EERA
European Energy Research Alliance
clean Energy tranSition for Sustainable Society

Joint Programme e3s
clean Energy tranSition for Sustainable Society

Strategic Research & Innovation Agenda 2023 – 2030

Version: September 2026

Contents

Current SRIA updates history

September 2026	First publication of the new JP e3s SRIA

Introduction

Established in 2013, the EERA Joint Programme on **clean Energy tranSition for Sustainable Society** (e3s) was created to address the systemic dimensions of energy transition pathways, beyond purely technical and technological aspects. The original scope of the Joint Programme focused on assessing the **economic, environmental and social impacts of the energy transition**, as reflected in its original name and acronym.

In 2022, following a decade of profound changes in the institutional, social, economic and technological landscape, JP e3s initiated a comprehensive renewal of its **Strategic Research and Innovation Agenda** (SRIA) to guide its activities over a multi-year horizon towards 2030. This renewal aimed to expand the scope of the Joint Programme beyond the assessment of impacts resulting from the energy transition, towards a broader and deeper analysis of the systemic role played by socio-economic and institutional factors in shaping the transition itself.

At the same time, the renewal sought to reflect contemporary contextual changes, while introducing a commitment to four-year updates to ensure continued alignment with the rapidly evolving EU and global energy landscape, shaped by the complex interaction of technological innovation, policy developments and geopolitical disruptions.

The repositioning of JP e3s in 2022 was also reflected in its updated name. Recognising the growing relevance and systemic nature of the topics it addresses, JP e3s members sought a name that would more accurately capture the current research paradigm. Consequently, while maintaining its established acronym and visual identity, the Joint Programme transitioned from "**Economic, Environmental and Social Impacts of Energy Transition**" to "**clean Energy tranSition for Sustainable Society**".

In line with the idea of a mid-term update, this version of the SRIA is conceived as a general revision of the Joint Programme's scope, objectives, ambition and streams of activities, with the aim of keeping its work aligned with both long-standing and emerging challenges for the energy transition.

In this vein, while the **2022 renewal** was inspired and shaped by the immediate needs of post-pandemic recovery and by the energy crisis triggered by Russia's invasion of Ukraine, this version responds to an emerging European paradigm centred on **strategic autonomy** and **industrial competitiveness**. This paradigm has gained prominence in response to the increasing uncertainty and fragility of energy provision in the EU, driven by instability in international relations and further pressured by the accelerating effects of climate change, which are challenging the operational reliability and resilience of the European energy system.

This shift reflects the Union's objective to strengthen its capacity for independent action, ensuring that strategic choices are grounded in European interests and values, rather than in excessive reliance on third countries for critical resources, sovereign technologies and energy supplies. These ambitions remain aligned with the target of reducing greenhouse gas emissions by 55% by 2030 and achieving climate neutrality by 2050. This trajectory is further reinforced by the new intermediate target of a 90% reduction by 2040, which became legally binding in March 2026.

This **2026 version** of the SRIA aims to **reposition JP e3s** in light of the challenges associated with promoting a **sustainable, competitive, secure and resilient European energy system**. As in the previous version, its ambition is to provide competences, as well as reliable and evidence-based knowledge, on the non-technical aspects affecting the premises, pathways and effects of the Clean Energy Transition, with specific attention to strengthening the role of **Social Sciences and Humanities (SSH)** perspectives in the scientific and policy debate. This reinforcement pursues a twofold objective. First, it aims to counterbalance the dominance of techno-economic approaches by framing technological innovation within the broader context of a systemic socio-technical transition. Second, it seeks to promote a genuinely interdisciplinary approach to understanding and supporting the energy transition, enabling productive collaboration between STEM and SSH communities.

Compared to the previous version, the two most significant novelties are: first, the repositioning of the JP's scope around new emerging topics and perspectives; and second, a stronger rebalancing between the scientific and policy dimensions of the JP's activities.

Regarding the first novelty, this repositioning requires careful reconsideration of the main non-technical open issues from both research and policy perspectives, in order to complement and support the deployment of renewable energy technologies and meet the ambitious targets set by a rapidly evolving policy framework. Since 2022, this framework has expanded beyond Fit for 55 and REPowerEU to include, for example, the Green Deal Industrial Plan, the Net-Zero Industry Act and the Critical Raw Materials Act, all of which place a strong emphasis on internal capacity, industrial resilience and strategic autonomy.

Technological innovation plays a crucial role across these policy streams. The ambition of JP e3s, as reflected in this SRIA, is to mitigate the risk of adopting a purely technocratic perspective that overlooks a wide range of non-technical dimensions, from the reproduction of technological lock-ins to unequal distributional effects, as well as barriers to adoption and social acceptance. At the same time, this requires identifying which SSH skills and competences are needed to address these issues effectively.

In this sense, the ambition of the SRIA is to provide an overview capable of matching the demand for and supply of SSH expertise in support of a **just, sustainable and effective Clean Energy Transition**, aligned with Europe's strategic goals.

With regard to the rebalancing between the scientific and policy domains, the ambition for the next four years is to increase the impact of JP e3s on policy design and implementation. This will be pursued by maintaining a strong focus on systematising and advancing the scientific analysis and understanding of the non-technical factors and dynamics related to the energy transition, while also strengthening the transfer of this knowledge into decision-making arenas through effective engagement with public and private decision-makers.

In this sense, JP e3s aims to reinforce the **science-policy interface** in the energy transition domain by providing EERA, other Joint Programmes, European institutions, national and local policymakers, and the wider research and policy communities with evidence, knowledge and tools to address the non-technical dimensions of the Clean Energy Transition.

In line with the ambition to capture emerging critical issues related to the Clean Energy Transition, this version of the JP e3s SRIA results from discussions within the e3s community, driven by a productive interaction between the JP e3s Management Board – composed of the Sub-Programme coordination teams – and the wider membership. It has also been further refined thanks to contributions from the broader EERA community. Other Joint Programmes played an active role in identifying and prioritising key research topics, while the EERA Secretariat provided support to ensure that JP e3s objectives are fully aligned with EERA's mission, vision and beliefs[1]. This collaborative framework ensures that JP e3s remains at the forefront of the EU's trajectory towards a sustainable, sovereign and equitable energy system.

This SRIA is conceived to guide the activities of JP e3s until 2030, in line with the time horizon established by key UN and EU policy frameworks for climate, energy and emissions targets. It is structured as follows.

The **Background** section presents the main principles, policy frameworks and stakeholder networks that shape the mission and activities of JP e3s. It situates the Clean Energy Transition within a broader systemic transformation and addresses key dimensions such as a just transition, sustainability, science for policy, responsible research, societal readiness and the alignment of the JP with EERA's mission, vision and beliefs.

The **Mission and objectives** section defines the strategic challenges and research priorities of the JP and explains how its organisational structure supports their implementation. The Impacts section describes the contribution that JP e3s aims to make to research, policymaking, the wider EERA community and society.

The following section presents an update of the JP's **Sub-Programmes**, outlining their respective scope, research priorities and expected contribution to the mission, objectives and impacts of JP e3s. The main scope of the Sub-Programmes has been maintained, while their topics and streams of activities have been updated in line with the ambition of the review and in response to contextual changes. The Sub-Programmes therefore continue to address energy consumption and demand reduction, just transition and governance, sustainability, transition pathway modelling, and the integration of Social Sciences and Humanities into the design of energy technologies.

The subsequent section introduces the three new JP e3s **Thematic Groups**, which aim to provide and cluster cross-cutting expertise within and beyond JP e3s, respectively on education and skills, gender perspectives in the energy transition, and societal readiness.

Finally, the Governance and rules section describes the JP bodies and roles, decision-making procedures and the preparation of the Yearly Work Plan, as well as interactions with the EERA Secretariat, central working groups and other Joint Programmes. The annexes provide supplementary and regularly updated information on JP e3s membership and the assignment of roles within the Programme.

Background

The Clean Energy Transition is unfolding within a rapidly evolving European policy, regulatory and research landscape. This section provides the main sources of inspiration for the scope, ambition and activities of JP e3s and is structured into two parts. The first outlines a set of conceptual building blocks that have shaped the non-technical policy and scientific debate on the energy transition; the second outlines the main EU policy initiatives and strategies shaping energy transition pathways.

The conceptual building blocks of JP e3s

The energy system as a socio-technical system

A fundamental principle shaping the overall JP e3s approach to the Energy Transition is the understanding of energy systems as **socio-technical systems** composed of interdependent technologies, infrastructures,

[1] Available here: https://www.eera-set.eu/about-us/what-is-eera.html

institutions, markets, regulations, organisational routines, user practices, cultural meanings and forms of expertise.
From this perspective, the energy transition is not simply a process of replacing fossil-fuel technologies with low-carbon alternatives, but a broader transformation in the ways energy is produced, distributed, governed and consumed. Drawing on the socio-technical transitions literature – notably Geels (2004) and Geels et al. (2017) – incumbent energy regimes are stabilised by mutually reinforcing infrastructures, policy frameworks, business models, professional competences and everyday practices. By contrast, emerging innovations often struggle to move beyond the niches in which they are generated, but may gain momentum when broader landscape pressures – such as climate change, geopolitical instability or changing societal expectations – destabilise existing arrangements.

The transition therefore depends on the alignment and co-evolution of technical and social elements. Renewable energy technologies can diffuse effectively only when they are supported by suitable regulations, infrastructures, institutional capacities, investment models, skills, user practices and forms of public legitimacy.

Conceiving the energy transition as a socio-technical transition thus highlights that technological innovation alone is insufficient. Systemic change also requires the reconfiguration of institutions, actor relations, ownership patterns, social practices and power structures that sustain the existing energy regime.

The Clean Energy Transition as a systemic transformation

In line with the socio-technical approach, the mission of JP e3s focuses on the **Clean Energy Transition**, as redefined in the EERA White Paper on the Clean Energy Transition. Within this perspective, the Clean Energy Transition extends beyond the objective of climate neutrality to incorporate the essential dimensions of social fairness, global sustainability and societal resilience.

