EERA REPowerEU Manifesto

About EERA

The European Energy Research Alliance (EERA) is the association of European public research centres and universities active in low-carbon energy research. EERA pursues the mission of catalysing European energy research for a climate-neutral society by 2050. Bringing together more than 250 organisations from 30 countries, EERA is Europe's largest energy research community. EERA coordinates its research activities through 18 Joint Programmes and is a key player in the European Union's Strategic Energy Technology (SET) Plan.

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List of abbreviations and acronyms

BCM	Billion cubic meters
CCS	Carbon Capture and Storage
CSP	Concentrated Solar Power
EC	European Commission
EERA	European Energy Research Alliance
EU	European Union
GW	Gigawatt
IEA	International Energy Agency
IPCEI	Important Projects of Common European Interest
LNG	Liquefied Natural Gas
PRIMES	Price-Induced Market Equilibrium System
PV	Photovoltaic
SET Plan	Strategic Energy Technology Plan
SSH	Social Science and Humanities
TES	Thermal Energy Storage
TRL	Technology Readiness Level
TWh	Terawatt hour
R&D	Research & Development
R&I	Research & Innovation
SMR	Small and medium-sized modular reactor

Introduction

1.

Within just a few months, the EU has been confronted with an energy and security crisis that is both unexpected and unprecedented, threatening the very continuity of its economic activity and social stability.

In fact, this is not just a crisis, which suggests a temporary exceptional situation, but a durable paradigm shift resulting from a major redefinition of the world geopolitical order. At the same time, combating climate warming remains at the heart of the EU's long-term strategy, while European citizens feel the consequences of delaying it more acutely every day.

In this complex scenario, it is essential for the EU to rapidly adopt an ambitious action plan to wean itself off fossil fuels, especially natural gas. Such a plan cannot be a mere extension of the emergency measures that are already in place. The entire energy model in Europe must be transformed, and alternatives that have not previously been exploited should be considered, such as substantially reducing energy demand and further extending the lifetime of existing nuclear power plants where possible.

Prompted by the commitment to reduce oil and gas use, the EU has released its strategic plan to change its energy profile, scale up usage of low-carbon energy sources and maximise energy-efficiency gains.

In this respect, the REPowerEU Plan[1] **is one of the most critical documents on which the von der Leyen Commission will have to work during its mandate.**

REPowerEU addresses the multiple challenges of maintaining the EU's short-term energy security and tackling energy affordability, while simultaneously maintaining its 2050 climate-neutrality targets and building robust EU strategic autonomy.

By the date of publication of this document, the EC had published an REPowerEU Communication[2], an EU Save Energy Communication[3] and several documents[4] associated with the REPowerEU Plan.

1. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions - REPowerEU Plan: *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483*
2. Ibid.
3. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – EU "Save Energy": *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A240%3AFIN&qid=1653033053936*
4. REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition: *https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131*

The present document puts forward the European Energy Research Alliance's (EERA) analysis of the REPowerEU Plan released by the European Commission in response to the energy crisis.

The background of REPowerEU is to propose pathways to emancipate the EU as soon as possible from Russian energy imports, which, before the full-scale invasion of Ukraine, accounted for about 30% and 40% of the EU's respective oil and gas energy imports[5]. Such an objective is highly challenging and calls for radical action that might lead to unexpected and wide-ranging consequences across the entire EU energy system and economy. The recommendations proposed by EERA in this document will therefore be updated as further analysis is undertaken. The purpose of this document is to highlight the most critical recommendations that, in the opinion of the EERA research community, are missing from or insufficiently addressed in the REPowerEU Plan. Of the three dimensions of the *energy trilemma*[6] (energy security, energy equity and environmental sustainability), this manifesto – while recognising the highly critical social perspective of the crisis – intentionally focuses mainly on energy security and environmental sustainability aspects.

Section 5 provides a set of key recommendations to policymakers, which are summarised below:

1. Communicating comprehensively with EU citizens on the energy and inflation crises
2. Reassessing our current economic paradigm, recognising the shifts in fundamentals
3. Fostering a structural, sustainable and fair reduction in energy demand
4. Embracing all energy uses beyond power only
5. Empowering the research community to be part of accelerated technology deployment
6. Operationalising R&I recommendations on REPowerEU into the SET Plan
7. Integrating climate adaptation within energy system planning
8. Aligning immediate energy needs with longer-term environmental objectives
9. Assessing REPowerEU against the EU's strategic autonomy objectives
10. Matching the deployment of clean energy technologies with value chain constraints
11. Strengthening the Energy Union
12. Boosting cooperation with strategic neighbouring countries and energy trading partners

5. *https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2c.html*
6. *https://www.worldenergy.org/transition-toolkit/world-energy-trilemma-index*

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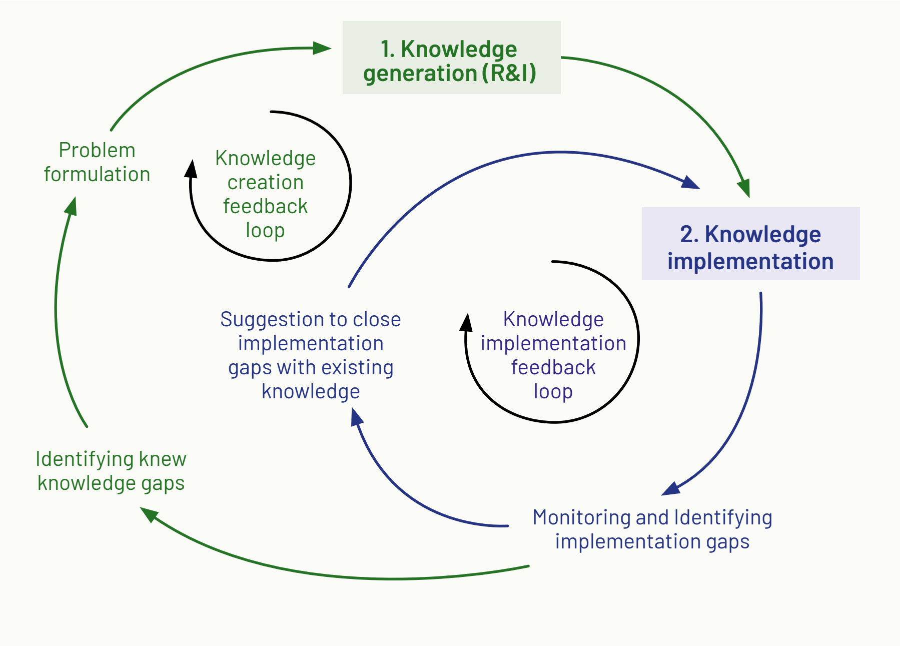
2. Role of research in facilitating REPowerEU implementation

As the largest European energy research community, EERA's historical role has been to deliver R&I by enabling continuous *knowledge generation* (see Fig. 1) that supports the technological and social innovations required to achieve the EU objective of climate neutrality by 2050. The time horizon for EERA's R&I processes is usually medium to long term.

