 of the proposed revised Energy Efficiency Directive sets out the direction of policymaking in the next years, mainly excluding from the Commission’s energy efficiency calculations the savings coming from direct fossil fuel combustion. The main opportunities in terms

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

of R&I challenges, in Mr Horáček's words, lie in better smart metering and appliances, coupled with the use of big data. Still, a mindset change will be key for energy efficiency efforts to become feasible. In particular, regarding the topic of energy sufficiency, the main impasse is represented by the heavy regulatory nature of the concept, which clashes with the objectives of the Commission in terms of growth.

The point of view of a Member State was brought forward by the second speaker, Mr Wolfgang D'Innocenzo, from the Permanent Representation of Italy to the European Union. He underlined the challenges in proposing EU standards for energy efficiency, as each Member State has specific conditions that might hamper or favour different approaches. Mr D'Innocenzo also highlighted that the energy efficiency principle, a key feature of the proposed revised Energy Efficiency Directive, might be limited in its application at individual project level by the systemic priorities of each country. He eventually raised doubts on implementing the energy sufficiency principle in a market economy without the risk of creating distortions in the system. When asked to express a point of view on the possibility of an annual carbon quota granted to every EU citizen (similarly to the current ETS system for EU industries), Mr D'Innocenzo expressed his interest in the idea. Still, he warned about the bureaucratic burden of its implementation.

The fundamental nature of continuous research efforts was the focal point of Ms Yvonne van Delft's intervention, representing the EERA Joint Programme on Energy Efficiency in Industrial Processes. The expert brought fundamental data to the conversation, showing that industry reached its peak in terms of energy efficiency throughout the 1990s until 2007. When comparing the 2007-2021 period, the pace of improvement has been slow-moving or non-existent in specific sectors. To invert this trend, and according to Ms Van Delft, industry needs to implement new production systems. In this respect, energy research in decarbonisation will be crucial, as green objectives will require increasing energy demand linked to hydrogen production and CO2 capture systems. Therefore, in the view of the expert, it is necessary to see such conditions taken into consideration by EU policies, starting from the currently proposed ‘Fit for 55’ legislation package.

The discussion was concluded by Mr Jakob Hebsgaard Mogensen, who brought to the audience's attention the successful experience of Green Lab Skive. A public-private initiative, GreenLab is a one-of-a-kind business park focused on producing in an environmentally friendly way. More than this, it represents an integrated system of renewable energy sources and industrial production, firmly imprinted on circular economy practices and green planning. With multiple companies coexisting in a single space exploiting a wind and solar farm, Mr Mogensen explained how GreenPark manages everything from energy production, storage, heating and cooling to highly smart industrial production. In the words of the speaker, this infrastructure shows that other realities could manage to create both growth and green production, concepts often put in contrast with each other.

Answering to points raised by other speakers and questions by the audiences, Mr Mogensen underlined that, in his perspective, industry would respond better to energy sufficiency practices by incentives and not by regulation.

The four pitches showed a high level of intertwining, with speakers addressing the same topics from different points of view and interacting both with each other and the audience. The conversation led to the emergence of challenging questions and possible points of action for energy efficiency and the clean energy transition. The webinar clearly showcased how joining forces can positively impact all sectors, favouring the emergence of an innovation ecosystem that will enable the energy efficiency and sufficiency efforts needed to achieve climate neutrality by 2050.

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

[4] https://supeera.eu/news-and-resources/3062:supeera-gathers-stakeholders-to-bring-forward-energy-efficiency-and-sufficiency-in-the-eu.html

V UPCOMING ACTIONS

In line with the actions identified in the Grant Agreement, Task 3.2 will continue to be active in the translation of EU policies into research challenges for the EERA community. Over the course of 2022, the SUPEERA team plans to publish four additional Policy Briefs, analysing and discussing R&I challenges related to the most recent EU policies in the area of energy and climate.

In addition to the next Policy Briefs, two more webinars will be organised in 2022 and one in the first semester of 2023, to comply with the proposed objectives for the time remaining in the project's schedule.

Furthermore, the future discussions at the EERA Annual Strategy Meeting will be carefully followed and reported in the future deliverables, to give an overview of the EERA community's reaction to the developments in SUPEERA.

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

ANNEX 1 – SUPEERA Policy Briefs

SUPEERA

Policy Brief

UPDATING THE 2020 NEW INDUSTRIAL STRATEGY

CHALLENGES AND OPPORTUNITIES AHEAD

Setting the scene

The European Green Deal celebrates its first year in 2021, testifying the renovated push from the European institutions to focus policymaking on the threats posed by climate change. To reach climate neutrality by 2050, the EU will need to incorporate several initiatives in energy and climate to develop a stable and coherent framework for concerted action. Within this framework, the recently published "Fit-for-55" package[5] represents a key milestone for the EU's ambitions and provides the roadmap to translate EU climate goals into concrete actions. The 13 proposals put forward within the package are strictly interconnected with each other and with the targets agreed in the European Climate Law, the centrepiece of the EU Green Deal.

The recently approved EU budget and the creation of Next Generation EU, a plan to boost the post-pandemic recovery of Europe, ensure substantial backing to many projects and initiatives supporting the reduction of emissions, while promoting its digital ecosystem and competitiveness. Green investments and collaboration on transnational projects are now crucial to ensure that the efforts of the Member States, industry, and research organisations will not fall short of the set objectives.

To complement the efforts made by policymakers, it is vital to ensure that R&I challenges are addressed in parallel, increasing the collaboration between research and industry to achieve the goals towards a climate-neutral energy system in the EU. The research community has a pivotal role 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.

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). The analysis of the policies identified has the two-fold objective of supporting recommendations towards the EERA membership and the SET-Plan ecosystem at large, also identifying potential areas for investment in energy R&I for EU policymakers. Specifically, this paper focuses on the Updated 2020 Industrial Strategy, as outlined in the Communication published on 5 May 2021 by the European Commission, which lays out a plan for how the EU's industrial ecosystem could lead the twin green and digital transitions.

[5] The "Fir for 55" Package is comprised of a set of 13 legislative proposals aiming to make the EU's climate, energy, land use, transport, and taxation policies fit for reducing greenhouse gas emissions by at least 55% by 2030. More info here: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0550

Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery

The European Commission's Communication "Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery" puts forward a set of policies aimed at boosting the EU's recovery and enhancing its open strategic autonomy. At the same time, it helps to drive the transformation towards a more sustainable, digital, resilient, and globally competitive economy.