The framework proposed in the White Paper adopts a holistic approach to the sources of greenhouse gas emissions across all economic sectors, recognising that only one third of emissions originate directly from the energy sector. Achieving climate neutrality therefore represents a much broader challenge than decarbonising the energy sector alone, and requires moving beyond traditional technology-centred approaches to the Clean Energy Transition.

The White Paper emphasises that transforming the energy system requires a broader transformation of the entire economy, supported by the active integration of Social Sciences and Humanities. This broader perspective is necessary to pursue three strategic objectives:

- designing innovative policies to accelerate public and private investment in low-carbon research, assets and infrastructure;
- promoting profound changes in citizens' consumption patterns and lifestyles, including food, mobility, housing and energy use;
- redesigning markets to ensure a more efficient, circular and sustainable use of energy and natural resources.

Just Energy Transition

A central pillar of the JP e3s mission is the pursuit of a **Just Energy Transition**, which serves as a conceptual umbrella for the three dimensions of energy justice: **distributional, procedural and recognition justice**, as defined in the JP e3s White Paper *A Just Energy Transition in the EU*.

This theoretical framework finds practical application in the **Citizens' Energy Package**, a comprehensive regulatory framework that redefines the role of individuals, moving them from passive consumers to active **prosumers** and participants in the energy market.

Within this framework, JP e3s addresses three key dimensions:

- **Distributional justice**, which concerns fairness in the allocation of costs and benefits. The Citizens' Energy Package operationalises this principle by granting citizens the right to generate, store and sell renewable energy, while promoting energy sharing schemes that democratise access to clean energy, including for tenants and energy-poor households.
- **Procedural justice**, which concerns inclusive participation in decision-making processes. The package establishes the legal basis for Renewable Energy Communities and Citizen Energy Communities, enabling citizens, SMEs and local authorities to collectively manage energy systems in pursuit of local social and environmental benefits.
- **Recognition justice**, which concerns the visibility and inclusion of vulnerable groups. The package strengthens consumer rights through improved billing transparency, easier supplier switching and targeted provisions to address energy poverty, thereby supporting the active inclusion of marginalised groups in the emerging energy economy.

A holistic view on sustainability

JP e3s adopts a sustainability perspective that goes beyond climate neutrality, encompassing environmental, economic, social and circularity-related dimensions. This reflects the understanding that energy technologies, energy futures and transition pathways must be assessed as part of broader socio-technical systems.

Sustainability assessments of technologies, energy futures and transition pathways are needed to provide orientation knowledge for decision-makers, in line with the objectives of the European Green Deal, the EU Circular Economy Action Plan and related EU policy frameworks. A strong focus on technical performance or techno-economic optimisation alone risks overlooking key EU concerns related to social fairness, resource efficiency, critical raw materials, circularity, resilience and competitiveness.

From this perspective, JP e3s contributes to the development and application of comprehensive sustainability assessment frameworks, including **Life Cycle Sustainability Assessment**, **Multi-Criteria Decision Analysis**, **Material Flow Analysis** and **energy system modelling** approaches. These approaches are essential to identify and manage trade-offs between climate mitigation, resource efficiency, circularity, social impacts and competitiveness.

Science for policy

Science for policy refers to the use of scientific evidence, expertise and knowledge to support and improve policymaking. It helps policymakers identify and understand policy challenges, assess interventions and policy alternatives, make informed decisions, and design more effective policy responses.

This principle is particularly relevant for JP e3s, as the Clean Energy Transition requires policy choices that are not only technically feasible, but also socially acceptable, environmentally sustainable, economically viable and institutionally robust. The SSH fields covered by JP e3s provide essential evidence to inform the design, implementation and evaluation of clean energy policies.

This role is aligned with the European Commission's efforts to strengthen the European science-for-policy ecosystem, including through networks, communities of practice, capacity-building activities and the improved use of research and innovation results in policymaking.

Responsible Research and Innovation and Societal Readiness

Responsible Research and Innovation (RRI) is another key reference for JP e3s. RRI provides a framework for orienting research and innovation towards societally desirable, ethically acceptable and sustainable outcomes by embedding anticipation, inclusion, reflection and responsiveness throughout the innovation process (Owen et al., 2012; Stilgoe et al., 2013).

Rather than assessing social consequences only after a technology has been developed, RRI requires researchers, innovators, policymakers and societal actors to collectively examine which problems innovation should address, whose needs and values are represented, how benefits and burdens may be distributed, and how research objectives and technological designs should be adapted in response to emerging knowledge and concerns.

Within RRI, SSH play a constitutive rather than merely supportive role. They help identify relevant actors and practices, analyse power relations and inequalities, anticipate unintended effects, support meaningful participation and co-production, and translate societal knowledge into technological and policy design.

The more recent **Societal Readiness** approach is closely connected to RRI and operationalises its principles across the research and innovation lifecycle. It complements Technology Readiness assessments by examining whether innovations are capable of responding to societal needs, values and expectations (Bernstein et al., 2022). The Horizon Europe Work Programme for climate, energy and mobility, particularly Cluster 5, has explicitly promoted Societal Readiness as a way to implement RRI processes through interdisciplinarity and knowledge integration.

Within JP e3s, Societal Readiness is understood not as a final measurement of public acceptance or societal sensitivity, but as an iterative capacity to align and co-develop innovation with society, increasing its legitimacy, inclusiveness, contextual suitability and potential for durable societal uptake.

Within this framework, JP e3s contributes to the wider adoption of RRI and Societal Readiness by supporting co-creation, citizen engagement, living labs, participatory governance, energy justice approaches and interdisciplinary collaboration between SSH and STEM communities.

The New European Bauhaus and societal transformation

The New European Bauhaus provides a crucial bridge between the European Green Deal and the everyday lives of European citizens. It translates climate objectives into tangible spatial and social transformations by integrating science and technology with art, design, and culture.

JP e3s adopts the core values of the NEB to guide its research on the built environment and community energy systems:

- **Sustainability:** advancing climate neutrality, circularity, and biodiversity;
- **Inclusion:** prioritising social diversity, accessibility, and affordability;
- **Aesthetics:** emphasising quality of experience and cultural value beyond functionality alone.

Through a commitment to co-creation, JP e3s mobilises the NEB framework to address complex societal challenges and to ensure that the energy transition contributes to sustainable, inclusive, and high-quality living environments.

Alignment with EERA Mission, Vision and Beliefs

JP e3s is intrinsically committed to advancing EERA's overarching mission and strategic objectives. In alignment with EERA's updated framework, the Joint Programme embraces a vision in which research and innovation are positioned at the core of a sustainable, resilient, and socially just European energy system.

Through the targeted activities of its Sub-Programmes, JP e3s contributes to the operationalisation of EERA's core beliefs, ensuring that interdisciplinary SSH-E research supports evidence-based policymaking. In particular, JP e3s contributes to:

- **Full Value-Chain Thinking:** ensuring that interdisciplinary knowledge is translated into innovations that benefit citizens, industry, and the environment by linking fundamental research to practical implementation and societal uptake;
- **Impact and Responsibility:** recognising planetary boundaries and promoting inclusive sustainability pathways that ensure no one is left behind;
- **Scientific Excellence and Integrity:** maintaining a firm commitment to independent, objective, and evidence-based research, safeguarded from political and industrial pressures.

JP e3s further upholds the principles of transdisciplinary collaboration, independence, and technology neutrality, maintaining an open and scientifically rigorous approach to all pathways of the energy transition.

JP e3s policy framework

The evolving regulatory landscape: 2040 and beyond

The **European Green Deal** remains the overarching framework for the EU's sustainable transition, framing the climate crisis as a catalyst for systemic socio-economic transformation. As energy production and consumption account for a major share of the EU's greenhouse gas emissions, the decarbonisation of the energy system constitutes the central pillar of this strategy. This requires a transition towards an energy model dominated by Renewable Energy Sources, at a pace significantly faster than historical decarbonisation trends.

The broad ambitions of the Green Deal were first translated into a concrete legislative roadmap through the **Fit for 55 package**, which established the intermediate objective of reducing net greenhouse gas emissions by 55% by 2030. To ensure a continuous and predictable trajectory towards climate neutrality by 2050, the European Commission introduced the **2040 Climate Target**. This milestone, targeting a 90% net reduction in greenhouse gas emissions, provides the essential bridge between the 2030 targets and the 2050 climate neutrality objective. Within this reinforced policy framework, JP e3s aligns its mission with the core principles of the European Green Deal while addressing the emerging systemic challenges of mass electrification, industrial competitiveness, strategic autonomy and societal transformation.

Accordingly, JP e3s focuses on the following energy policy priorities:

- Prioritising energy efficiency and sufficiency to achieve overall demand reduction;
- Developing a power sector based on renewable energy sources, complemented by a progressive fossil fuel phase-out;
- Ensuring secure and affordable energy for households, consumers, and businesses;
- Promoting a fully integrated, interconnected, and digitalised European energy market;
- Addressing energy poverty to ensure that the transition is inclusive and socially beneficial;
- Advancing smart infrastructure and reinforcing Member State commitments through robust energy and climate planning.

Market design, regulation, and consumer protection

In its 2023 Strategic Research and Innovation Agenda, JP e3s called for a revision of REMIT, the Regulation on Wholesale Energy Market Integrity and Transparency, to address the evolving energy landscape. This recommendation materialised through the adoption of REMIT II and the Electricity Market Design reform.
These regulatory developments function synergistically to safeguard the energy transition:

- **REMIT II – Market Integrity:** strengthens oversight in wholesale energy markets by preventing price manipulation and speculative behaviour, thereby ensuring that consumer prices reflect genuine market conditions rather than artificial distortions;
- **Electricity Market Design Reform – Market Structure:** redesigns electricity market architecture to prioritise social equity by introducing protections for vulnerable consumers, promoting long-term contracts to stabilise prices, and enabling Energy Sharing mechanisms that empower citizens to participate directly in local renewable energy systems.