At the same time, a considerable research-based contribution can be made in the short term by accelerating the existing *knowledge implementation* (see Fig. 1) in order to scale up already tested and validated solutions and technologies. The research community is committed to strengthening such a contribution by studying and advising on the conditions for faster and more efficient implementation of these technologies. Figure 1 illustrates how the *knowledge generation* and *knowledge implementation* feedback loops interact and drive knowledge generation and implementation dynamics.

The EERA research community is already actively contributing to the implementation cycle[7]. However, this role of research is still not sufficiently recognised and should be further supported by policymakers.

FIGURE 1:
Knowledge creation and knowledge implementation feedback loops.



With regard to the implementation of the REPowerEU, EERA – in addition to its critical role in knowledge generation – advocates for the research community to boost its contribution to knowledge implementation and to provide expert advice on policy action. By monitoring and critically analysing the implementation processes through a scientific lens, researchers can best support the policymaking processes while at the same time help identify new R&I challenges that might emerge during the accelerated implementation phase.

7. See, for example, the Lighthouse initiative of EERA JP Wind *https://www.eerajpwind.eu/lighthouse-initiative-explained-in-3-minutes/*

Suggested areas of improvement in REPowerEU

3.

3.1. PRIORITISING REDUCTION IN ENERGY DEMAND

Energy demand-reduction measures should be a fundamental part of REPowerEU. Such measures – especially lowering natural gas use – can produce the fastest results, reducing the impact of the energy crisis on European citizens. According to the IEA, energy-saving actions by EU citizens could save enough natural gas to heat 20 million homes[8]. The REPowerEU Plan addresses the importance of energy savings as an integral part of the strategy. **However, the scope of the proposed demand-reduction measures, as well as the level of expected impact, needs to be significantly increased.**

- Whereas REPowerEU focuses on individual consumers, energy-demand reductions resulting from changes in individual consumer behaviour are seen as being very timid. **The potential complete disruption of Russian gas imports will dramatically impact EU society as a whole. A strong political message on the need for those citizens who can afford price spikes to reduce their energy demand (especially heating, cooling and electricity) is an essential lever that will have an immediate impact on smoothening the gas supply shortage.** Bolder support and appropriate

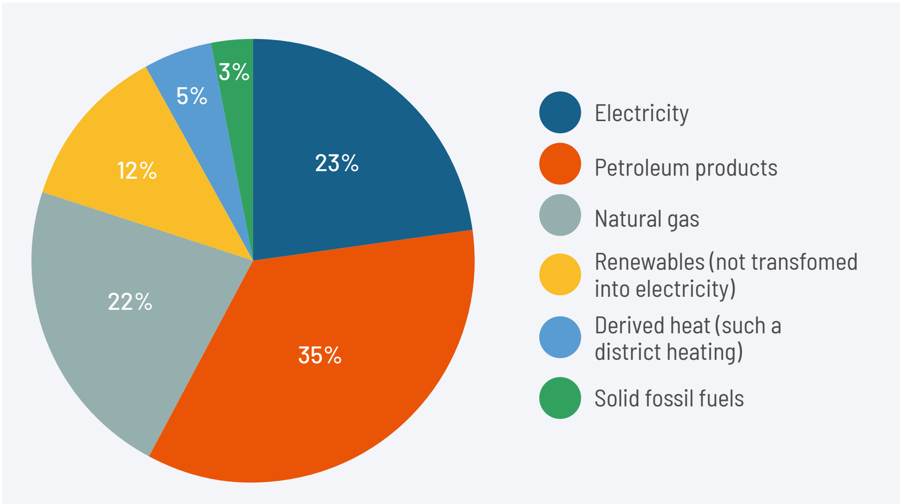
8. *https://www.iea.org/news/energy-saving-actions-by-eu-citizens-could-save-enough-oil-to-fill-120-super-tankers-and-enough-natural-gas-to-heat-20-million-homes* policies should **encourage much stronger voluntary and mandatory energy-demand reduction**, recognising the specific characteristics and potential of the various target groups.

- Industry is not perceived as the main focus of the REPowerEU demand-reduction plan. However, reducing electricity[9], heating and cooling demand in the industrial sector through technology changes and higher energy-efficiency targets must be one of the main priorities of REPowerEU, minimising the need for alternative natural gas imports from other countries, potentially creating new dependencies.

3.2. DIFFERENTIATING BETWEEN ELECTRICITY AND HEAT

The REPowerEU Plan primarily focuses on the electricity sector. This approach is consistent with the EU's clean energy transition strategy, which heavily relies on substantial electrification of many sectors, supported by the accelerated deployment of renewable electricity generation capacity. However, **it is essential to highlight that electricity currently represents only about 23% of the final energy consumption in EU-27** (see Fig. 2: Final energy consumption in EU-27, 2020).

FIGURE 2: Final energy consumption in EU-27, 2020[10].