The Communication revolves around three strategic priorities that will guide the EU actions in the months and years ahead. The table below provides an overview of these priorities and the related areas for development defined by the European Commission. They are reported as identified R&I challenges as the present analysis focuses solely on the areas with the highest potential for further improvements through European R&I actions.

Key priorities	Identified R&I challenges
Strengthening Single Market resilience	1) Introduce a **Single Market Emergency Instrument** with the aim of ensuring the availability and free movement of persons, goods, and services in the context of possible future crises. This instrument should guarantee more **information sharing, coordination, and solidarity** when Member States adopt crisis-related measures. 2) Build a mechanism through which Europe can address critical product shortages by **speeding up product availability** and **reinforcing public procurement cooperation**. This mechanism should be aligned with other relevant international practices aiming to address emergency situations, like pandemics or ensure and speed up the availability of essential products. 3) **Improve transparency and coordination on intra-EU export restrictions and services restrictions**. 4) Enhance **market surveillance procedures**. 5) Support and encourage market surveillance authorities to **step up the digitalisation of product inspections and data collection** and use state-of-the-art technologies to trace non-compliant and dangerous products. 6) Ensure the proper transposition and implementation of the Posting of Workers Enforcement Directive across Member States by **developing a common form, in an electronic format, for the declaration of the posting of workers**. 7) **Strengthen the solvency and growth of SMEs** by mobilising significant investments through the InvestEU programme, as well as by facilitating the exchange of best practices on measures and incentives to target support on viable companies.
Dealing with dependencies: Open strategic autonomy in practice	1) **Deepen** conducted **in-depth reviews of strategic areas** (I.e., raw materials, batteries, active pharmaceutical ingredients, hydrogen, semiconductors and cloud and edge technologies) to provide further insights on the origin of EU's strategic dependencies and their impact. 2) Launch a **second stage of in-depth reviews** of potential dependencies in key areas, including products, services or technologies key to the twin transitions such as renewables, energy storage, and cyber security. 3) Establish a **periodic review process** of strategic dependencies and monitor associated risks. 4) **Diversify international supply chains** and **pursue international partnerships** to increase preparedness.

	5) **Examine reverse dependencies** and map areas where other countries depend on the EU to better informthe EU's policy response. 6) Support the establishment and development of further **industrial alliances** in strategic areas where such alliances are identified as the best tool to accelerate activities that would not develop otherwise and where they help to attract private investors. 7) Support Member States' efforts to pool public resources via **Important Projects of Common European Interest** (IPCEIs) in areas where the market alone cannot deliver breakthrough innovation. 8) Adopt a **standardisation strategy**. 9) Adopt a legal instrument to address the potentially **distortive effects of foreign subsidies** in the Single Market. 10) In general,capitalise on Europe's first-mover advantage and its renewable energy resource potential to ensure **industrial leadership in key low-carbon technologies** of today and in the future.
Accelerating the twin transitions	1) Support Member States to join forces in **multi-country projects** to build digital and green capacities. 2) Support the **co-creation of green and digital transition pathways** for relevant ecosystems, starting with energy-intensive industries and tourism. 3) Conduct an **extensive review of the EU competition rules** to make sure they are fit to support the green and digital transition to the benefit of all Europeans. 4) **Revise the environmental and energy State aid rules** to enable Member States to support businesses to decarbonise their production processes and adopt greener technologies. 5) **Revise State aid rules on IPCEIs** in order to further enhance their openness and provide guidance on the criteria to pool funds from national budgets and EU programmes. 6) Support actions to **promote renewable Power Purchase Agreements (PPA)** in the proposal for a revised Renewable Energy Directive. 7) Establish a **European approach to carbon contracts** for difference in the proposal for a revised ETS Directive. 8) Develop **Energy and Industry Geography Labs** providing geospatial information for companies and energy infrastructure planners.

Establish research as a preferred partner for industrial development

The transition to carbon neutrality will be demanding for the industrial sector, not only given the scale of the challenge but also the level of investments necessary to drive production changes. EU industries face an additional layer of difficulty compared to peers in other regions of the world, as Europe **depends on raw materials** in many strategic sectors. The theme of strategic dependencies represents one of the most important challenges for the EU when it comes to industrial production, an issue that emerged during the COVID-19 pandemic with the disruption of global value chains and the effect on essential products and inputs.

In this context, **energy efficiency** surely constitutes one of the many important levers for change that needs to be swiftly implemented across the board for EU industries. Still a largely underutilised source of carbon abatement, it represents a key pillar of any effective energy policy aimed at ensuring Europe's

energy security and decarbonisation of the economy while creating new jobs and stimulating economic growth. Energy efficiency can also improve the safety of the work environment and reduce maintenance, raw materials, and environmental compliance costs. Therefore, research in this field needs to be starkly stepped up to quickly capitalise on its benefits derived from mass scale.

With regards to value chains, **instability needs to be carefully addressed** in order to prevent future ruptures in processes, as has been the case for the recent semiconductors shortage that struck the EU automotive industry. In such cases, it is important to **enhance the EU's ability to increase domestic production** to avoid relying entirely on outside sources. This step will be crucial as the EU is highly dependent on imports critical for energy-intensive industries. To this end, research will be decisive not only to make industrial processes greener through a mix of **new production techniques** and **carbon capture and storage (CCS) technologies**, but also to increase and expand the development and incorporation of circular economy processes.

Raw materials are a central issue, particularly for sectors that heavily rely on external dependency; batteries, hydrogen, and semiconductors are only a few to be mentioned. In all these sectors, increasing circularity will have a beneficial effect on the usage of raw materials. Research efforts should be directed at **studying new ways to repurpose materials**, **recovering important components,** and **finding new ways to use second-hand resources**. Models should also be developed to **predict emissions linked to recycling** and calculate the exact environmental gains obtained through circular processes.

Among the other sectors touched by the Communication, steel receives a primary focus. Here, major R&D efforts will be required to meet the targets for 2050, mainly regarding circularity and production processes. While steel is already a very circular material, with up to 84 Mt reused every year, new techniques are needed to increase the share of secondary steel, ranging from **enhanced circular design** in the production phase to **better scrap sorting processes**. In the production phase, new technologies are being developed and scaled up for market diffusion, including **hydrogen direct reduction** and **CCUS steelmaking processes**. In addition, as part of the twin green and digital transition, **blockchain technologies that can facilitate emissions tracking** should also be improved and deployed at a market scale.