Together, these reforms reinforce market transparency and structural stability while contributing to the substantive empowerment of European citizens, a cross-cutting objective addressed across several JP e3s Sub-Programmes.

In light of the strategic challenges identified in the Draghi Report, JP e3s explicitly integrates environmental sustainability with European economic resilience. These recommendations have been operationalised through the Competitiveness Compass, the EU's strategic framework for positioning decarbonisation as a driver of industrial leadership. JP e3s provides the SSH-E expertise required to analyse the implementation of key policy instruments, including the Clean Industrial Deal, the Action Plan on Affordable Energy, and the Circular Economy Act.

The European Research Area & SET Plan

The European Research Area remains the primary framework for establishing a unified European market for research and innovation. Within this context, EERA plays a formalised institutional role as a member of the ERA Forum, where Member States and stakeholder organisations co-design European research policy.

EERA and JP e3s are strategically positioned also to contribute to the objectives of the Letta Report, which advocates the establishment of a "Fifth Freedom" based on the free movement of research, innovation, knowledge, and education. By coordinating Joint Programmes and aligning national research agendas with EU priorities, EERA serves as a key operational pillar of this vision, ensuring that scientific excellence transcends national boundaries and accelerates the European energy transition.

The revamped Strategic Energy Technology Plan, in which EERA is formally recognised as the research pillar, constitutes another fundamental cornerstone of JP e3s. It reflects a shift towards a mission-oriented approach that places cross-cutting collaboration at the centre of energy policy and explicitly integrates social sciences, humanities, digitalisation, and circularity into the energy innovation agenda.
A key feature of the revised SET Plan is its streamlined governance structure, organised around strategic Task Forces designed to address systemic challenges. JP e3s plays an active role in the Task Force on Societal Needs, providing interdisciplinary expertise on consumer behaviour, social acceptance, and energy poverty mitigation.

Mission, strategic challenges and objectives

Mission

The mission of JP e3s is to coordinate and provide the interdisciplinary SSH perspectives and expertise required to support the Clean Energy Transition (CET), with specific attention to the careful assessment of its sustainability. The Clean Energy Transition constitutes a complex and systemic transformation of contemporary European society, reshaping its social, technological, economic, institutional and environmental dimensions.

To address this transformation, JP e3s adopts a holistic, systemic and interdisciplinary approach that integrates technical, economic, institutional, environmental and social perspectives. This framework enables the Joint Programme to generate robust, evidence-based knowledge and analytical tools to inform policymaking at the intersection of energy and society.

Strategic challenges and research priorities

Based on the background outlined above, the mission of JP e3s is framed by two overarching challenges for the energy transition in the EU:

- **Accelerating renewable energy deployment and fossil fuel phase-out** by expanding renewable electricity, heating and fuels, and strengthening energy system integration.
- **Strengthening energy security and strategic autonomy** by reducing dependence on imported fossil fuels, while also addressing emerging dependencies on critical raw materials and external supply chains.

The mission can be detailed into a set of e3s specific **key strategic challenges** that define its scope of action:

- **Linking decarbonisation with industrial competitiveness** by supporting low-carbon industrial transformation, quality employment, and markets for sustainable products and services.
- **Assessing and promoting the sustainability of the Energy Transition by developing and disseminating reliable and effective approaches to address its multidimensional and systemic nature**
- **Embedding circularity across the energy system by promoting resource efficiency, reuse and recycling to mitigate risks related to EU critical raw material supply throughout clean energy technology value chains**
- **Delivering a just and inclusive transition and empowering citizens and communities** by addressing energy poverty, unequal access to technologies and territorial disparities, while ensuring a fair distribution of costs, benefits and decision-making opportunities.
- **Reducing energy demand through efficiency and sufficiency** by combining technological efficiency with changes in consumption practices and behaviors to reduce overall energy and material demand.
- **Ensuring affordability and effective consumer protection** by designing markets, tariffs and regulatory instruments that stabilise prices and protect vulnerable consumers.
- **Strengthening governance and implementation capacity** by improving coordination among European, national, regional and local authorities, and reinforcing administrative, regulatory and planning capacities.
- **Reorienting research and innovation towards societal transformation by promoting socio-technical innovations for the ET that are technically robust and mature, socially legitimate and fair, and institutionally implementable.**

In order to address these strategic challenges, the scope of the Joint Programme is defined by six main **Research Priorities and three Cross-cutting Strategic Objectives**

Joint Programme e3s' Research Priorities (RP)

1. **Socio-technical pathways for accelerating the Clean Energy Transition** - To advance interdisciplinary understanding of how technological deployment, societal change, institutional transformation, market evolution and changing patterns of energy demand interact in shaping feasible and effective CET pathways.
2. **Just, inclusive and citizen-centred energy transitions** - To strengthen the evidence base on how the costs, benefits, risks and opportunities of the Clean Energy Transition are distributed across social groups and territories, and on how participation, empowerment and energy citizenship can contribute to socially legitimate transition pathways.
3. **Sustainable, circular and resilient energy transition pathways** - To develop integrated knowledge and assessment approaches for understanding the environmental, economic and social sustainability of energy technologies and transition pathways, including circularity, resource dependencies, resilience and interactions with European strategic autonomy.
4. **Energy demand, practices and flexibility in a changing energy system** - To advance knowledge on how efficiency, sufficiency, behavioural and organisational change, demand-side flexibility and digitalisation can contribute to reducing energy and material demand while ensuring fairness, affordability and societal resilience.
5. **Markets, governance and policy frameworks for a secure, affordable and competitive transition** - To investigate how energy markets, business models, regulatory frameworks and multilevel governance can support a secure, affordable, competitive and socially equitable Clean Energy Transition, while enabling investment and technological deployment.
6. **Integrated evidence, modelling and decision support for transition policy** - To strengthen interdisciplinary methods, models, scenarios and shared evidence for assessing transition pathways, anticipating policy impacts and trade-offs, and supporting robust, transparent and evidence-based decision-making across governance levels.

Joint Programme e3s Cross-Cutting Strategic Objectives

A. **Integrate knowledge** – strengthen integration among social, economic, institutional, environmental and technological knowledge across the energy research community
B. **Coordinate and build capacity** – reinforce collaboration within E3S and across EERA Joint Programmes, aligning dispersed competences and fostering interdisciplinary research capacity
C. **Translate knowledge into impact** – support the SET Plan and European energy and climate policy through accessible evidence, open research data, stakeholder engagement and knowledge valorisation

Implementation: the e3s Sub-Programmes and Thematic Groups

The JP's structure

The JP organisational structure is designed in line with the Research Priorities and the Cross-Cutting Strategic Objectives.
To align the organisational structure with the Research Priorities, JP e3s has organised their implementation around five Sub-Programmes and three Thematic Groups. Each SP broadly corresponds to one of the five more thematic Research Priorities (RP2–RP6), while RP1 – Socio-technical pathways for accelerating the Clean Energy Transition – plays an overarching and cross-cutting role, providing a common systemic perspective that connects and integrates the contributions of all five Sub-Programmes. Each Thematic Group, in turn, addresses a timely issue emerging from the scientific and policy debate that requires dedicated cross-cutting attention.
The five Sub-Programmes through which these research priorities are operationalised are:

- **Sub-Programme 1 (SP1):** Fostering changes in energy consumption: a pathway to demand reduction;
- **Sub-Programme 2 (SP2):** Just Transition and Governance of the Energy Transition;
- **Sub-Programme 3 (SP3):** Sustainability of the Energy Transition;
- **Sub-Programme 4 (SP4):** Understanding and Strengthening EU Energy Market Dynamics for a Secure, Resilient and Clean Transition
- **Sub-Programme 5 (SP5):** Scenarios and modelling of Energy Transition Pathways

In addition to these five Sub-Programmes, JP e3s is also responsible for the Social Sciences and Humanities Sub-Programme within the EERA transversal Joint Programme "Digitalization for Energy" (tJP DfE).

In 2025, JP e3s also launched three **Thematic Groups** intended to complement the work of the Sub-Programmes by addressing transversal dimensions that require dedicated attention across different research areas and policy challenges. The temporary Thematic Groups focus on:

- **Gender Perspectives in the Energy Transition;**
- **Education and Skills for the Energy Transition;**
- **Societal Readiness.**

Each SP and TG contributes to the Cross-Cutting Strategic Objectives. Their integration and alignment are supported by the Management Board's ongoing monitoring and, in particular, by the two deputy coordinators responsible for Communication and Policy, as outlined in the governance structure.

Sub-Programmes

SP1 - Fostering changes in energy consumption: a pathway to demand reduction

Scope, objectives and contribution to e3s Research Priorities

The scope of SP1 is to better understand and expand knowledge of the social, cultural and economic factors that influence contemporary energy consumption patterns. To this end, it is essential to identify the challenges and opportunities for behavioural, practice and organisational changes that could potentially reduce the aggregate final energy demand of individuals, companies and public institutions. This will be achieved by accounting for energy efficiency, energy savings and energy sufficiency, as well as direct and indirect energy consumption.

The specific objectives of the SP are:

- Improving the integration of behavioural, economic, social, cultural and organisational perspectives to identify measures that improve energy consumption patterns among citizens, companies and public institutions, while also accounting for interactions among these actors;
- Increasing knowledge of the different perceptions of climate change and energy-related issues and their link with changing attitudes, behaviour, practices and investments in the context of energy reduction;
- Understanding drivers and barriers to the adoption of effective solutions and technologies to reduce energy consumption in households, companies and public institutions, with special attention to non-technical factors;
- Analysing the effect of public measures (e.g. incentives, taxes, nudges, etc.) and legal frameworks on behaviour and practices of the actors in the energy market, and how such measures are perceived by them.