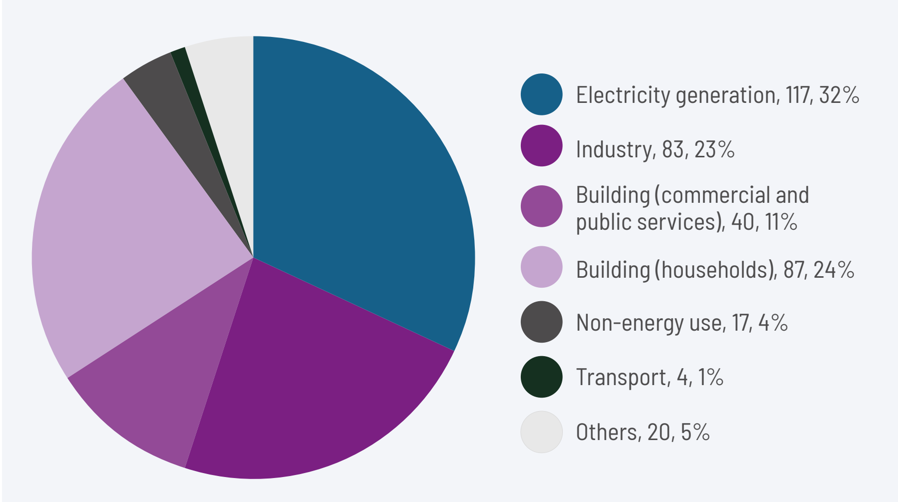


Consequently, **despite the strong electrification trend, the REPowerEU Plan should have a stronger focus on measures related to heating and cooling**. The heating sector, specifically, needs decisive policy intervention, as it is hugely dependent on Russian gas imports. Heating and cooling constitute about 50% of the final energy demand in Europe and represent by far the most significant energy sector to be decarbonised. Figure 3 illustrates the main demand categories for gas in the EU. It can be seen that buildings (private, commercial and public) and industrial applications use most gas.

9. Here, electricity demand-reduction measures are implied for the industrial processes that are already electrified.

10. *https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-3a.html?lang=en*

FIGURE 3: Breakdown of EU gas use, 2019 (BCM and % demand share)[11].



By better directing measures at specific gas uses, the REPowerEU Plan could pave the way for a range of solutions that target specific types of energy uses, which could lead to more efficient and consistent implementation of the Plan.

3.3. STRENGTHENING THE ENERGY SYSTEM INTEGRATION PERSPECTIVE

An energy system integration perspective is fundamental for achieving the goals of the clean energy transition in Europe, including those dictated by the REPowerEU Plan. Insufficient consideration of such a perspective leads to a fragmented, silo-based approach to the transition, which affects its speed, cost and effectiveness. An energy system integration approach should be at the core of the REPowerEU strategy. For example, the deployment of renewable power generation capacity must cover the many competing increases in power demand resulting from higher electrification, such as demand due to the growing electric vehicle fleet and power demand required to produce green hydrogen.

3.3.1. Energy storage

Energy storage, a key component for achieving the clean energy transition, is also a prerequisite for implementing REPowerEU.

Available energy storage technologies include, for example, both electricity and thermal storage solutions. However, **energy storage is not presented as an integral part of the REPowerEU Plan and is mentioned only in the specific context of natural gas storage**. This is a significant limitation, as not including electricity and heat storage solutions jeopardises the accelerated scale-up of intermittent renewable power generation capacity and the shift in the energy balance required to successfully achieve the REPowerEU goals.

11. *https://www.irena.org/newsroom/expertinsights/2022/May/Europe-must-simultaneously-replace-Russias-fossil-exports-and-accelerate-its-clean-energy-deployment*

As an illustration, meteorological conditions of several days with no wind and no sunshine occur in Europe each year. Increasing reliance on these intermittent sources will require an energy storage capacity of hundreds of gigawatts[12] to be built. Such storage capacity must be distributed over Europe, and preferably concentrated in areas with a particularly high share of intermittent renewable generation.

It is essential to consider both electricity and heat storage solutions, as heat storage can often be the best option to address significant seasonal fluctuations in heat demand.

3.3.2. Energy efficiency factor

The technology choices for the various transition pathways must be carefully assessed against the full-cycle energy efficiency factor of the various technology alternatives under consideration.

3.3.3. Hydrogen

The ambitious hydrogen goals set out in REPowerEU also require a strong systems integration perspective. **Hydrogen is a highly versatile energy vector and is therefore expected to play several distinctive roles in the clean energy transition**, particularly as fuel, energy storage system, industrial feedstock and also as an enabling technology for sector coupling. Distinguishing between these different roles is essential for designing optimal sourcing scenarios, relating to both EU domestic production and imports.

3.3.4. Energy modelling

Energy modelling is another essential component for optimally integrating the energy system. **Currently, modelling that supports the quantitative targets and technological priorities set in the REPowerEU Plan is performed using PRIMES, a proprietary model that is not accessible to most of the research community.** This therefore constitutes a significant threat to the robustness of the REPowerEU Plan. To EERA's knowledge, the scenario simulation results of the REPowerEU Plan have not been reproduced by any other EU-wide modelling exercises. In the past, attempts by the EERA community to reproduce PRIMES results with their own models have yielded very different results.

3.4. CONSIDERING TIMEFRAMES, SYNERGIES AND TRADE-OFFS

The REPowerEU Plan aims to provide solutions for overcoming dependency on Russian fossil fuel imports and simultaneously make the European energy system clean, sustainable and affordable. In its current form, the Plan does not provide a clear vision of how the different yet complementary

12. *https://ease-storage.eu/publication/energy-storage-targets-2030-and-2050/*

solutions are linked across short-, medium- and long-term horizons, given their inherent implementation time. For example, the current trend in the EU of temporarily switching back to coal is questionable, as it might jeopardise the progress of the clean energy transition in the medium and long run.

Another aspect that requires additional analysis concerns the consequences of current fast-track investments in new fossil-based assets that represent new lock-ins in fossil-based infrastructure, and therefore constitute potential obstacles to faster transition towards the low-carbon energy targets. Scaling up LNG infrastructure in the EU is an example of fossil-fuel investment that raises concerns in the expert community[13] and that must be carefully assessed against the EU's long-term energy and climate objectives.

Given the urgency, high level of ambition and complexity of the clean energy transition, synergies and trade-offs between solutions chosen to implement the REPowerEU Plan should be explored using simulation modelling tools and digital twin technology to test different energy supply and demand scenarios in Europe over time. Such analysis can provide insights into opportunities to limit dependency on fossil fuels (particularly Russian), help identify potential lock-ins, and ensure that governments proceed with implementation of the scenarios most favourable for individual EU Member States.