The Communication also targets multi-country projects in the fields of hydrogen, 5G corridors, common data infrastructure and services, sustainable transport, blockchain or European Digital Innovation Hubs. The recent publication of the **"Fit for 55" legislative package** further indicates which areas will need to accelerate the transition to low carbon processes. **Transport** will be a major field for action in the coming years, with plans to ban fossil fuel cars by 2035. The objective is among the most criticised, given the current state of infrastructure for e-mobility across the EU. Here, significant investments will be needed to equip transportation systems and roads with the necessary charging points and other instruments to ensure that end-users are provided with the conditions and incentives to buy zero-emission cars. R&D developments can speed up the transition, not only on the side of **improved batteries** in terms of efficiency and charging speed, but also towards new methods like **wireless charging** through magnetic fields, large-scale use of **fuel cells**, advanced **exhaust scrubbers,** and the large scale deployment of **Vehicle to Grid (V2G) technology**. The role of digital developments will also be fundamental, with a **digital grid and algorithms** monitoring the battery capacity and playing a role in the system's stability.

Transport is not only confined to road transport but also aviation and maritime shipping. New regulations will underpin the sectors to the **EU Emission Trading System**, creating the need for improved propel systems for airplanes and ships. In this case, the major breakthroughs in technology will come from **hydrogen-based engines** and an increase in the use of **alternative fuels**, mainly represented by **biofuels**. In this category, the EU will not consider crop-based biofuels as sustainable aviation fuels (SAFs) given their "limited environmental benefits"[6]. Research and industrial efforts shall instead focus on developing **advanced biofuels** obtained through the reuse of EU-based **agricultural and forestry waste** to reduce dependence on foreign raw materials.

As per maritime shipping, new developments in the field of alternative fuels are needed. **Methanol** is currently being used and developed. In addition, **ammonia-based fuels and engines** may be key to increase the sustainability of the sector, given the low level of ammonia's carbon emissions and its good performance in energy density compared to other alternative fuels. Besides, shifting transport from aviation to rail or replacing cement and steel with alternative building materials, such as sustainable wood, should be complementary strategies to increasing jet fuel efficiency or decarbonising steel and cement industrial processes.

Digitalisation will also pose challenges with the increase in the need for data centres and data volume on the cloud. Data centres require a high amount of electricity to work, most of which is still derived from fossil fuel sources. Electricity, still, is used to power the servers and efficiently implement **cooling systems** for the machines, which otherwise risk over-heating and increasing fire hazards. **Connecting data centres to renewable energy** will be more crucial than ever if Europe plans to deploy the twin green and digital transition in full synergy. In this respect, a significant R&D effort will be needed to make computing and internet resources more environmentally friendly.

Outside technological aspects, the Commission plans to **reinforce international partnerships** to develop alternative value chains. In these partnerships, research should play a pivotal role in the talks with external countries. It will be crucial to connect research centres and alliances from Europe with international peers, creating the conditions for broad collaboration on energy and climate topics. The EU is, for example, a world leader in renewable energy technology, but it can still benefit from external expertise while driving the adoption of sustainable solutions in low- and middle-income countries. Fostering international partnerships and cooperation should go hand in hand with pursuing an open strategic autonomy in a context of global competition for industrial and technological leadership. On this, it will be essential for Europe to capitalise on its first-mover advantage to maintain and expand its industrial lead in key low-carbon technologies.

Finally, the Communication mentions that for an inclusive transition, **a well-functioning social dialogue** will be key. Strong partnerships between the EU, Member States, social partners, industrial actors, and other relevant stakeholders across and within industrial ecosystems will be critical in this respect. An important leverage to couple industrial transformation with socio-economic change will be **public spending through procurement**, which amounts to 14% of EU GDP each year. This will help to

6 https://www.euractiv.com/section/biofuels/news/eu-green-jet-fuel-proposal-shuns-crop-based-biofuels-focuses-on-next-generation/

strengthen companies' competitiveness through the use of strategic criteria, notably for green, social, and innovative procurement while ensuring transparency and competition. In this regard, **research on technology consistently coupled with a sound socio-economic analysis** can become a formidable tool for the Clean Energy Transition to effectively deliver on a technical level while ensuring socio-economic awareness and acceptance.

Conclusions

The proposals contained in the EU Updated 2020 Industrial Strategy are critical for the success of the European Green Deal in the years to come. Indeed, they lay the foundations to effectively deliver on the twin green and digital challenges. In this context, it is now more important than ever to streamline the role that R&I can play in accelerating a **holistically thought Clean Energy Transition** in the industrial sector.

This perspective entails counting on **research as a preferred partner for industrial development** both on technological and socio-economic levels, for the change to be effective and viable across the board. R&I on energy efficiency, greening of industrial processes, and circularity are part of the equation, especially considering the potential that digitalisation can play in those processes. Likewise, research is also required to ensure that the transition is carried out in a socially and economically sustainable way. The shift towards new industries and market models will inevitably generate opportunities for economic growth and job creation in some sectors, while accelerating the collapse in others. In this regard, the Carbon Border Adjustment Mechanism[7] is a sample of the policies needed to avoid the relocation of critical industrial sectors in regions of lower labour or environmental standards.

Leveraging best practices for greater effectiveness of existing innovation ecosystems will also be critical for the new industrial strategy to succeed. Higher investments in R&I should be combined with more efficient innovation ecosystems, accelerating the conversion of intellectual capital into marketable products and services, and promoting their market uptake. In line with the EC Communication, "A new ERA for Research and Innovation"[8], **a change of collaboration culture needs to occur in Europe to allow stronger cooperation between research and industry**. "**European Centres of Excellence**" should be seen in this respect as blueprints for highly effective innovation ecosystems. Besides this, and in order to ensure a robust industrial leadership, the management of an **innovation funnel across the whole TRL range is required**. Also, policies should support start-up creation, the rapid roll-out of intrapreneurship, and the uptake of frugal innovation.