SP1 contributes primarily to **JP e3s Research Priority 4 – Energy demand, practices and flexibility in a changing energy system**, by advancing knowledge on the social, behavioural, cultural, organisational and economic factors shaping energy consumption, demand reduction and demand-side flexibility. In particular, SP1 addresses the following research questions:

1. **How can behavioural, social, cultural and organisational changes, together with energy efficiency and sufficiency strategies, enable substantial and persistent reductions in energy demand across households, businesses and public institutions?**
2. **Under what conditions can demand-side flexibility, digital technologies and dynamic pricing support energy demand reduction and system resilience, while remaining accessible, acceptable and affordable across different groups of consumers?**
3. **Which combinations of policies, regulatory frameworks and enabling conditions are most effective in fostering durable energy demand reduction, and how do their impacts differ across social groups, sectors and national contexts?**

While RP4 represents its main area of contribution, SP1 also supports several other JP e3s research priorities. It contributes to **RP1 – Socio-technical pathways for accelerating the Clean Energy Transition** by analysing how technologies, infrastructures, policies and market arrangements interact with everyday practices, organisational routines, capabilities and social norms in shaping the evolution of energy demand. It contributes to **RP2 – Just, inclusive and citizen-centred energy transitions** by examining affordability, energy poverty, unequal capabilities to participate in demand-side flexibility, and the distributional effects of demand-reduction measures. SP1 is also relevant to **RP5 – Markets, governance and policy frameworks for a secure, affordable and competitive transition**, through its analysis of how tariffs, incentives, regulations and other policy instruments influence behaviours and practices, and to **RP6 – Integrated evidence, modelling and decision support for transition policy**, by providing empirically grounded evidence on behavioural responses, technology adoption, flexibility, persistence of change and barriers that can inform models, scenarios and policy assessment.

Background and challenges

Changes in energy consumption patterns cannot be achieved through attitudinal shifts alone. They require coordinated action and a collective orientation toward the common good, supported by energy citizenship, empowerment and enabling infrastructures. This is intensified by the post-2022 energy crisis experience: large-scale demand reductions can occur quickly, but maintaining them requires institutional design that supports durability, fairness and legitimacy, not only short-lived awareness (IEA, 2023; IEA, 2025).

Experience from recent years shows that demand reduction can be achieved rapidly under crisis conditions but also reveals a major challenge: persistence. Qualitative and practice-theory research documents that some household practice reconfigurations persist after the most acute crisis months, while others revert, making the mechanisms of persistence (new meanings of frugality/sufficiency, changed routines, enabling infrastructures) a key barrier and opportunity for policy design (Björner Brauer et al., 2024). Both internal barriers—such as skills, trust and awareness—and external barriers—including infrastructures, land-use patterns and economic constraints—shape the durability of these changes, and their relative importance varies across social groups and sectors.

At the same time, electrification is shifting the problem from annual energy consumption to peak demand, congestion and timing of use. Demand reduction is therefore coupled to demand-side flexibility, but not all consumers can respond equally: flexibility depends on building type, heating technology, household schedules and automation. Evidence from field experiments shows households can respond to variable hourly prices, which strengthens the case for integrating behavioural insights into tariff design and communication—while explicitly managing fairness and capability constraints (Hofmann & Lindberg, 2024).

Climate change is also altering the nature of energy demand itself. More frequent heatwaves increase cooling needs and overheating risks in buildings, creating new demand peaks and shifting attention to summer resilience, passive cooling and adaptive comfort. Recent building-focused work reinforces that demand-reduction strategies must address both winter heating and summer cooling service provision (Ach-Chakhar et al., 2025) as well as the larger-scale issue of urban microclimate and UHI (urban heat island) mitigation, e.g. through climate shelters and green infrastructures.

Digitalisation and the deployment of smart technologies create further opportunities to support demand reduction by providing real-time information, personalised feedback and automated control. However, synthesis evidence indicates that smart-meter feedback effectiveness depends strongly on design and context, so data availability alone is not sufficient; governance, usability and inclusion are increasingly central barriers (Samancioglu, 2026).

A further question concerns whether feedback primarily empowers end-users or mainly serves supplier optimisation objectives, highlighting the need for transparent governance of digital energy services.

While these technologies offer considerable potential, they also raise challenges related to privacy, data security and the digital divide; moreover, the rapidly increasing use of Artificial Intelligence and Large Language Models generates largely invisible additional energy demand. Beyond traditional communication channels, more structural engagement—particularly through the education system and collaboration with younger generations—can act as an enabler of change at family and community level, with digital skills and social media amplifying outreach.

The growing use of dynamic tariffs and real-time pricing introduces additional challenges. While these schemes can incentivise load shifting and flexibility, they also raise concerns about complexity, bill volatility and perceived risk—particularly for vulnerable households or organisations with limited control over loads. Evidence indicates that meaningful economic benefits often require enabling technologies such as home energy management systems; this creates a policy design challenge to avoid a two-tier transition where flexibility and savings are unevenly distributed (Stute et al., 2024).

Traditional barriers remain relevant, including the energy-efficiency gap, rebound effects, split incentives and limited skills or time. In the post-crisis context, these barriers interact more directly with trust and legitimacy: research on gas savings during the 2022/23 winter suggests conservation outcomes were not explained mainly by marginal individual incentives alone, implying that social priority-setting, shared norms and broader societal engagement can materially shape demand outcomes, an important lens for designing durable programmes (Dertwinkel-Kalt et al., 2024). In addition to efficiency, growing attention is paid to sufficiency-oriented strategies that question levels and purposes of energy service demand, complementing technological improvements.

Another emerging perspective concerns social tipping points and the identification of measures capable of triggering self-reinforcing dynamics of demand reduction and energy transition.

Taken together, these challenges call for a broad methodological approach. SP1 will combine quantitative and qualitative methods to integrate behavioural, social, organisational and cultural dimensions in the analysis of consumption patterns and the adoption of effective solutions and technologies. A particularly relevant line of work is to strengthen evaluation designs for digital interventions, automation and dynamic pricing in order to test persistence, acceptability and distributional impacts using high-frequency consumption data and privacy-preserving analytics.

Areas of intervention

On this basis, SP1 works on the following areas:

- Exploring how conditions differ across Member States in triggering successful EDR policies;
- Considering societal readiness levels to assess and enhance engagement in energy demand reduction;
- Accounting for energy sufficiency in legal frameworks and public policies to complement efficiency and energy savings objectives;
- Investigating effects of policies on behavioural change (e.g. incentives, nudging, regulation, etc.);
- Identifying barriers and drivers that hinder/foster behavioural change;
- Exploring potential unfair distributional effects of EDR (e.g. impact on energy poverty (including cooling poverty), affordability, needs ...).

Contribution to JP e3s mission, Cross-Cutting Strategic Objectives and relations with other EERA JPs and networks (ETIPs, IWGs, CoEs, etc.)

SP1 contributes to the mission of JP e3s by building the research capacity and expertise needed to assess the potential of individual and collective changes in energy consumption and their contribution to energy demand reduction. It is also aligned with the Vision, Mission and Beliefs outlined in the EERA strategy, in particular with the principles of **"Full value-chain thinking"** and **"Impact and responsibility"**. The former is addressed by explicitly connecting fundamental research on the behavioural, social, cultural and organisational drivers of energy use with applied policy design and real-world implementation. The latter is reflected in SP1's focus on identifying effective energy demand reduction strategies while accounting for fairness, energy poverty, affordability and societal acceptance.

These contributions are closely connected with the activities of the other JP e3s Sub-Programmes. Research on citizen engagement and empowerment in energy demand reduction provides a direct link with **SP2**, particularly regarding participation, energy citizenship and justice. Energy demand reduction and sufficiency strategies are connected with **SP3** through their implications for the environmental, economic and social sustainability of transition pathways. The analysis of energy consumption patterns, demand-side flexibility and the adoption of renewable energy and energy-efficiency technologies creates strong synergies with **SP4**, particularly in understanding how market design, tariffs and business models interact with consumer and organisational behaviour. Finally, SP1 provides evidence on behavioural, social and organisational drivers and barriers that can inform the policy assessment, modelling and scenario analysis undertaken in **SP5**, especially regarding the realistic representation of energy efficiency, demand reduction and flexibility in national and EU transition pathways.

Beyond JP e3s, SP1 can contribute to collaboration with other EERA Joint Programmes, SET Plan Implementation Working Groups, ETIPs and related research networks by providing SSH-based knowledge on the demand-side conditions affecting technology uptake, energy efficiency, flexibility and the real-world implementation of clean energy solutions.

With regard to the **JP e3s Cross-Cutting Strategic Objectives**, SP1 contributes to **knowledge integration** by connecting behavioural, social, cultural, organisational and economic perspectives with the technologies, infrastructures and policy instruments that shape energy demand. It **supports coordination and capacity building** by fostering interdisciplinary research on demand-side change and by strengthening collaboration across JP e3s and the wider EERA community. It also **contributes to knowledge-to-impact** by translating evidence on behaviour, sufficiency, flexibility and affordability into insights that can support the design and implementation of effective demand-reduction policies.

SP2 - Just Transition and Governance of the Energy Transition

Scope, Objectives and contribution to Research Priorities

The premise of SP2 is that the energy transition (ET) can only be successful if it is just for all. Building on the three dimensions of energy justice – distributional, procedural and recognition justice – SP2 seeks to understand how structural power, spatial and socio-economic dynamics, and environmental conditions shape the transition in democratic societies. It therefore focuses on the justice implications of relevant policies across institutional levels and on how governance can support more inclusive and legitimate transition processes.

The specific objectives of SP2 are:

- To guide empirical research on social impacts of the ET with specific attention to vulnerable groups in the face of wider societal developments such as digitalisation and AI, regional economic disparities and global energy shocks
- To analyse energy-related policies with respect to their effects on the ET at multiple levels (EU, national, local) and analyse how all energy system stakeholder groups can be heard in policy design and implementation
- To provide guidance for the governance of the transition process, to identify and address the regulatory gaps that hamper ET policy integration at EU level and harmonisation at Member State levels (e.g., through regulatory experimentation)
- To identify effective citizen participation and engagement strategies (e.g., living labs and co-creation hubs) to empower people in the energy transition, also drawing on other societal domains, such as the cultural sector.