3.5. ADDRESSING LIMITATIONS AND BOTTLENECKS OF ACCELERATED DEPLOYMENT OF LOW-CARBON TECHNOLOGIES

In REPowerEU, the speed of deployment assumed for some low-carbon electricity generation technologies is unprecedented. **Scaling up renewable electricity generation is a significant challenge requiring additional R&D even for the most mature technologies, such as wind energy and solar PV.** Some of the main risks and bottlenecks in accelerated deployment of renewable energy technologies include:

- **Supply chain limitations**
  The increase in renewable electricity generation is likely to be limited by global manufacturing capacity and supply chain constraints that are often out of the EU's control. For example, the EU Solar Energy Strategy[14] aims to bring online over 320 GW of solar PV by 2025 (an increase of more than 200% compared with 2020), and about 600 GW by 2030. In comparison, global solar PV production was around 178 GW[15] in 2020. **This makes the feasibility of the EU Solar Energy Strategy questionable, especially considering the additional challenge of deploying smaller, highly distributed facilities (integrated PV) compared with large-scale PV power plants.**

13. See, for example: *https://ember-climate.org/app/uploads/2022/03/EU-can-stop-Russian-gas-imports-by-2025.pdf*
14. *https://energy.ec.europa.eu/topics/renewable-energy/solar-energy_en#photovoltaics*
15. *https://www.statista.com/statistics/668764/annual-solar-module-manufacturing-globally/*

- **Human resource limitations**
  Acceleration of the deployment of clean energy transition technologies will inevitably be constrained by a shortage of skilled manpower across the implementation cycle of the various technologies: designers, construction workers, installation engineers, operations and maintenance technicians, grid engineers, etc. In addition to technical expertise, there is an enormous need to reskill a range of key non-technology stakeholders, such as policymakers, regulators and legal practitioners who play a crucial role in supporting the clean energy transition at local, regional and national level.
  The structural shortage of labour in the clean energy sector already existed before the current energy crisis and has been significantly slowing down the transition process. Overcoming human resource limitations should therefore be at the core of policy to achieve the REPowerEU goals as one of the most critical factors hindering accelerated transition.

- **New resource dependencies associated with scaling up renewables**
  The switch to clean energy technologies creates new dependencies on imports from less stable and/or less reliable countries or partners:
  - Critical minerals are mostly sourced from a few countries (many of which are non-democratic) that have deposits of or control most of the global production of resources critical to clean energy technologies. The availability of these minerals is often much more geographically concentrated than is the case with fossil fuels[16].
  - Minerals and resources that are not considered to be critical today, but are expected to become scarce when renewable energy technologies are scaled up dramatically[17].
  - Critical components, such as micro-chips.
  - Finished products, such as PV modules.
  - The end of life of materials and component disposal.

- **The EU's strategic autonomy vs new dependencies**
  Promoting the EU's independence from Russian fossil fuel imports is an essential step towards greater EU autonomy. At the same time, it may create other dependencies that need to be carefully assessed from a geopolitical perspective. New fossil fuel import agreements with new partners must be evaluated in terms of diversification and the nature of export countries in a context where many potential providers might be unstable, non-democratic and/or unreliable regimes that conflict with

16. *https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions*
17. See, for example: *https://www.frontiersin.org/articles/10.3389/fenrg.2019.00056/full*

European democratic values. **Compromising on ethical standards and European values in these trade agreements undermines the credibility of European principles, jeopardises democracy and might eventually compromise the EU's stability.** The same principles and concerns apply to any fuel imports, such as green hydrogen and ammonia, or any other security-critical imports, such as critical minerals and rare earth materials.

Given the challenge of building a renewable electricity sector that is scheduled to be many times larger in 2050 than it is today, the focus on R&I, regulation, policymaking and implementation should be substantially increased, especially for the key technologies that can help achieve the REPowerEU goals.

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4. Specific recommendations to help achieve the REPowerEU goals

Section 2 described the dual role of research, summarised by the conceptual model shown in Figure 1.

In this section, we put forward the recommendations that can be implemented by policymakers based on existing knowledge. Such recommendations are for the short- to medium-term and correspond to the **Knowledge Implementation** cycle. In addition to this, we provide R&I recommendations targeting medium- to long-term measures that correspond to lower TRL research activities and thus refer to the **Knowledge Generation** cycle.

The recommendations to help achieve the REPowerEU goals focus on the following key areas:
- Reduction in energy demand
- Heating
- Electricity

- Energy storage
- Gas, hydrogen and other chemicals

4.1. REDUCTION IN ENERGY DEMAND

Reducing energy demand must be considered the main short- and medium-term priority across all sectors and must include measures that explicitly target the energy demand of both individual consumers and industry. The latter is especially important, since industry represents significant untapped potential. Special attention must be devoted to reducing demand for heating, which accounts for the biggest share of gas consumption. It is fundamental to see energy demand reduction not only as a symptomatic initiative for tackling the energy crisis but also as a long-term structural measure. EERA therefore explicitly differentiates between energy-efficiency measures and structural demand-reduction measures. Furthermore, energy justice and digitalisation should be overarching principles guiding the design of energy demand-reduction solutions.

For buildings, individual consumers		**For industry**	
Aiming to maximise energy efficiency	**Aiming to change demand structurally**	**Aiming to maximise energy efficiency**	**Aiming to change demand structurally**
• Improve **buildings' insulation** and quality of **heating systems**. Use the **EC's Renovation Wave programme**[18] to support these actions. • Integrate available knowledge on social acceptance and attractiveness into energy-efficiency policy design.	• **Ban all subsidies for fossil heating** systems in both new and renovated buildings. • Implement the end-user electricity price reform.[19]	• Design regulations **encouraging companies to save energy** and reduce natural gas demand.[20]	• Prioritise **industrial decarbonisation targets** that go beyond increased industrial energy efficiency. • Scale up industrial symbiosis solutions and other **circularity-oriented business** models. • Reduce energy use in building material production and in the entire building life cycle.

18. *https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en*
19. Currently, electricity is taxed more heavily than natural gas in many EU countries.
20. Such measures could include reduction of heating and air-conditioning set points, prohibition of certain services and practices that consume a lot of energy in relation to the service provided (e.g. advertising boards with screens, refrigerators without doors in shops, illuminated displays at night).