Finally, zeroing emissions by 2050 in a context of increasing global emissions[9] mandates a **strong acceleration and intensification of international collaboration**. To support this, policies should foster international cooperation while recognising that the race to net-zero will trigger fierce competition for industrial and technology leadership. It will be essential for Europe to capitalise on its first-mover advantage to maintain and expand its industrial leadership in key low-carbon technologies of today and the future. Yet, as the EU accounts for less than 9% of global emissions, international cooperation and partnerships are essential to address climate change globally. In this sense, an active climate

[7] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12228-Carbon-Border-Adjustment-Mechanism

[8] Communication from the European Commission: “A new ERA for Research and Innovation”: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:628:FIN

[9] Energy related emissions dropped by 6% in 2020 following Covid pandemic, but are rebounding in 2021; IEA, Global Energy review, emissions in 2020 – Understanding the impact of Covid-19 on global emissions, March 2021

multilateralism in line with the UN Sustainable Development Goals is crucial to foster global understanding and action towards climate neutrality.

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

SUPEERA

Policy Brief

THE EUROPEAN CLIMATE LAW

CHALLENGES AND OPPORTUNITIES AHEAD

Setting the scene

The European Green Deal celebrates its first year in 2021, testifying the renovated push from the European institutions to focus the attention of policymaking on the threats posed by climate change. To reach climate neutrality by 2050, the EU will need to incorporate several initiatives in energy and climate to develop a stable and coherent framework for concerted action. Within this framework, the recently published "Fit-for-55" package, a set of 13 legislative proposals aiming at making the EU's climate, energy, land use, transport, and taxation policies fit for reducing greenhouse gas emissions by at least 55% by 2030, represents a key milestone for the EU's ambitions and provides the roadmap to translate EU climate goals into concrete actions. The 13 proposals put forward within the package are strictly interconnected between each other, as well as with the targets agreed in the European Climate Law, the centrepiece of the EU Green Deal.

The recently approved EU budget and the creation of Next Generation EU, a plan to boost the post-pandemic recovery of Europe, ensure substantial backing to many projects and initiatives supporting the reduction of emissions and promoting the EU's digital ecosystem and its competitiveness. Green investments and collaboration on transnational projects are now crucial to ensure that the efforts of the Member States, industry, and research organisations will not fall short of the set objectives.

To complement the efforts made by policymakers, it is vital to ensure that R&I challenges are addressed in parallel, increasing the collaboration between research and industry to achieve the goals towards a climate-neutral energy system in the EU. The research community has undoubtedly a pivotal role 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, for the advancement of breakthrough technologies, materials, and 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). The analysis of the policies identified has the two-fold objective of supporting recommendations towards the EERA membership and the SET-Plan ecosystem at large, also identifying potential focus areas in energy R&I for EU policymakers. Specifically, this paper focuses on the European Climate Law, as outlined in the Communication published on 4 March 2021 and updated on 17 September of the same year by the European Commission, which enshrines into law the goal set out in the EU Green Deal – for Europe's economy and society to become climate-neutral by 2050.

The European Climate Law

The European Commission's Communication on the European Climate Law enshrines into law the EU's climate-neutrality objective, ensuring that all EU actions and policies contribute to it in a socially-fair and cost-efficient manner, with all sectors of the economy and society playing their part.

The Communication revolves around four strategic priorities that will guide the EU actions in the months and years to come. The table below provides an overview of these priorities and the related areas for development defined by the European Commission. They are reported as identified R&I challenges as our analysis focuses solely on the areas with the highest potential for further improvement through European R&I actions.

Key priorities	Identified R&I challenges
Achieving climate neutrality	a) Take the necessary measures at Union and national level to enable the **collective achievement of the climate-neutrality objective**. b) The trajectory to reach climate-neutrality developed by the EU Commission should take into account the following: i. **Cost-effectiveness** and **economic efficiency**; ii. **Competitiveness** of the Union's economy; iii. **Best available technology**; iv. **Energy efficiency**, energy **affordability**, and **security of supply**; v. **Fairness and solidarity** between and within Member States; vi. The need to ensure **environmental effectiveness and progression** over time; vii. Investment needs and opportunities; viii. The need to ensure a **just and socially fair transition**; ix. International developments and efforts undertaken to achieve the long-term objectives of the Paris Agreement and the ultimate objective of the United Nations Framework Convention on Climate Change[10]; x. The best available and most recent scientific evidence, including the **latest report of the IPCC**[11].

[10] For more information on the United Nations Framework Convention on Climate Change (UNFCCC) visit the following page: https://unfccc.int/.
[11] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf

Enhance adaptation to climate change	a) Ensure continuous progress in **enhancing adaptive capacity**, strengthening resilience and reducing vulnerability to climate change. b) Develop and implement **adaptation strategies and plans that include comprehensive risk management frameworks**, based on robust climate and vulnerability baselines and progress assessments.
Assessment of national and Union progress and measures	a) Regularly assess the following: i. The **collective progress** made by all Member States towards the achievement of the climate-neutrality objective; ii. The collective progress made by all Member States on adaptation. b) Once the assessment has been conducted, the EU Commission should submit its conclusions, together with the State of the Energy Union Report prepared in the respective calendar year. Both documents must be submitted to the EU Parliament and Council. c) By the end of September 2023, and every 5 years thereafter, the EU Commission should review the following: i. The **consistency of EU measures with the climate-neutrality objective**; ii. The **adequacy of EU measures to ensure progress on adaptation**. d) In the case it is found that EU measures are inconsistent or inadequate, the necessary measures should be taken, in accordance with relevant EU Treaties. e) Assess draft measures and legislative proposals in light of the climate-neutrality objective. Such analysis should be included in any impact assessment accompanying these measures or proposals. Furthermore, the result of the assessment must be public at the time of the adoption.
Enhance public participation in climate activity	a) Engage with all parts of society to enable and empower them to take action towards a climate-neutral and climate-resilient society. b) Facilitate the **building of an inclusive and accessible process at all levels** i. Promoting multilevel governance and policy design practices open to the involvement of stakeholders ii. Promoting participatory process aimed at involving the wide public into the policy design and implementation process (e.g. public consultation, deliberative arena…)

Ensuring the successful transition towards climate-neutrality will heavily rely on research

Also referred to as the “law of laws” due to its key importance for achieving the EU Green Deal’s objectives, the European Climate Law provides the conditions to set out a trajectory leading the EU to climate-neutrality. At the same time, it enhances certainty and confidence in the EU’s commitment for businesses, workers, investors and consumers, as well as transparency and accountability, thus promoting prosperity and green job creation.