SP2 contributes primarily to **JP e3s Research Priority 2 – Just, inclusive and citizen-centred energy transitions**, by strengthening the evidence base on the distribution of transition costs, benefits, risks and opportunities and on the role of participation, empowerment and energy citizenship in shaping socially legitimate transition pathways. In particular, SP2 addresses the following research questions:

1. **How are the costs, benefits, risks and opportunities of the Clean Energy Transition distributed across different social groups and territories, particularly among vulnerable and marginalised groups?**
2. **Which forms of participation, engagement and energy citizenship can effectively empower citizens and communities and enhance the legitimacy and inclusiveness of energy transition processes?**
3. **How can governance arrangements, regulatory frameworks and policy processes at EU, national and local levels better integrate distributional, procedural and recognition justice into the design and implementation of the Clean Energy Transition?**

These questions reflect SP2's focus on democratising the energy system, strengthening energy justice, equity and social inclusion (Biresselioglu et al., 2024), developing effective approaches for citizen engagement and empowerment (Borragán et al., 2024), and analysing transformative policies and multilevel governance arrangements capable of supporting the energy transition (Borrás and Schwaag Serger, 2022; Gladkykh et al., 2023). Particular attention is given to vulnerable groups and to the need to better integrate justice considerations into European energy-transition policies (Gladkykh et al., 2023; Patki et al., 2026).

While RP2 represents its main area of contribution, SP2 also supports other JP e3s research priorities. It contributes to **RP1 – Socio-technical pathways for accelerating the Clean Energy Transition** by examining how institutional arrangements, power relations, stakeholder participation and social legitimacy interact with technological change in shaping transition pathways. In this respect, SP2 builds on approaches that connect responsible innovation, social practices and energy justice and that understand societal transformation as an integral component of energy-system change (Sovacool, Hess and Cantoni, 2021).

SP2 has a particularly strong connection with **RP5 – Markets, governance and policy frameworks for a secure, affordable and competitive transition**, through its analysis of multilevel governance, transformative policies, regulatory gaps and the capacity of different stakeholder groups to participate effectively in policy design and implementation (Borrás and Schwaag Serger, 2022; Gladkykh et al., 2023). It also contributes to **RP6 – Integrated evidence, modelling and decision support for transition policy** by generating empirical evidence and conceptual approaches that can support the assessment of social, institutional and distributional implications of alternative policies and transition pathways. Its work on energy justice, vulnerability and social impacts further provides relevant input to the social sustainability dimension of **RP3 – Sustainable, circular and resilient energy transition pathways**.

Background and challenges

These research questions arise from a transition process that is inevitably intertwined with competing interests and may generate conflicts between incumbent energy-system actors and new stakeholders (Krupnik et al. 2022). At the same time, digitalisation and AI may enhance transparency and accessibility and support the integration of renewable energy technologies and more decentralised and resilient infrastructures. Their contribution, however, depends on how they are governed and on whether broader objectives of environmental sustainability and social inclusion are taken into account.

Against this background, a justice perspective requires the interests, behaviours and practices of all affected actors to be considered in the governance of the energy transition, including:

i. all actors in the energy system (owners and operators of grid infrastructure, large as well as small-scale producers, storage providers, as well as private and industrial end users);
ii. stakeholders involved in transforming the energy system (policymakers, public administrations, research organisations, civil society organisations, interest groups and citizens).

For the ET to be successful in a democratic system, it must be a just transition, as stated in the EU energy strategic framework. New forms of governance (e.g., energy communities) have to be found to achieve social acceptance of the ET, and the diversity of social groups have to be represented in decision-making, particularly the most vulnerable, who are at risk of suffering from unintended side-effects of the transition (Williams and Doyon 2019). Three energy justice tenets have been proposed providing effective guideposts for the just transition (e.g., Carley and Konisky 2020; Jenkins et al. 2016): *distributional justice* (equity in the distribution of costs and benefits); *procedural justice* (right of all affected groups to participate in decision-making); and *recognition justice* (recognising vulnerable groups and how they are impacted).

The European Green Deal encompasses legislative packages such as Fit for 55, REPowerEU, the Renewable Energy Directive, the Energy Efficiency Directive, the Just Transition Mechanism, the Social Climate Fund, the Carbon Border Adjustment Mechanism and the Internal Energy Market directives. This policy framework has the potential to contribute significantly to the ET, but is paying highly uneven attention to the three justice tenets (Gladkykh et al. 2023). Bearing in mind that more than one fifth of the EU´s population is at risk of poverty and social exclusion, incorporating justice considerations into European ET policy remains a core desideratum (Patki et al. 2026).

In this context, the European Innovation Agenda and the New European Bauhaus initiative are promoting rights-based, people-centred approaches to the clean energy transition, using heritage, creativity, and the arts as vehicles for engagement. These initiatives also emphasise the need to gather evidence on the societal impacts

they generate. Moreover, the integration of energy, climate, and cultural policies at national, regional, and local levels is already demonstrating positive outcomes.
These challenges also shape SP2's methodological approach. Its objectives will be pursued through networking, interdisciplinary knowledge exchange and the initiation and coordination of collaborative research among EERA partner institutions and beyond. Conceptual and empirical work using qualitative and quantitative SSH methods will be combined with participatory approaches such as citizen science. This broad methodological toolkit can connect communities working on Responsible Research and Innovation (RRI), social practices, Societal Readiness and ethics (e.g., Sovacool, Hess, and Cantoni 2021; Bernstein et al. 2022), thereby supporting citizen engagement, democratic ownership and accountability in the transition.

Topics

Against this background, SP2 will mainly focus on the following domains:

- Transformative policies supporting the ET (Borrás and Schwaag Serger 2022)
- Transparency regarding the multi-level governance structure and regulatory frameworks (Gladkykh et al. 2023)
- Democratising the energy system, securing energy justice, equity and social inclusion (Biresselioglu et al. 2024)
- Securing engagement and empowerment of people by means of new approaches both in real and in virtual environments (Borragán et al. 2024)

Contribution to JP e3s mission, Cross-Cutting Strategic Objectives and relations with other EERA JPs and networks (ETIPs, IWGs, CoEs, etc.)

SP2 contributes to the mission of JP e3s by strengthening the knowledge, research capacity and methodological approaches needed to ensure that the Clean Energy Transition develops along socially just, inclusive and democratically legitimate pathways. Building on the principles of **distributional, procedural and recognition justice** (Jenkins et al., 2016; Carley and Konisky, 2020), SP2 provides evidence on the social impacts and justice implications of transition processes, while developing conceptual and practical approaches to improve citizen participation, stakeholder inclusion and governance. In doing so, SP2 supports the broader JP e3s ambition to complement technological and economic perspectives with a deeper understanding of the social, institutional and political conditions that shape the implementation and legitimacy of the Clean Energy Transition (Krupnik et al., 2022).

These contributions create close links with other JP e3s activities. SP2 interacts with **SP1** on citizen empowerment, energy practices and the distributional consequences of demand-side measures; with **SP3** on the social and justice dimensions of sustainability assessment; with **SP4** on fairness, accessibility and the distributional implications of energy markets and business models; and with **SP5** by providing institutional, participation and justice-related evidence that can be incorporated into transition pathways, scenarios and policy assessment. SP2 also has a particularly strong connection with the **Thematic Group on Societal Readiness**, where approaches based on Responsible Research and Innovation, Societal Readiness, social practices and ethics can support co-creation, citizen participation and democratic ownership of the transition (Bernstein et al., 2022; Sovacool, Hess and Cantoni, 2021).

Beyond JP e3s, SP2 can interact with other EERA Joint Programmes, particularly **JP Digitalisation for Energy**, regarding the social, participation and governance implications of digitalisation and AI, and with JPs addressing physical energy infrastructures, where inclusive governance, social acceptance and equity represent important conditions for successful technological deployment. Cooperation with **JP Hydropower**, for example, can support research on the role of citizens in democratic energy policymaking and on the conditions required to strengthen legitimacy, resilience and societal support for energy-transition projects. At the international level, collaboration with networks such as **IEA-ISGAN**, particularly Working Group 7 on Smart Grids Transitions, can provide an important interface with research on the societal needs, governance, regulation and human-behaviour dimensions of smart energy systems (Ge et al., 2019).

In relation to the **JP e3s Cross-Cutting Strategic Objectives**, SP2 advances **knowledge integration** by linking energy justice, governance, participation, power relations and social impacts with broader processes of technological and institutional transformation. It **strengthens coordination and capacity building** through interdisciplinary and participatory approaches involving researchers, policymakers, stakeholders and citizens. SP2 also **supports knowledge-to-impact** by providing evidence and guidance for more inclusive, legitimate and effective energy-transition policies and governance arrangements.

SP3 – Sustainability of the Energy Transition

Scope, Objectives and contribution to Research Priorities

The mission of SP3 is to guide the further development and application of stakeholder-based comprehensive sustainability assessment frameworks for energy technologies contributing to a sustainable energy system, as well as for possible energy futures and pathways towards them, taking into account the needs of decision-makers and the objectives of the European Green Deal and the EU Circular Economy Action Plan.

Comprehensive assessment in SP3 goes beyond environmental impacts and includes economic, social, and circularity-related dimensions, reflecting EU policy priorities on climate neutrality, resource security, industrial competitiveness, and social fairness. For energy technologies, this implies the application and further development of Life Cycle Sustainability Assessment (LCSA) approaches that are extended to capture material circularity, critical raw material dependency, and end-of-life performance, in line with emerging EU regulatory frameworks such as the Ecodesign for Sustainable Products Regulation (ESPR).