Technological R&I priorities:

- Develop solutions for **joint use of multiple energy services** (electricity, transportation, heating and cooling) to maximise energy-efficiency potential for individual consumers in Europe.

Non-technological R&I priorities:

- Ensure **ongoing research on social acceptance** and attractiveness of different energy-efficiency and energy demand-reduction solutions.

Non-technological R&I priorities:

- Fund research on exploring alternative energy-demand models based on **energy sufficiency/ energy sobriety/ alternative-to-growth paradigms**.

Technological R&I priorities:

- Develop more efficient industrial separation technologies; **process intensification solutions**, including: energy-efficient solutions for drying and dewatering; heat-to-power technologies.

Non-technological R&I priorities:

- Fund research on developing **new business models** for industry that would fit in with the energy sufficiency/ energy sobriety/ alternative-to-growth models and would implement the "energy-as-a-service" approach[21].

4.2. HEATING

As mentioned earlier, heating is a critical sector to be addressed to both minimise EU dependency on fossil fuels and speed up the clean energy transition. In the proposed recommendations, we distinguish between measures targeting heating in buildings and households, and industrial use of heating. We highlight the importance of favouring direct renewable heating solutions where possible. Geographical location, population density and other factors should be considered when choosing the most suitable heating solutions in different parts of the EU. Heating and cooling roadmaps developed by Heat Roadmap Europe[22] constitute valuable resources for better addressing heating and cooling within the REPowerEU Plan.

21. See, for example: *https://op.europa.eu/en/publication-detail/-/publication/58c3af16-f692-11ec-b976-01aa75ed71a1/language-en*

22. *https://heatroadmap.eu/*

Heating recommendations for buildings, individual consumers

- Use the **Heat Roadmap Europe** as a guide for supporting heating-related measures to achieve the REPowerEU goals.
- Highlight the role of **heating savings** as well as the role of solar thermal energy and low-enthalpy[23] geothermal energy as direct sources of **renewable heating**[24].
- Scale up **district heating solutions** in the manner most suitable for particular areas of Europe.[25]
- Maximise the use of **combined heat and power** for district heating solutions.[26]
- Scale up use of **individual heat pumps** in the manner most suitable for particular areas of Europe.
- Modernise the **heat networks** initially designed for fossil fuels and biomass, and use them for renewable heat.
- Increase the number of **heating plants** that deliver higher heating efficiencies and better pollution control than localised boilers.

Heating for buildings R&I Priorities

- Develop solutions to accommodate fluctuating supply and demand from renewable energy sources, especially combined with **large-volume seasonal heat storage**.
- Foster research into **solar thermal** technologies to provide both clean electricity and heat in large quantities.

Heating recommendations for industry

- Encourage the use of technologically mature low-temperature **heat pumps for industrial processes**, specifically when combined with solar thermal or geothermal technologies.
- Use **solar heat** to partially replace gas use in industry for heat production in the low-mid temperature range (50-400°C).
- Apply **technologies' integration** approach when designing industrial heating solutions. Integrate TES technologies with other thermal technologies, for instance waste heat recovery and CSP, in a modular manner to satisfy different industrial needs.

Industrial heating R&I Priorities

- Design **high-temperature (up to 200°C) heat pumps** for industrial use – one of the main potential game-changing technologies.
- Develop solutions that can help **couple the heat sector** with the electricity, gas, fuel, and chemical sectors.
- Develop solar **heat-to-electricity-generation** solutions for high-temperature industrial processes above 200°C (up to 1500°C).[27]
- Foster research into **SMRs for producing heat** in addition to electricity in cogeneration mode, effectively contributing to the decarbonisation of heat production[28]. The design operating temperature can be calculated for the reactor to provide district heating or industrial heat.

23. For example, geothermal energy already provides heat to about 240 district heating systems, while for large solar thermal energy systems, the number is 230.
24. The choice of heating solution needs to consider the area where it is adopted, e.g. district heating is mainly a solution in northern and central Europe. In contrast, decentralised heating systems are more suitable in southern Europe.
25. This has proved to be the cheapest method of cutting carbon emissions and has one of the lowest carbon footprints of all fossil fuel-based generation plants.
26. 51% of final energy consumption in EU industry is used to generate heat above 200°C, according to the Heat Roadmap Europe.
27. *https://snetp.eu/wp-content/uploads/2020/10/NC2I-roadmap-October.pdf*

4.3. ELECTRICITY

4.3.1. System stability

With the expected increasing electrification level and the larger penetration of intermittent renewable power-generating sources, ensuring increased flexibility and stability of the power system becomes a critical challenge. Such a challenge must be addressed by making the energy grid system smarter and by increasing central and distributed energy storage capacities, as discussed in Section 4.4.

In addition, REPowerEU should also further acknowledge the importance of leveraging the potential of dispatchable renewables, such as hydropower, geothermal energy, CSP (with storage capacity) or waste-to-power solutions, all of which can make key contributions to system stability.

4.3.2. The EU's strategic autonomy

The goals of accelerating deployment of clean power generation technologies, such as wind energy and solar PV[28], in the REPowerEU strategy must be assessed against creating new dependencies on the value chains beyond Europe.

REPowerEU must therefore carefully consider bringing critical value chains back to Europe. In the case of PV[29], 75% of global production is currently located in China, and less than 3% of PV modules are now manufactured in Europe. REPowerEU should therefore highlight the importance of fostering specific applications of PV – such as "Building Integrated PV" where traditional methods of manufacturing highly standardised PV modules can be replaced by localised solutions that are less subject to international competition and enable industry and employment to become firmly established in Europe. At the same time, there are clean energy technologies, such as CSP, for which value chains are already located in Europe. This is a very important factor with regard to accelerating the clean energy transition in line with the principles of the EU's strategic autonomy.

28. Currently, the EU imports 75% of PV modules from China, which does not guarantee a secure and timely supply.

29. *https://www.iea.org/data-and-statistics/charts/solar-pv-manufacturing-capacity-by-country-and-region-2021*

30. Integrated PV solutions fit perfectly within the Near-Zero Energy Building (NZEB) framework and Positive Energy Districts, Agri-PV, solar@sea.