More specifically, the path towards climate-neutrality set out within the Communication addresses the necessary steps to be taken at national and European level. First of all, based on a comprehensive impact assessment presented in September 2020, the EU Commission has proposed to raise the greenhouse gas (GHG) emissions reduction target to at least 55% compared to 1990 levels. Additionally, and if deemed appropriate, an **intermediate target for 2040** will be proposed, an important initiative ensuring the alignment of national efforts. Such target will be informed by the **Union’s GHG budget for 2030-2050**, which outlines the maximum level of emissions that can be released in the atmosphere without undermining the EU pledges under the Paris Agreement. Incentivising early action and leading the way towards carbon-neutrality, the latter represents a necessary tool providing a clear and transparent budget that can help assess national and European progress.

EU Climate Law

« In order to reach the climate-neutrality objective set out in Article 2(1), the binding Union 2030 climate target shall be a domestic reduction of net greenhouse gas emissions (emissions after deduction of removals) by at least 55 % compared to 1990 levels by 2030. »

These measures open a large window of opportunity for clean energy research, as the foreseen greenhouse gas emissions cuts will require an **immediate boost to R&I investment to step up the identification and conception of new technologies and the development of those that are not yet on the market.**

Coupled with regular reporting by Member States and their National Energy and Climate Plans (NECPs), and additional mechanisms ensuring the efficient evaluation of Union-wide progress, the 2030-2050 emissions budget will also serve as a basis to **issue recommendations and re-direct national climate policies where necessary** – e.g. in the case inconsistencies are found between national measures and EU climate objectives or measures are regarded as inadequate. Otherwise, without an overarching coordination effort, researchers will have less opportunities to collaborate across borders and produce results that can fit different environments.

Alongside regular evaluation processes, several additional factors need to be taken into account when designing the EU's trajectory towards climate-neutrality. First of all, as mentioned within the Communication, Member States need to **make use of the best available technology** in order to achieve a timely energy transition. In this respect, research and innovation will be crucial for expanding the range of options, improving performance and reducing costs in key technological areas. Structural changes in the energy system are needed if we are to achieve a rapid decline in emissions and innovation will play an increasingly important role. In particular, the European Commission underlines that **solar photovoltaics (PV), electric mobility and energy storage** will be among the most important innovations on the current horizon. However, efforts will need to be increased in many other key sectors, considered the large scope of the energy research field and its potential applications in real life situations. **Carbon capture and storage (CCS) and carbon removal mechanisms,** for instance, will be necessary to ensure the compensation of GHG emissions from sectors where decarbonization is challenging. Key technologies in these areas should, therefore, be made cost-effective and deployed at large-scale. Other crucial fields of research include the **digitalisation** of the energy sector, the **circular economy,** and the **integration of energy systems** for a more cross-cutting approach to the clean energy transition process.

The **European High Performance Computing Joint Undertaking** could be an important instrument to make climate research one of the key purposes of the use of supercomputer, helping in terms of modelling and predicting

The digital and the ICT sectors will also play a crucial role in the transition to a greener energy system. Based on new IT technologies such as **high performance computing (HPC), modelling, robotics and artificial intelligence,** platform concepts for accelerated material development and device design will speed up the development and innovation chain for new energy system components by at least a factor of 10. This will make a difference, empowering more innovative and energy-efficient processes in possibly all energy sectors and reducing the long times associated with developments in key technology areas.

International collaboration and a stronger knowledge-exchange among researchers in different geographical areas will also be key to succeed. In this respect, support for public and private initiatives pooling knowledge and resources together will need to be increased and communication channels between researchers improved.

Social considerations should also be taken into account. **Strengthening the social dimension of the energy transition** is an important precondition to ensure its success both in terms of addressing current and potential social impacts (e.g. energy poverty, inclusion of vulnerable groups in the transition pathways) and in terms of exploiting the

potential of social dynamics to foster the transition process (e.g. networks, culture and values, community identity, embedded knowledge). More specifically, what is needed is the development of a **detailed and inclusive narrative of the energy transition** envisioning how climate action can improve the quality of life of citizens and contribute to social cohesion, avoiding the exacerbation of social inequalities brought by climate change and related extreme weather events[12].

Managing the social impact of the transition through the implementation of financial mechanisms such as the **Just Transition Fund (JTF)** and the **new Social Climate Fund** proposed within the framework of the recently published "Fit for 55" legislative package, will also be of pivotal importance. Through well-defined transition strategies, such mechanisms should guarantee enough support is given to fossil-fuel dependent regions and vulnerable households in order to efficiently transition to cleaner energy alternatives.

All of these innovations, nonetheless, will only be obtained if researchers increase their level of cooperation and communication. Still today, most sectors are crippled by the lack of **effective framework mechanisms** for researchers to work with and receive feedback from peers. In this sense, it is fundamental to **foster networks between researchers** and participation in activities that strengthen knowledge creation and knowledge sharing.

The crucial missing link is the communication and dissemination of research results. **Most of today's advancements in research activities are not properly shared by the research communities**, and the low performance in communication activities by project consortia and research organisations weakens the capability of researchers to have a solid impact on society. Increased attention should be therefore paid to such critical aspect to, among others, generate better engagement with stakeholders, raise awareness on the benefits of research, maximise results' impact and inform regulatory decisions.

[12] EERA White Paper "Clean Energy Transition": https://www.eera-set.eu/index.php?option=com_attachments&task=download&id=675:Digital-final_EERA_White_Paper_Clean_Energy_Transition

Conclusions

The European Climate Law represents the most ambitious legislative attempt to make the clean energy transition a reality. The provisions included in it set the goals for the next decades and will help the EU reach the transition in an inclusive, sustainable, and just way. To achieve these objectives, the support of research activities will be crucial, and **it should become a focus of the EU institutions to plan extensive support to the research activities conducted in energy matters**.

The importance of early-stage research is undisputed, and financial efforts from the EU institutions should be directed to increase the attractiveness of the sector. **Support to low TRL research will unlock new ideas and help scaling up projects in high-potential, high-risk sectors**. At the same time, **research needs a boost to reach the market stage.** In this case, high TRL research calls for market-supporting mechanisms to protect investments and enterprises from the risks inherent to investing in new technologies.