While sustainability remains the primary focus, SP3 also addresses the increasing importance of resilience in energy technologies and systems, particularly where resilience is strengthened through circular strategies such as diversified supply chains, reduced dependency on primary raw materials, modular system design, and decentralized infrastructures, consistent with the objectives of the Critical Raw Materials Act (CRMA).

The general scope of SP3 is methodological development; no specific technologies or energy systems are the primary focus. However, methodological discussions will be carried out in the context of selected technologies, to be identified by SP3.

The following objectives are the main focus of SP3:

- Further development of stakeholder-based LCSA approaches of selected technologies, including environmental, economic, social, and EU-aligned circular economy indicators (e.g. material efficiency, circular material use, durability, reparability, recyclability), supported by Multi-Criteria Decision Analysis (MCDA).
- Development of approaches to couple model-based analysis (e.g. energy systems models, Life Cycle Assessment (LCA), Material Flow Analysis (MFA)) with sustainability assessment frameworks.

SP3 contributes primarily to **JP e3s Research Priority 3 – Sustainable, circular and resilient energy transition pathways**, by developing integrated knowledge and assessment approaches capable of capturing the environmental, economic and social sustainability of energy technologies and transition pathways, including circularity, resource dependencies and resilience. In particular, SP3 addresses the following research questions:

1. **How can integrated sustainability assessment frameworks comprehensively assess the environmental, economic, social and circularity performance of energy technologies and transition pathways?**
2. **How can circular economy strategies and resource dependencies be incorporated into the assessment of energy technologies and systems, and under what conditions can they strengthen their sustainability, resilience and contribution to European strategic autonomy?**
3. **How can quantitative and qualitative methods, stakeholder perspectives and model-based analyses be integrated to identify and manage trade-offs among climate mitigation, resource efficiency, circularity, social impacts, resilience and competitiveness?**

While RP3 represents its main area of contribution, SP3 also supports other JP e3s research priorities. It contributes to RP1 – Socio-technical pathways for accelerating the Clean Energy Transition by recognising energy technologies and energy systems as embedded in wider socio-technical configurations and by assessing how their sustainability depends on the interaction between technological choices, societal conditions and stakeholder perspectives. It has a particularly strong methodological connection with RP6 – Integrated evidence, modelling and decision support for transition policy, through the development and integration of Life Cycle Sustainability Assessment (LCSA), Life Cycle Assessment (LCA), Material Flow Analysis (MFA), Multi-Criteria Decision Analysis (MCDA) and energy-system modelling. SP3 also contributes to RP2 – Just, inclusive and citizen-centred energy transitions by incorporating social sustainability indicators and stakeholder perspectives into sustainability assessment and by making social and distributional trade-offs more visible in technology and pathway evaluation.

Background and challenges

The objectives above build on the understanding that energy technologies and energy systems are embedded in society and emerge through co-evolutionary processes in which social stakeholders can play an important role. Energy systems should therefore be understood as socio-technical systems.

From this socio-technical perspective, sustainability assessment of technologies, energy futures and transition pathways is needed to provide orientation knowledge for decision-makers, particularly in support of EU policy objectives. A strong focus on technical performance or techno-economic optimisation can overlook key EU concerns and produce assessments that are insufficiently robust for policy and strategic decision-making.

Taking into account the above-mentioned limitations, there is a need to:

- Identify sound methods to handle conflicting findings (e.g. trade-offs between climate mitigation, resource efficiency, circularity, social impacts, and competitiveness).
- Link the claims of sustainability assessment with established energy and material system modelling approaches.

Sustainability assessment has a comprehensive ambition; however, many analyses of energy technologies or systems are based on empirical algebraic models. By design, these models often focus on a limited number of important aspects, typically technological or based on simplified economic assumptions. Many societal, political, circular or broader economic aspects are treated exogenously or neglected. There is therefore a need to broaden the scope of models to include, in a policy-relevant, systematic and systemic way, dimensions that are important from a sustainability perspective.

Experience shows that sustainability assessment seldom leads to straightforward findings: improvements in some indicators may coincide with deterioration in others. For example, gains in climate-related performance may be accompanied by increased material demand or social impacts in supply chains, a trade-off explicitly recognised in EU policy debates. Circular strategies can add further complexity. MCDA offers ways to structure these trade-offs, but conventional approaches often rely mainly on quantitative indicators, whereas comprehensive sustainability assessment also requires qualitative information. Key methodological challenges therefore include selecting appropriate criteria and indicators, combining quantitative and qualitative evidence consistently, and defining context-specific sustainability targets aligned with EU policy goals. The Sustainable Development Goals (SDGs), complemented by EU policy frameworks, can provide a starting point, but need to be contextualised to the technology or system under review. Approaches such as Cross-Impact Balance (CIB) may help integrate different types of information, although experience in coupling them with energy-system models or LCA remains limited. Important issues include system boundaries, differences in model logic, and the consistent integration of systemic quantitative and qualitative approaches, including circular-economy dynamics.

With respect to MCDA, the main challenge is to find a stakeholder-based but robust approach which allows for reliable sustainability assessment.

The inclusion of resilience further increases complexity. This is not only because there is no common understanding of what resilience means in practice, but also due to the implicit complexity of each of the available resilience definitions.

Topics

Building on these methodological challenges, SP3 will work on the following topics:

- Single-score and structured aggregation approaches to address trade-offs between environmental, economic, social, and circular economy indicators, consistent with EU policy assessment practices.
- Coupling model-based analyses with sustainability assessment, including LCA, MFA, and energy system modelling.
- Methodological integration of circular economy strategies (e.g. durability, repairability, reuse, recycling, material substitution) into sustainability assessment of energy technologies and systems, in line with EU regulatory developments.
- Stakeholder-based MCDA frameworks capable of combining quantitative and qualitative indicators related to sustainability, circularity, and resilience.

Through these topics, SP3 strengthens the research capacity and methodological competence needed for integrated sustainability assessments of energy technologies, energy futures and transition pathways, in support of EU policy objectives.

Contribution to JP e3s mission, Cross-Cutting Strategic Objectives and relations with other EERA JPs and networks (ETIPs, IWGs, CoEs, etc.)

SP3 contributes to the mission of JP e3s by strengthening the research capacity and methodological competence required for comprehensive and integrated sustainability assessments of energy technologies, energy futures and transition pathways. By extending assessment beyond technical performance and conventional techno-economic optimisation, SP3 integrates environmental, economic, social, circularity and resilience dimensions and provides orientation knowledge to support policy and strategic decision-making.

These contributions require close interaction with the other JP e3s Sub-Programmes. **SP1** provides knowledge on the social, cultural and economic factors shaping energy consumption patterns, which influence both future energy demand and the sustainability of alternative transition pathways. Cooperation with **SP2** is important for integrating governance, energy justice and social impacts into the assessment of future pathways, while sustainability targets developed within SP3 can in turn provide orientation regarding the direction of desirable changes. A particularly strong methodological synergy exists with **SP5**, as many of the challenges addressed by SP3 require connecting sustainability assessment frameworks with energy-system models and transition scenarios.

Beyond JP e3s, cooperation is relevant across the EERA Joint Programmes, although its nature differs between technology-oriented and system-oriented activities. In support of EU Circular Economy objectives, cooperation with technology-oriented JPs such as **Photovoltaics, Wind Energy, Concentrated Solar Power, Geothermal Energy, Bioenergy, Energy Storage and Smart Grids** can enable consistent life-cycle-based assessment of material efficiency, durability, reparability, recyclability and critical raw material dependency. Cooperation with system-oriented JPs such as **Energy Systems Integration, Hydrogen and Smart Cities** can support the assessment of circular economy strategies at system level, including infrastructure lifetime extension, secondary material flows and system resilience.

With respect to the **JP e3s Cross-Cutting Strategic Objectives**, SP3 contributes strongly to **knowledge integration** by combining environmental, economic, social, circularity and resilience dimensions within comprehensive sustainability assessment frameworks. It **supports coordination and capacity building** through the development and application of shared methodologies across JP e3s and in collaboration with technology- and system-oriented EERA Joint Programmes. It also **enables knowledge-to-impact** by providing integrated assessment tools and orientation knowledge to support technology choices, transition pathways, and EU sustainability and circularity policies.

SP4 – Market and business models for Energy Transition

Scope, Objectives and contribution to Research Priorities

The scope of SP4 is to understand and support the dynamics of secure and resilient energy and capacity markets within the Clean Energy Transition, adopting a system-level and multi-scalar perspective, examining markets and business models in interaction with technological development, governance frameworks, societal dynamics and value chains. This perspective recognises that energy markets must proactively anticipate and respond to operational, technological, geopolitical and societal challenges, while ensuring fairness, accessibility, and long-term system resilience.

The specific objectives of SP4 are:

- Developing a system-level and multi-scalar analytical framework to assess the dynamics of EU energy capacity and storage markets, examining the interactions between markets, market design, business models, technological development, digitalisation, governance frameworks and societal behaviour.
- Advancing methodologies to assess how energy market mechanisms affect fairness, accessibility, vulnerability and social value creation.
- Analysing the performance and systemic value of innovative, citizen-centred and cross-sectoral business models across electricity, hydrogen, heating, storage and flexibility markets.
- Assessing how market design and integrated business models can enhance resilience to operational disruptions, geopolitical pressures and extreme events, while supporting EU strategic autonomy and long-term climate neutrality.
- Creating cross-connections with clean energy technologies, including solar PV, wind power and storage technologies, while considering the market impacts of grid-integration challenges.
- Providing user perspectives to improve cross-cutting digitalisation solutions for market integration, supporting innovation and solutions for fairness and system efficiency.