31. Taylor, N., Solar Thermal Electricity Technology Development Report 2020, EUR 30501 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-27268-7, doi: 10.2760/76672, JRC1231

32. *https://pvimpact.eu/towards-set-plan-targets-ip-progress/ipcei/*

Electricity sector recommendations

General recommendations:

- Develop **coordinated pan-EU legislation** and legal rules for renewable energy deployment.
- Design policy instruments that encourage the use of **locally produced renewables and storage use**.
- Design policy instruments supporting **renewable energy communities**.
- Consider **structural shortages of qualified labour** when planning all new projects aiming to increase renewable energy deployment.

PV and CSP:

- Prioritise use of **Integrated PV,** which is key to speeding up renewable energy deployment in Europe.[30]
- **Include CSP in the solar strategy** part of the REPowerEU, in addition to solar PV.
- Use **CSP to complement PV** plants and to replace existing combined-cycle and coal-fired power plants.
- Maximise use of renewable energy technologies that are less prone to critical **raw material supply limitations**[31] (for example, CSP).

Wind power:

- Simplify and shorten **permitting procedures for wind energy** deployment and ensure concerted action for strengthening Europe's wind energy supply chain.
- Substantially increase investment in **offshore grid infrastructure** to speed up offshore wind deployment.

Electricity sector R&I priorities

- Strengthen research across a **variety of SSH topics** that can directly inform legislation and policy design.

- Support R&D to speed up PV deployment. In particular, initiatives such as the IPCEI[32] can bring EU research and industry closer to help swiftly **return the PV value chain to Europe**.
- Support R&D for CSP focusing on cost reduction, enhancing component lifetime and sustainability, and optimisation and further integration of **hybrid systems**.
- Accelerate R&D efforts in designing solutions to help overcome dependency of renewable energy technologies on **critical materials**. Include lithium and other critical materials extracted from geothermal brines in the research priorities.

- Support **assessment of wind power generation resources** onshore and offshore given the latest technology developments and latest existing data on wind conditions.
- Accelerate R&I and R&D efforts in **floating offshore wind** technology to maximise exploitation of offshore wind resources in the EU.
- Ensure ongoing support for **developing sustainable methods** of wind power generation compatible with the net-zero goals.

Hydropower and Geothermal:

- Acknowledge hydropower and deep geothermal energy role as the main **renewable energy contributors to the flexibility** of the European energy system in the context of the planned increase in the share of wind and solar power. Add **hydropower to the SET Plan** in the list of priority technologies to achieve the REPowerEU goals.[33]

Nuclear power:

- Extend, where possible, the **operating lifetime of existing nuclear power plants** in Europe during the transition to renewable electricity generation.[34]

- Support R&I in **fourth-generation SMR** technology, which can potentially provide long-term, flexible low-carbon solutions to complement renewable electricity generation.

4.4. STORAGE

Energy storage is a prerequisite for ensuring the security and stability of the EU's energy system and must therefore be more explicitly addressed in REPowerEU.

It is crucial to include energy storage priorities in both electricity and heating technological pathways. Market design and investment mechanisms should therefore incentivise the development and deployment of energy storage technologies - both electricity and heat - in parallel with renewable energy generation technologies.

Heat storage is directly linked with electrification scenarios. Electrification of the heating sector increases seasonal fluctuation in electricity demand, requiring highly inefficient excess capacity for the winter months. Large-scale heat storage might therefore be a solution to mitigate seasonal peak loads in the power system. Heat storage can also become a key instrument for power-to-heat sector coupling, by enabling surplus electricity in summer to be stored as heat that can be made available for heating

33. Today, hydropower accounts for 10% of the EU's electricity generation mix. EURELECTRIC and VGB Powertech. (2018). Facts of Hydropower in the EU. *https://cdn.eurelectric.org/media/3178/facts_of_europe-2018-030-0372-01-e-h-32C5DF62.pdf*

34. The IEA has stressed that if the four nuclear reactors scheduled to shut down in 2022 in the EU were to be kept online, this could cut EU natural gas demand by almost 1 billion m3 per month. *https://iea.blob.core.windows.net/assets/1af70a5f-9059-47b4-a2dd-1b479918f3cb/A10-PointPlantoReducetheEuropeanUnionsRelianceonRussianNaturalGas.pdf*.

when demand exceeds supply (e.g. in winter). The geological subsurface may provide the large heat storage capacities required for seasonal storage. Integration of subsurface heat storage into a heat network also enables buildings to be cooled in the summer. In view of the EU's long-term climate and energy targets and the implications of REPowerEU on fossil fuel infrastructure, CCS should be made an integral part of REPowerEU.

Energy storage recommendations

- **Make energy storage an integral part** of EU, national, regional and local energy transition plans.
- Add large-capacity **renewable storage to national targets** in order to protect the EU's energy system against periods of Dunkelflaute[35].
- Incorporate the requirement for **heat storage into EU policies** on electrification of industrial processes, as most of the energy demand in the process industry is in the form of thermal energy.
- Adapt **electricity market rules** to ensure remuneration of flexibility services and storage in a fair way.
- Develop clear conditions and **long-term perspectives for investments** in hydropower and industrial thermal energy storage so that they are de-risked for investors.
- Scale up **storage solutions in district heating and cooling** systems.[36]
- Maximise use of **TES for industry** as a measure to reduce natural gas use.

Energy storage R&I priorities

- Support R&D on **large-volume seasonal heat storage** for combined cooling and heating to help balance the fluctuating supply from other renewables, including power-to-heat solutions.[37]
- Build **demonstration sites for storage** solutions in several European locations to test how storage can compensate for fluctuations in energy supply.
- Support PV & CSP hybrid projects that can provide **combined renewable electricity generation and thermal energy storage**.
- Support R&D on hydropower energy storage solutions, including converting existing **hydroelectric power plants into pumped hydropower storage** plants.[38]
- Support demonstration projects for **high-temperature subsurface storage**, which can reduce the number of electricity-generating plants required to meet peak demand.
- Support demonstration, scaling-up and best practices dissemination of **industrial TES technologies and business models** in various industrial processes at regional, national and EU level.
- Foster R&I in the **underground storage of hydrogen** to ensure its containment.
- Support R&I and R&D on emerging technology **using CO2 for electricity supply**[39]. Within the **SET Plan, create a working group on "Advanced materials"** to accelerate development and integration of multifunctional materials that can be used in a wide range of energy applications (conversion, storage, efficiency and/or transport).