The research community is called to increase its efforts to collaborate and present a united front when consulted on priorities for investments and planning. **The main challenge in the coming years will be the de-siloing of many areas of energy research**. Attention should be dedicated **to research in the field of energy systems integration**, which can lead to better planning for the exploitation of energy sources in a way that is beneficial for different technologies and sectors. It will be important to **study methods to support new industrial sectors and instruments, in order to enable a cross-cutting transition. Stronger consideration to the social aspects of the Clean Energy Transition and the development of a holistic perspective** that promotes equity and solidarity will be equally crucial to achieve the desired results.

The main challenge in the coming years will be the **de-siloing of many areas of energy research**. In, this respect, attention should be dedicated to research in the field of **energy systems integration**

Ultimately, it will be of utmost importance that **the research community and the European institutions keep an open dialogue about how each can best support the other**. Without clear objectives and a common vision on how to bring the 2030 and 2040 goals to reality, the process of urgently moving towards a climate neutral and sustainable EU will not be reached in due time.


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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

THE EU ADAPTATION STRATEGY

CHALLENGES AND OPPORTUNITIES AHEAD

Setting the scene

The European Green Deal testifies the renovated push from the European institutions to focus the attention of policymaking on the threats posed by climate change. To reach climate neutrality by 2050, the EU will need to incorporate several initiatives in energy and climate to develop a stable and coherent framework for concerted action. Within this framework, the recently published "Fit-for-55" package, a set of 13 legislative proposals aiming at making the EU's climate, energy, land use, transport, and taxation policies fit for reducing greenhouse gas emissions by at least 55% by 2030, represents a key milestone for the EU's ambitions and provides the roadmap to translate EU climate goals into concrete actions. The 13 proposals put forward within the package are strictly interconnected between each other, as well as with the targets agreed in the European Climate Law, the centrepiece of the EU Green Deal.

The approved EU budget and the creation of Next Generation EU, a plan to boost the post-pandemic recovery of Europe, ensure substantial backing to many projects and initiatives supporting the reduction of emissions and promoting the EU's digital ecosystem and its competitiveness. Green investments and collaboration on transnational projects are now crucial to ensure that the efforts of the Member States, industry, and research organisations will not fall short of the set objectives.

To complement the efforts made by policymakers, it is vital to ensure that R&I challenges are addressed in parallel, increasing the collaboration between research and industry to achieve the goals towards a climate-neutral energy system in the EU. The research community has undoubtedly a pivotal role 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, for the advancement of breakthrough technologies, materials, and 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). The analysis of the policies identified has the two-fold objective of supporting recommendations towards the EERA membership and the SET-Plan ecosystem at large. This paper analyses the European Commission new Adaption Strategy, published on February 24 of 2021, which sets a pathway to increase Europe's preparedness to the inevitable consequences of climate change impacts. This updated version of the 2013 Climate Change Adaptation Strategy goes beyond an improved understanding of the problem, by making adaptation measures a central element to be considered across the board.

Forging a climate-resilient Europe – the new EU Strategy on Adaptation to Climate Change

In its Communication "Forging a climate-resilient Europe – the new EU Strategy on Adaptation to Climate Change"[13], the European Commission outlines a long-term vision for the EU to become a climate-resilient society, fully adapted to the unavoidable impacts of climate change by 2050.

The Communication revolves around four strategic priorities to build a climate-resilient society, by improving knowledge on adaptation, step up adaptation planning, speed-up adaptation actions, and help strengthening climate adaptation globally. The table below provides an overview of these priorities and the related areas for development defined by the European Commission. They are reported as identified R&I challenges as this analysis focuses solely on the areas with the highest potential for further improvement through European R&I actions.

Key priorities	Identified R&I challenges
Improving knowledge of climate impacts and adaptation solutions	1. Translate the wealth of climate information into customised and user-friendly tools. 2. Push the frontiers of adaptation knowledge and acquire more and better climate-related data. 3. Draw on science to improve our understanding of the nexus between climate hazards and socioeconomics vulnerabilities and inequalities 4. Promote the use of the latest technologies and climate services to underpin decision-making (for example remote sensing, smart weather stations, AI, and high-performing computing). New instruments such as Destination Earth and Digital Twins hold great promises to advance our understanding of present and future climate impacts. 5. Need for science-based, robust ecosystem restoration and management that helps minimise risks, improve resilience, and ensures the continued delivery of vital ecosystem services and features: food provision, air and water purification, flood protection, biodiversity, and climate mitigation. 6. Improve the accuracy of data on climate-related risk and losses to better inform decision-making, homeowners, SMEs, businesses, banks, and city planners. 7. Harmonise data collection and extend public access to climate-related disaster loss data by recasting the INSPIRE Directive as part of the "GreenData4All" initiative. 8. Making Climate-ADAPT the authoritative European platform for adaptation; expand the capabilities of online tools and knowledge platforms for the collecting and sharing of data.
Stepping up adaptation planning and climate risk assessments	1. Mainstream climate resilience considerations across all public and private sectors. 2. Ensure adaptation strategies at all National, regional, and local level are effective and based on the latest science. 3. Develop suitable indicators and a resilience assessment framework to improve the monitoring, reporting and evaluation of adaptation progress of Member States. 4. Ensure that regulation and funding take into account disaster risk to avoid creating new expose; reduce existing risk by building resilience, prevention and preparedness; and manage residual risk. 5. Support the local uptake of data, digital and smart solutions related to climate adaptation tailored to local and regional specificities, building upon existing initiatives and instruments such as the Smart Cities Marketplace, Digital Europe Programme, Horizon Europe and the Intelligent Cities Challenge. 6. Support the reskilling and requalification of workers that lead to green jobs, as well as improve our understanding of climate change on workers, working conditions, health and safety. 7. Develop ways to measure the potential impact of climate-related risks on public finances.

[13] https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:52021DC0082

	8. Quantify the benefits of blue-green (as opposed to grey) infrastructure to be communicated to decision-makers and practitioners at all levels. 9. Develop certification mechanism for carbon removals, which will enable robust monitoring and quantification of the climate benefits of nature-based solutions.
Speed-up adaptation action across the board	1. Close the financing gap for climate resilient investments. 2. Accelerate the rollout of adaptation solutions and step-up innovation. 3. Enhance climate-proofing guidance to increase investments in resilient, climate-proof infrastructures. 4. Promote synergies across projects to promote best practices, standards, guidance, targets, resources and knowledge at National, EU and International levels. 5. Include climate resilience considerations in critical infrastructures. 6. Explore the wide use of financial instruments and innovative solutions to deal with climate-induced risks (Renewed Sustainable Finance Strategy). 7. Improve water management across sectors; reduce water use and guarantee a stable and secure supply of drinking water.
Helping strengthen climate resilience globally	1. Cooperate closely with third countries on adaptation strategies and sharing of best practices to strengthen global adaptation strategies. 2. Scale-up international finances to build climate resilience.