In line with these objectives, SP4 contributes primarily to **JP e3s Research Priority 5 – Markets, governance and policy frameworks for a secure, affordable and competitive transition**, by investigating how market design, business models, regulatory frameworks and policy interventions can enable investment, technological deployment and system integration while safeguarding security, affordability, competitiveness and social equity. In particular, SP4 addresses the following research questions:

1. **How can energy market design, regulatory frameworks and policy interventions support an efficient, affordable and competitive Clean Energy Transition while ensuring fairness, accessibility and adequate investment?**
2. **Which business models and market arrangements can effectively enable cross-sectoral integration across electricity, hydrogen, heating, storage and flexibility markets while supporting technological deployment and citizen participation?**
3. **How can energy markets and governance arrangements enhance resilience and energy security in the face of operational disruptions, geopolitical pressures and extreme events, while strengthening European strategic autonomy?**

While RP5 represents its main area of contribution, SP4 has strong connections with several other JP e3s research priorities. It contributes to **RP1 – Socio-technical pathways for accelerating the Clean Energy Transition** by analysing market evolution as part of the interaction between technological deployment, governance arrangements, institutions and societal behaviour. In particular, its multi-level perspective allows SP4 to analyse how interventions at one level of the energy system can produce effects on participation, investment and distributed energy resources at other levels (Köhler et al., 2019).

Background and challenges

The European energy system is undergoing a structural transformation driven by decarbonisation imperatives, digitalisation, geopolitical instability and climate-related risks. Energy markets are increasingly functioning not only as price-setting mechanisms but also as central instruments for delivering climate neutrality, resilience and social cohesion. Recent analyses highlight the need for market design that addresses systemic risks, distributional impacts, and structural vulnerabilities within the clean transition (Jasiunas et al., 2021).

The twin green and digital transition is reshaping energy market architectures. Trends such as electrification, sector coupling and distributed generation require new forms of integration across the electricity, hydrogen, heat and flexibility markets. Meanwhile, geopolitical tensions and supply chain dependencies underscore the urgency of strengthening resilience and strategic autonomy in EU markets (European Commission, 2025).

Understanding these dynamics requires a system-level perspective that captures interactions between market design, business models, technological deployment, governance frameworks and societal behaviour. Cost and benefit sharing must be further elaborated to ensure a fair, user-centred transition to harmonised energy markets across vectors and user groups.

Sustainability transitions research emphasises the importance of multi-level analysis to understand cross-scale interdependencies and feedback effects in socio-technical systems. Market interventions at one scale (e.g., wholesale electricity reform) can have significant unintended effects on consumer participation, investment decisions and distributed energy resources at other levels (Köhler et al., 2019).

A further challenge arises from the need to integrate social and territorial dimensions into market assessment. Distributional impacts, energy poverty and vulnerability are core aspects of equitable energy transitions, yet they are often marginalised in market evaluation (Middlemiss et al., 2019). Scholarship on energy justice highlights how market mechanisms shape outcomes for different social groups and territorial contexts (Jekins et al., 2016).

Incorporating social and territorial externalities into analytical frameworks requires methodological tools that extend beyond traditional economic metrics. Social Life Cycle Assessment (S-LCA) offers an approach to evaluate social impacts along value chains — including labour conditions, community well-being and territorial effects (UNEP, 2021). Recent technical reports advocate integrating life-cycle methods into policy and decision-making to support sustainable transitions.

Another challenge concerns assessing citizen-centred and integrated business models. Energy communities, prosumer platforms and hybrid service providers may enhance participation and flexibility, but their impact on system integration and resilience requires systematic evaluation (Mihailova, 2023). Literature on social innovation emphasises that business model transformation and market evolution are interdependent processes (Mihailova, 2023).

Resilience — including the ability of markets to withstand and recover from extreme events — has become a key dimension of energy transitions. Resilience research underscores that this property is not only technical but also institutional and market-design oriented, requiring mechanisms capable of adapting to stress conditions and supporting risk diversification (Jasiunas et al., 2021).

Against this backdrop, SP4 adopts an integrated analytical approach that combines system mapping, cross-sectoral performance assessment, distributional analysis, and resilience-oriented evaluation. This includes:

- Mapping interactions between market rules, technologies, digital infrastructures and governance arrangements;
- Assessing cross-sectoral integration across electricity, hydrogen, heating, storage and flexibility markets;
- Evaluating distributional impacts and social value creation using structured methodologies such as Social LCA and vulnerability analysis;
- Analysing resilience under stress scenarios, including supply disruptions and extreme events.

By embedding these analytical dimensions within a coherent multi-scalar framework, SP4 addresses the structural complexity of EU energy market transformation and contributes to strengthening the alignment between market design, societal expectations and long-term climate neutrality objectives.

SP4 and the UN Sustainable Development Goals

SP4 contributes to UN Sustainability Goal 7: "Ensure access to affordable, reliable, sustainable and modern energy for all" by promoting the inclusion of low-emission energy and storage resources in the energy mix. Special attention has been devoted to developing low-emission solutions not only in countries with high rates of electricity access but also in Africa, where electricity coverage is significantly lower, to enhance quality of life and well-being.

The combination of SG17: "Climate action" and SG7 is important, as it integrates low- and zero-emission technologies into energy markets alongside the decline in subsidies for fossil fuel solutions. SP4 supports the development of markets that combine low-emission technologies for both energy and storage. We also contribute to the development of science-based information on the climate impacts on energy systems and on energy system development in Europe.

Finally, SP4 addresses energy market issues related to SG15: "Life on land," focusing on land and water use and their impact on the Social Readiness (SR) levels of energy technologies. As an example, the collaboration with EERA JP Hydropower on freshwater biodiversity and environmental design considers the impact of market integration of hydropower.

Topics

SP4 will work to close the following knowledge gaps and support policy development within the themes of power and energy markets.

Market impacts and policy efficiency of market interventions

Various support measures are used on the demand and generation sides of the energy and power markets. It is important to understand the consequences of support measures on the markets and, not least, the impact on the long-term development of the energy sector. This topic will target the efficiency of different measures and how both the market and wealth distribution are impacted. Under this topic, collaboration at the policy level is important for discussing and proposing solutions that implement policies without damaging the price mechanism that optimises overall sector operations and transition efficiency. This topic also considers how SP4 can elevate societal engagement and fairness in the power market setting, and can provide reliable information about the power markets and their role.

Investment adequacy in energy markets

With the Draghi report addressing stalled productivity and stagnant European growth, and the Letta report introducing the fifth freedom for research and innovation, it is a natural consequence that EERA JP e3s unites its capacity to secure competitiveness and transition strength, targeting investment and resource efficiency in the energy markets. Energy is an important component of production and service costs for European industry sectors, and lowering this cost requires adequate investment levels in the energy sector. This section will address how to achieve investment adequacy and the role of research in driving low-cost solutions in renewable energy and storage.

Interaction between energy markets and energy infrastructures

Energy and energy infrastructures go hand in hand, providing the infrastructure from source to sink. The energy markets are deregulated, while infrastructures are typically monopolistic in nature. At present, limited transmission and grid capacity is hampering the green transition. New green industries have not been developed, and the inclusion of green solutions for energy generation is therefore also slowed down due to an unnecessarily large cannibalisation effect. This topic will address this challenge by analysing and supporting the measures in the Grid Package (2025) and providing concrete policy advice.

Energy security aspects of market design and implementation

Following Russia's invasion of Ukraine, REPowerEU accelerated the deployment of renewable technologies and reinforced the objective of reducing Europe's external energy dependencies. Rapid system change also highlights the need to address energy security over different time horizons. Recent power-system disruptions have underlined short-term operational challenges, while long-term security depends on adequate volumes of affordable energy, storage and flexibility. SP4 will therefore examine how market regulation and energy policy can support both dimensions, including the role of market-design rules and the allocation of reserves at local and system-wide levels.

Transition from power markets to energy markets

The power market has served Europe well, as also confirmed in the process leading up to the Power Market Reform (2024/1747). There is still a distance to cover to create a level playing field for different energy vectors, including also externalities, not only GHG emissions, but also land use, water use, environmental impact, etc. This topic will explore the possibility of extending and harmonising market rules across vectors in alignment with the European energy policy. This topic will concentrate on the connection between the technological and social aspects of a more coherent energy market and what it would require in terms of regulation and policy to create a system for optimising energy carriers and technologies. SP4 suggests addressing two challenges in this topic:

1. How to create cross-sectoral business models for an integrated energy market and not only for separate distinct markets for, e.g., hydrogen and power? How can the company and the societal value of multi-vector energy markets be estimated?
2. How can the involvement of citizens and communities as decision-makers, partners in energy projects and even project initiators trigger investment and action for the further development of energy and power markets?

Contribution to JP e3s mission, Cross-Cutting Strategic Objectives and relations with other EERA JPs and networks (ETIPs, IWGs, CoEs, etc.)

Power and energy markets play a central role in Europe's Clean Energy Transition by supporting the optimisation of the technology mix, efficient resource allocation, investment and energy-system integration. SP4 contributes to the mission of JP e3s by bringing together expertise on energy markets, business models and regulatory frameworks and by providing science-based insights for the design of effective and implementable policies. Adopting a system-level and multi-scalar perspective, SP4 examines market arrangements in interaction with technological development, digitalisation, governance frameworks, societal behaviour and energy value chains. This perspective is particularly important as energy markets increasingly need to address not only efficiency but also systemic risks, distributional impacts, structural vulnerabilities and resilience (Jasiunas et al., 2021; European Commission, 2025).

These contributions create strong synergies across JP e3s. Cooperation with **SP1** is particularly relevant for understanding how market signals, tariff structures, flexibility mechanisms and digital solutions interact with consumer and organisational behaviour. **SP2** provides complementary expertise on energy justice, participation, vulnerability and the fairness of market arrangements and business models. Cooperation with **SP3** can help integrate environmental, social, resource and resilience considerations into the evaluation of markets and energy value chains. A particularly strong link exists with **SP5**, where SP4 can provide detailed representations of market mechanisms, regulatory frameworks and business models for incorporation into integrated transition modelling and policy scenarios.