35. Dunkelflaute is a term used in the renewable energy sector to describe a period of time in which little or no energy can be generated by wind and solar power.
36. The Netherlands and Austria are examples of EU countries that store heat and use it as baseload heat during the wintertime.
37. For example, use of power-to-heat from the excess amount of power generated by PV in summer.
38. A hydro plant conversion takes two to three years. In terms of speed of reaction for stability of the energy system, it will take seconds or even milliseconds with the proper technological equipment.
39. This is currently being tested by several major industry players.

4.5. NATURAL GAS, HYDROGEN AND OTHER CHEMICALS

Plans related to the use of natural gas, hydrogen and other chemicals in the EU, in the medium- and long-term, should be designed taking into account expected energy demand scenarios. In particular, the development of gas infrastructure should be carefully assessed against the potential for decreasing gas use in the years ahead. Such an assessment should consider gas price volatility, as well as the impact of creating investments or contractual lock-ins that would be incompatible with EU decarbonisation objectives.

Green hydrogen production, which is expected to play a prominent role in the medium- and long-term REPowerEU Plan, should be critically assessed in the context of both the electrolyser capacity needed for it[40] and the availability of corresponding clean power required for the electrolysis process.

Natural gas and Hydrogen R&I

- Support investment in LNG and **hydrogen infrastructure with modelling exercises** assessing feasibility and associated medium- and long-term risks.
- Increase R&I and R&D in **infrastructure for hydrogen transport. Hydrogen transport safety** is one of the key topics requiring research on polymeric and metallic materials.
- Increase R&I in the areas **targeting renewable fuels and gases** in contrast to targeting hydrogen only. For example, solar-driven, biomass and plastic-waste fuel production can take place via various processes (pyrolysis, gasification, Fischer-Tropsch, etc.). Support research on **power-to-gas technologies** (e.g. for hydrogen, synthetic methane) as a method of absorbing surplus renewable electricity produced during phases of high electricity supply.
- Support the development of solutions targeting **hydrogen production methods that use neither fossil fuels nor renewable electricity** (e.g. solar-driven high-temperature thermochemical water splitting).
- Adopt a long-term R&D programme for **CSP technologies** that have the potential to produce hydrogen, synthetic fuels and chemical commodities.
- Foster research on **high-temperature SMRs** that can benefit the low-carbon hydrogen production process.
- When planning new natural gas and hydrogen infrastructure, ensure ongoing support for developing **CCS solutions**, and a supportive infrastructure to avoid potential lock-ins incompatible with the climate goals.

40. Currently, in the EU, the entire renewable electricity production over one year can generate only 18% of the electrolysers needed to cover annual hydrogen needs for industry.

The full-scale Russian invasion of Ukraine in February 2022 marks a fundamental reshuffling of the post-Cold War geopolitical order. Its implications for the European Union – and for the world – are profound and pervasive, and are expected to be long-lasting. The war in Ukraine also catalyses several distinct deep-rooted global crises, including climate change, biodiversity and resource depletion.

While the European Union has been prompt in addressing the acute energy crisis unfolding since the end of 2021[41], **EERA believes it is of utmost importance to recognise the wider scope of its systemic implications for EU society over a longer time perspective**.

In its White Paper on the Energy Transition[42], EERA had already highlighted the multidisciplinary nature of the energy transition resulting from the strong interweaving of social, economic and technological dimensions.

In this respect, in addition to making technology-related recommendations, EERA underlines the importance of highlighting a socio-economic perspective on the successful implementation of REPowerEU (see below).

41. EERA's statement on the European Energy Crisis and Clean Energy Transition: *https://www.eera-set.eu/news-resources/2980:eera-s-statement-on-the-european-energy-crisis-and-clean-energy-transition.html*

42. EERA White Paper on the Clean Energy Transition: *https://mailchi.mp/eera-set/clean-energy-transition*

Policy recommendations

5.

5.1. SOCIO-ECONOMIC PERSPECTIVE

5.1.1. Communicating comprehensively with EU citizens on the energy and inflation crises

In view of the fact-based impacts of the energy and inflation crises on EU citizens and the research-based projection of the expected socio-economic consequences of these crises, policymakers should develop a comprehensive forward-looking communication initiative at EU and national level. This should provide EU citizens with a clear understanding of the root causes, implications and remediation strategies adopted, supported by a transparent and comprehensible analysis of the expected short-, medium- and long-term impacts.

Such an initiative is key to maintaining popular support for EU political choices, preserving and further consolidating cohesion within the European Union, and successfully driving REPowerEU implementation.

5.1.2. Reassessing our current economic paradigm, recognising the shifts in fundamentals

Beyond the short-term emergency measures resulting from dealing with the economics of war, policymakers should without any further delay recognise the underlying pervasive geopolitical, economic and societal shifts occurring in the EU and globally. They must therefore fully explore the opportunity for a reassessment of our current economic paradigm.

Such a reassessment should be performed in the light of the new EU security of supply paradigm, within the boundaries of biodiversity, climate change and resource constraints, while recognising the imperative to accelerate the transition towards a sustainable, fair and climate-neutral society by 2050.

5.2. ENERGY SYSTEM PERSPECTIVE

5.2.1. Fostering a structural, sustainable and fair reduction in energy demand

While the latest REPowerEU communications have increasingly highlighted the importance of moderating energy demand, policymakers must urgently recognise the need to address the complexity of this vastly unchartered opportunity (see Sections 3.1. and 4.1.).

New, highly differentiated policies must be targeted at the specific characteristics of the diverse consumer groups. They should protect the most vulnerable groups while primarily targeting those with most reduction potential. In the industrial sector, targeted sustainable demand-reduction policies should be designed to protect the EU's economic and industrial independence.

Demand-reduction measures should be driven at all levels of society. Appropriate approaches should be developed to support this societal shift, for example by upskilling experts and policymakers and by further informing and empowering citizens to make the right decisions.