Adaptation might prove to be one of research's most difficult challenges in the years to come

As shown in studies published by the likes of the Intergovernmental Panel on Climate Change[14], the International Energy Agency[15], the European Union[16] and the European Environmental Agency[17] and other relevant organisations, climate change cannot be halted anymore. While it is indeed true that it can be contained, with countries aiming at limiting global temperature rise to around 1.5C degrees in comparison to pre-industrial levels, its effects are already visible nowadays and will continue to provoke disruptions to the environment and human life on earth. The quest for adaptation to climate change is already a crucial part of international efforts, as it is central to the United Nations Sustainable Development Goals (SDG) 7 and 13.

Adaptation to climate change

Adaptation is the process of adjustment to actual or expected climate and its effects (IPCC AR5). It is not a one-time emergency response, but a series of proactive measures to deal with the nexus of hazard (e.g., drought, sea level rise), exposure (e.g., less water in the South), and vulnerability (e.g., poverty or lack of education).

[14] IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change: https://www.ipcc.ch/report/ar6/wg1/

[15] "Net Zero by 2050 - A Roadmap for the Global Energy Sector": https://www.iea.org/reports/net-zero-by-2050

[16] Communication from the Commission on The European Green Deal: https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f1aa75ed71a1.0002.02/DOC_1&format=PDF

[17] Adaptation challenges and opportunities for the European energy system - Building a climate-resilient low-carbon energy system: https://www.eea.europa.eu/publications/adaptation-in-energy-system

The impacts of climate change on the energy system are various and cross-cutting, potentially reaching many different areas and affecting, for example, renewable energy availability. In this sense, research challenges may be specifically posed to the energy community, as many of the renewable sources we know today depend highly on factors directly touched by climate change. To name a few, modifications in water supply, soil quality, and temperatures will alter supply patterns for a diverse range of renewable energy sources.

The importance of the energy-water nexus

Different energy sources pose various challenges. Water is a primary element in producing energy from hydropower, nuclear energy, Concentrated Solar Power (CSP), biofuels, and ocean energy, while it is less fundamental in wind energy and solar photovoltaic (PV). Water-using energy sources will face increasing challenges in the coming years, although in different ways depending on geographical positioning. Climate change adaptation will therefore spur various conditions across Europe, with alteration in water availability in both the North and the South of the continent.

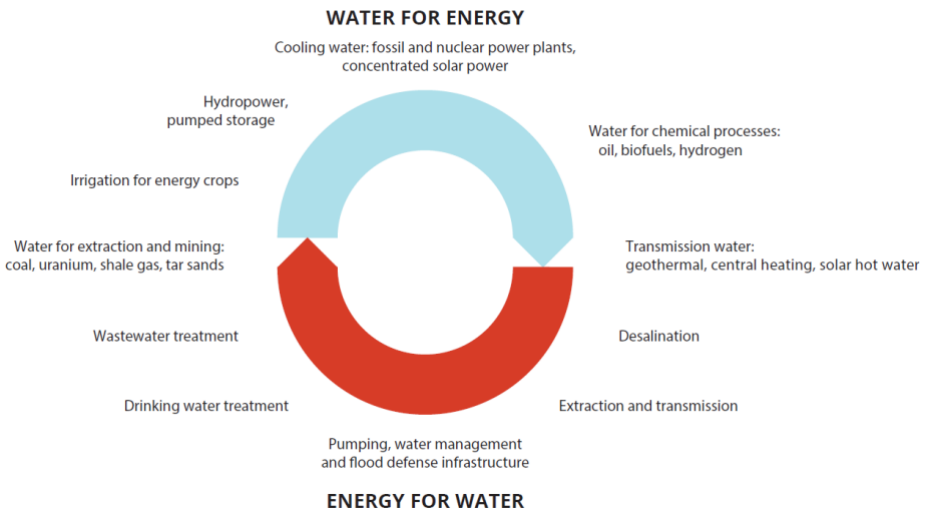

Fig. 1: The energy-water nexus. Source: EEA, based on EP (2012)

Hydropower technology is susceptible to a changing climate, as it can benefit or suffer from very different developments. Northern Europe is projected to experience increased rainfalls and higher temperatures, melting glaciers. On the contrary, ; Southern Europe is expected to be confronted with fewer rainfalls and suffer from a lack of water. This will pose an immediate threat to hydropower plants and infrastructures in both locations: in the South, draughts could decrease hydropower potential, while in the North, floods could increase risks of damages to structures and the ecosystem around the plants. **Research challenges include new assessments of plants stability and waterflow modelling, together with new environmental studies tackling the main impact of increased streamflow on river and dam ecosystems.**

Not only energy production, but also the choice of cooling technology for power generation will need to undergo new adaptation assessments. Once-through cooling systems are cheap and efficient, but they also demand high water withdrawals. The dry cooling option uses very little water, but it is also costly and not yet as efficient as other options. **Research can go a long way in making dry cooling more easily deployable and efficient, but efforts should also be directed towards decreasing water input in other technologies.**

Developments in this sector will be crucial for CSP and nuclear power plants. Both plants make intensive use of water in their processes, and forecasting scarcity of water in countries where the technologies are used will create serious difficulties to operation management. **Cooling technologies will need to become more efficient and less water-intensive. Nuclear power plants might also risk being the victim of floods, which means additional research in the waterproofing of plants should be developed.**

Higher temperatures, more extreme climate events

In a warmer climate, energy systems will have to be carefully designed to adapt to the new conditions. Once again, Europe is expected to experience different situations depending on geographical locations. Northern Europe is set to see a reduction in total energy demand due to higher average temperatures, while Southern Europe's energy demand is predicted to increase. The difference will be in the need for cooling systems in environments subject to higher temperatures, especially in the summer. As a result, peak electricity demand for cooling will rise in Europe, increasing the need for electricity and creating an additional burden on the system.

Collapsing power cables causes temporary loss of power to users, and brings about additional reparation costs for power providers. Storms can damage power lines, and cause power outages and black-outs, through direct impact or indirect impact (e.g., falling trees). Furthermore, storms can increase the rate of lightning flashes, a further cause of power outages through damage to power lines.