5.2.2.
Embracing all energy uses beyond power only

Reference energy transition scenarios all rely on massive deployment of renewable technologies (especially power generation technologies such as PV and wind) and on accelerated electrification, in particular for hard-to-abate sectors (e.g. transport, industry and space heating).

However, it is crucial to recognise that, today, electricity still only represents less than 25% of the EU's final energy demand, while heating and cooling account for about 50%, highlighting the critical importance of carefully addressing all energy vectors in connection with each other (see Sections 3.2. and 3.3.).

In addition, and as highlighted in the *EERA White Paper on the Clean Energy Transition*, the systemic nature of the energy system mandates for the use of open-source modelling and simulation tools to enable the research community to provide a robust analysis of the EU's clean energy transition pathways, including those that are specifically related to REPowerEU (see Section 3.3.4).

5.2.3.
Empowering the research community to be part of accelerated technology deployment

While the design of new generations of low-carbon technologies needed to achieve decarbonisation targets beyond 2030 remains a central mission for the EU research community, the urgent crisis also calls for an unprecedented acceleration in the deployment of existing technologies.

Recognising its capabilities to contribute to identifying, analysing and addressing implementation bottlenecks to faster deployment of existing technologies (see Sections 2 and 3.5), policymakers should fully empower the research community with mission-oriented instruments to channel research efforts towards the implementation challenges.

In addition, close collaboration between the research community and industrial players is essential to ensure that demonstration projects in the EU Member States use the best available knowledge. Similarly, the clean energy research community benefits from engaging with industry and participating in demonstration projects, thereby having the opportunity to test research results and further accelerate development of research methods and tools.

5.2.4. Operationalising R&I recommendations on REPowerEU into the SET Plan

The SET Plan and associated funding instruments should incorporate the R&I recommendations put forward by the energy research community in the context of REPowerEU (see Section 4).

5.2.5. Integrating climate adaptation within energy system planning

Given the rapidly increasing frequency of extreme weather events and their impact on energy infrastructure, climate adaptation considerations should be fully integrated into the design of REPowerEU strategies, recognising their current and expected impact on energy infrastructure (e.g. impact of heatwaves and droughts on hydropower and nuclear power generation).

5.2.6. Aligning immediate energy needs with longer-term environmental objectives

While recognising the imperatives dictated by ensuring security of supply in the EU, it is essential to transparently assess the implications of short-term emergency measures, particularly redeployment of fossil-fuel assets, against their impact on achieving the EU's long-term transition towards an environmentally sustainable and climate-neutral society.

In particular, REPowerEU strategies need to be assessed against the following:

- Achieving climate objectives:
  Any investments in fossil fuel-based infrastructure constitute a divergence from transitioning to a low-carbon energy system. They must therefore be critically assessed, taking into account their repurposing potential from a strategic and technical point of view (for example, repurposing the use of LNG infrastructure for hydrogen should be not only feasible but also desirable from the strategic clean energy transition pathway perspective).
- Minimising impact on biodiversity:
  Production, deployment and operation of new energy infrastructure must be critically assessed against its environmental footprint with the aim of minimising its impact on ecosystems, especially their biodiversity.

5.2.7.
Assessing REPowerEU against the EU's strategic autonomy objectives

The energy crisis has significantly affected the EU's capacity to ensure security of energy supply and has therefore hampered its efforts to achieve greater strategic autonomy.

Given that REPowerEU relies primarily on the diversification of energy imports and the accelerated deployment of clean energy technologies, special attention should be paid to pursuing these two objectives in a sustainable and ethical manner. In particular:

- The **diversification of energy imports** (natural gas, green hydrogen and other green gases) should be carefully assessed against political risks and environmental and ethical implications associated with the partner exporting country.
- The **accelerated deployment of clean energy technologies** should be assessed in terms of increased EU geopolitical dependency on countries exporting clean technology, finished goods, intermediate components and/or critical minerals.

Policymakers should design clean technology procurement strategies pertaining to the implementation of REPowerEU by focusing on:

- Sourcing from EU industry whenever possible and reshoring critical value chains.
- Diversifying import sources (finished products, components, critical minerals) and assessing them in terms of their political, ethical and environmental implications.
- Boosting material research to minimise usage of critical minerals, foster higher recyclability of critical minerals, use alternative-to-mining ways of extracting critical minerals (such as lithium and other critical materials extracted from geothermal brines) and promote their substitution by non-critical minerals.
- Funding energy system modelling initiatives to include critical materials and other components needed in energy system models.

5.2.8.
Matching the deployment of clean energy technologies with value chain constraints

REPowerEU relies on the accelerated deployment of low-carbon technologies, including wind, solar PV, heat pumps, green hydrogen and biomethane. However, the speed of deployment of each technology remains in most cases highly dependent on global supply chain considerations that need to be carefully analysed, as most of these are beyond the EU's control.

EERA recommends setting up technology-specific multidisciplinary expert groups tasked with assessing deployment conditions through research-based analysis, including dependencies on:

- External value chains, such as manufacturing and transport of finished or intermediate products.
- EU value chains, such as those resulting from planning, permitting, financing, procurement, installation, integration, commissioning and operation of clean energy assets.
- Other components of the energy system (e.g. dependency of wind and PV on grid infrastructure or dependency of clean hydrogen production on availability of green power).

5.2.9. Strengthening the Energy Union

Evidenced during the Covid-19 pandemic by the EU's success in better negotiating favourable access to vaccines than individual Member States in isolation, further consolidating the Energy Union will prove essential to overcome the crisis collectively and more effectively.

EU solidarity mechanisms and collaboration will be essential to collectively minimise the impacts of import cuts, as well as to create stronger negotiation power on international energy markets. Furthermore, harmonising policy response within the EU will enable fairer and more effective management of crises, in particular related to the handling of windfall profits, which should be done in a way that will preserve a level playing field in order to avoid internal market distortions.

5.2.10. Boosting cooperation with strategic neighbouring countries and energy trading partners

Rebuilding security of supply in the EU calls for increased collaboration with neighbouring countries and energy trading partners. Policymakers are therefore urged to foster measures that contribute to this objective, while ensuring that political, environmental and ethical imperatives in line with European needs.


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