In this context, **the adaptation's main challenge will become the design of integrated and stable energy networks throughout the continent.** There are different measures that can be adopted to reduce unstable or overloaded networks' risk, **including new efficiency standards to reduce the load on the transmission lines, augmented network capacity, increased energy storage technology and the introduction of more water-saving technologies in the energy mix, such as solar PV.** Moreover, it will be crucial to collaborate with Transmission System Operators (TSOs) and distribution system operators (DSOs) to address correct and updated planning and management of energy production and distribution. Particularly in the context of the EU Renovation Wave Strategy[18] and the New European Bauhaus[19], **developments in energy-efficient buildings should also be encouraged to design structures that require less cooling or deploy advanced cooling technologies to reduce the need for electricity use.**

The issues with increased temperatures do not end at cooling. Various research studies have shown how a warmer climate impacts the efficiency of thermal power plants, with an estimated loss in power output of around 0.5% per additional degree[20], and the transmission capacity of

[18] A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603122220757&uri=CELEX:52020DC0662
[19] The New European Bauhaus: Beautiful, Sustainable, Together: https://europa.eu/new-european-bauhaus/system/files/2021-09/COM%282021%29_573_EN_ACT.pdf
[20] European Environmental Agency, 2019, "Adaptation challenges and opportunities for the European energy system - Building a climate-resilient low-carbon energy system", p. 37, Publications Office of the European Union, ISSN 1977-8449, doi:10.2800/227321

power lines by reducing it approximately 1.5% per degree in the summer[21]. **Developments in transmission lines technology and new output production processes will be needed if global temperature will not be halted at 1.5C degrees.**

An additional effect of climate change will be the occurrence of extreme climate events, which are now increasing every year. These include storms, hail, floods, high-speed winds, which impact energy installations. Among the main events, we can list storm damages to the transmission systems, drought (loss of cooling water) and ice build-up. **It will be critical for researchers and industrial partners to collaborate on improving facilities to overcome these challenges.** Wind power will also be highly affected by storms increase, as damages to machinery will grow larger, although not as much as in other energy technologies. The effects are already visible today, with the IEA estimating that weather conditions have prevented a possible 9% increase globally in renewable electricity generation[22].

Changes in soil, growing conditions and the land-energy dilemma

Land use will become an additional issue of increasing concern for different energy outings. Significant impact can be expected in the biofuels domain as climate change will affect the seasons and the areas in which crops for biofuels can be grown. In practical terms, this will mean that certain regions in Southern Europe might become unfavourable for crops growing, while the North of the continent could discover its potential.

Other essential aspects need to be considered, such as increased forest fire hazards (as shown by the fires ravaging Europe throughout the summer of 2021) and a change in soil composition and chemistry due to increased temperature and humidity. **Improvements in technology will be needed to ensure that important crops for biofuels will not be lost due to changing conditions, which may risk driving producers towards imports from outside of Europe.** Such an approach would reduce traceability, increase transport-related emissions and decrease strategic autonomy of the EU in the sector.

A second but no less important issue regards the choices made for land use. In terms of deployment, certain renewable energy sources (RES) can have higher land use requirements than fossil fuels. This large land footprint is an important factor in the land-energy dilemma, defined as the trade-off in building energy infrastructure instead of allocating the land to other possible uses, such as food and nature protection. Conflicts are already arising around the world where local communities protest over solar PV installations in place of agricultural land. **With the purpose of preventing the emergence of such struggles, it will be vital to devise new strategies and technologies that can combine multiple purposes on the same land (for example, agro-photovoltaics).** It is also important to remark that, by default, Renewable Energy Sources do not use more land than fossil fuel plants, and that policy and regulation have a pivotal role to play as far as destination of use is concerned. It will then become key **that researchers, producers and policymakers engage in constant exchanges to identify the best space planning strategy for RES installations to be deployed for the best interest of communities.**

[21] Ib.
[22] IE1, 2021, “Renewables 2021 - Analysis and forecast to 2026”, International Energy Agency

Conclusions

The new EU Strategy on Adaptation to climate change, “Forging a climate-resilient Europe”, sets the scene for more ambitious action on climate adaptation. The strategy's objective is to progress swiftly toward the **2050 resilience vision** by making **adaptation action smarter, more systemic, and faster.**

Strong scientific evidence points towards **sudden and more extreme weather events**. These will challenge our current plans for constructing stable power lines, lasting infrastructures, and the use and cultivation of our land.

The mission “Adaptation to climate change” focuses on solutions and preparedness to protect lives and assets from the impact of climate change. It includes behavioural changes and social aspects by addressing new communities beyond usual stakeholders, whose help will lead to a societal transformation.

“**Adaptation to climate change**” is a standalone topic chosen for one of the **six EU missions** and interlinks strongly with three others, i.e., "Climate-Neutral and Smart Cities", "Ocean, Seas and Waters" and "Soil Health and Food". The first drafts of the *Adaptation to climate change mission* focus on risk and asset level modelling at a regional level, developing adaption strategies, large scale demonstrators and public involvement in the decision process. The three related Missions have their own focus on developing emission-free cities, clean waters and restoration of ecosystems, and soil health. Climate change will undoubtedly impact city infrastructures, affect energy-water nexus issues, and alter how our soil can continue producing the food we need.

EERA believes that **more research is needed to model the impact of climate change on critical infrastructures, waterways and land use. At the same time,** to **address these issues both at a systems-level and at a more specific, individualised approach,** like hydropower, flood control, drainage in cities, and more powerful storms, to mention just a few.

It is also important to remember one of the main conclusions of the Stern report from 2006*: "the costs of stabilising the climate are significant but manageable; delay would be dangerous and much more costly".*[23] The above means that **preventive measures to limit the impact of climate change should be a part of the assessment for adaption**, balancing preventive and impact protection actions at regional and local levels to soptimise measures taken.

As a starting point, EERA suggests the following approach for addressing the adaptation challenge: **focusing on modelling the impact of higher temperatures and more extreme climate events and the effects on critical societal infrastructures**. Research in these fields will be crucial to design more stable, resilient and better performing energy systems in the run to climate neutrality by 2050.

23 https://www.lse.ac.uk/granthaminstitute/publication/the-economics-of-climate-change-the-stern-review/


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