Beyond JP e3s, SP4 will ensure structured and continuous engagement with other EERA Joint Programmes, actively involving both market and technology experts and thereby strengthening the knowledge base and enabling a comprehensive value-chain perspective on market design and policy. SP4 will also foster dialogue with European institutions, in particular relevant Directorates-General of the European Commission, and strengthen collaboration with **European Technology and Innovation Platforms (ETIPs), Implementation Working Groups (IWGs) and Centres of Excellence (CoEs).** These interactions can facilitate exchange between industry, academia and policy experts and support the translation and dissemination of research results into robust and actionable policy recommendations.

In terms of the **JP e3s Cross-Cutting Strategic Objectives**, SP4 supports **knowledge integration** by analysing markets and business models in connection with technological development, digitalisation, governance, societal dynamics and value chains. It **contributes to coordination and capacity building** through cross-sectoral and cross-JP collaboration on market integration and related systemic challenges. SP4 also **strengthens knowledge-to-impact** by generating science-based evidence for market design, investment, regulation and policy approaches that combine efficiency with affordability, fairness and resilience.

SP5 – Scenarios and modelling of Energy Transition Pathways

Scope, Objectives and contribution to Research Priorities

SP5 focuses on the **policy, social and environmental dimensions of the Clean Energy Transition and energy-system development**.

Its main objective is to strengthen the European competence base and research capacity in socio-techno-economic modelling, policy analysis and tools for assessing progress towards the Clean Energy Transition. This is closely aligned with EERA's mission of "catalysing Europe's low-carbon energy research to shape science-based policies and advance world-class innovation". SP5 contributes by developing state-of-the-art tools and methods that integrate policy, social and environmental dimensions with technical energy-system development and transition pathway analysis. Its specific objectives include:

- Build competence and models to analyse different energy-market regulations, including tools to assess market operation and competition levels through actor-based models.
- Build models and methods suitable for the ex-ante assessment of energy-related policy measures and the ex-post impact evaluation of current policies. Assess which policies effectively advance the energy transition and identify policy changes that can benefit the transition and the development of the energy system and energy market.
- Ensure that environmental, social and policy dimensions are consistently represented in models used for integrated European energy-system analysis, and include policy and social impacts in the modelling of transition pathways.
- Analyse the impact of uncertainty and risk, including natural events such as weather extremes as well as disruptions due to sabotage and cyber threats, and assess how robust transition pathways can be designed.
- Advance methods for scenario building and planning, including qualitative components of scenario modelling and the processes used to construct scenarios.
- Acknowledge the complementarity and potential trade-offs of policy measures targeting different goals, e.g., energy transition, climate transition, energy security, biodiversity, circularity, competitiveness, strategic autonomy, etc.

SP5 contributes primarily to **JP e3s Research Priority 6 – Integrated evidence, modelling and decision support for transition policy**, by developing interdisciplinary models, scenarios and analytical tools for assessing transition pathways, evaluating policy impacts and trade-offs, and supporting robust and transparent decision-making. In particular, SP5 addresses the following research questions:

1. **How can interdisciplinary models and scenarios integrate technological, economic, social, environmental, institutional and policy dimensions to represent feasible and robust Clean Energy Transition pathways?**
2. **How can modelling, ex-ante policy assessment and ex-post impact evaluation improve understanding of the effectiveness, distributional consequences and trade-offs of alternative energy and climate policies?**
3. **How can uncertainty, risk and competing policy objectives be incorporated into transition pathway modelling to support robust and transparent decision-making across EU, national and regional governance levels?**

While RP6 represents its main area of contribution, SP5 has particularly strong connections with other JP e3s research priorities. It provides a major contribution to **RP1 – Socio-technical pathways for accelerating the Clean Energy Transition** by developing models and scenarios that integrate technical system change with societal, institutional, economic and regulatory transformations. In particular, SP5 seeks to develop realistic socio-technical storylines that connect quantitative transition scenarios with their implications for society.

SP5 contributes to **RP5 – Markets, governance and policy frameworks for a secure, affordable and competitive transition** through the modelling and assessment of energy-market regulation, policy interventions and alternative market arrangements. Its analysis of environmental impacts, uncertainty, risk, resilience, circularity, competitiveness and strategic autonomy supports **RP3 – Sustainable, circular and resilient energy transition pathways**. SP5 also contributes to **RP2 – Just, inclusive and citizen-centred energy transitions** by incorporating into pathway analysis the distribution of costs and benefits across population groups and implications for energy poverty, employment and income inequality. Finally, evidence on demand-side behaviour, efficiency and flexibility generated particularly within SP1 can strengthen the representation of **RP4 – Energy demand, practices and flexibility in a changing energy system** within transition models and scenarios.

Background and challenges

The objectives above respond to the need for new methods capable of analysing and modelling transition pathways that encompass both technical system changes and social and institutional transformations.

Against this background, SP5 focuses on the following challenges:

- **Pathways should consider** physical constraints on deployment as well as the economic, environmental, societal, political and regulatory features of a country or region.
- **Modelling also has a narrative role: it can help communicate the value and implications of the transition while supporting accountability by assessing whether energy markets deliver both efficient resource allocation and fair welfare distribution. Analyses must therefore consider the requirements of a just transition, including how costs and benefits are distributed across population groups and the implications for energy poverty, employment and income inequality.**
- **Realistic and attractive socio-technical storylines** that reflect quantitative scenarios and their implications for society.
- **Macroeconomic analysis** at the European level, while also accounting for global linkages and the role of neighbouring countries, is a key focus of JP e3s SP5. The aim is not only to examine how different regulations affect the energy and power sectors, but also to quantify the benefits of alternative solutions and evaluate the effectiveness of evolving market rules. Such analysis helps estimate the consequences of energy policy, building confidence in well-designed measures or highlighting ways to make them more effective in driving and adapting to the clean energy transition.

Topics

Building on these challenges, SP5 will focus on the following main topics:

- Regulation of the energy market.
- Policy ex-ante assessment and ex-post impact evaluation.
- Robust energy transition pathways.
- Socio-technical energy system modelling.
- Environmental impact evaluation of energy transition pathways.
- Decision-support systems and scenario planning.

Contribution to JP e3s mission, Cross-Cutting Strategic Objectives and relations with other EERA JPs and networks (ETIPs, IWGs, CoEs, etc.)

SP5 contributes to the mission of JP e3s by strengthening European research capacity and competence in interdisciplinary socio-economic modelling, scenario development, policy assessment and decision-support tools for the Clean Energy Transition. Its distinctive contribution is to integrate technological and energy-system developments with social, economic, environmental, institutional and policy dimensions, enabling the assessment of alternative transition pathways and supporting science-based decision-making across governance levels. By combining quantitative modelling with socio-technical perspectives and qualitative scenario approaches, SP5 helps bridge the gap between energy-system analysis and the broader systemic transformation addressed by JP e3s.

These contributions make SP5 inherently cross-cutting within JP e3s. **SP1** can provide empirical evidence on behavioural change, demand reduction, technology adoption and flexibility that improves the representation of demand-side dynamics in models. **SP2** contributes knowledge on public acceptance, institutional contexts, participation, energy justice and distributional impacts, all of which are relevant for assessing the effectiveness and legitimacy of transition policies. Close cooperation with **SP3** can strengthen the integration of sustainability and environmental dimensions into pathway assessment, while **SP4** provides detailed knowledge on energy-market regulation, technological implementation and emerging market solutions that can improve the realism of socio-economic and energy-market modelling.

Beyond JP e3s, SP5 can complement and support techno-economic model development within **EERA JP Energy Systems Integration (ESI)** and make use of results from ESI activities addressing the technical aspects of energy-system integration across multiple energy carriers and technologies. SP5 can also strengthen collaboration with technology-focused ETIPs and broader platforms such as **ETIP-SNET**, providing system-level scenarios and analytical frameworks for the uptake of cost-effective and secure energy technologies.

The **Energy and Climate Modelling Forum (ECMF)** represents an important platform for cooperation with the wider European energy and climate modelling community, including several JP e3s members. In addition, the alignment in scope between SP5 and the **EERA Centre of Excellence on Energy Transition Modelling**, linked to JP ESI, provides opportunities for collaboration connecting research-oriented methodological development with the application of modelling tools to policy and decision-support challenges.

With regard to the JP e3s Cross-Cutting Strategic Objectives, SP5 makes a particularly strong contribution to **knowledge integration** by incorporating technological, economic, social, environmental, institutional and policy dimensions into models, scenarios and transition pathway assessments. It **supports coordination and capacity building** by strengthening interdisciplinary modelling competences at European level and by connecting expertise across JP e3s and other EERA Joint Programmes. Through scenarios, ex-ante and ex-post policy assessment, and decision-support tools, SP5 also **contributes to knowledge-to-impact**, providing a stronger evidence base for transparent and science-based policymaking.

European Energy Research Alliance
clean Energy tranSition for Sustainable Society

Sub-Programme on Social Science and Humanities in DfE

The description provided below is a summary. The full text is available here in the SRIA of JP DfE.

Background

The roadmap to the energy transition requires a thorough transformation of the energy ecosystem. One of the main pillars of this transformation is the empowerment of individuals so that they shift their roles from being solely consumers to active players in all fields of the energy ecosystem. This includes the citizens becoming energy producers, members of energy communities, or utilising data about their energy consumption profiles to manage their energy demand.

Another critical pillar of this transformation of the energy ecosystem for the transition is the change from a fossil-fuel-based energy ecosystem to a renewable-based energy ecosystem. As the backbone of the energy transition, this change requires integrating and synchronising a broad spectrum of technological, economic, social, cultural, political, and environmental components.

Along these two main pillars, digitalisation of the energy ecosystem arises as a cross-cutting issue.

Many of these new roles for individuals in the energy ecosystem rely on digital tools and more active management of energy use. Examples include smart meters for two-way information exchange and demand management, and smart grids that integrate community energy plants into the wider system. As operations and communication become increasingly digital, citizens' roles in the energy ecosystem are also becoming more closely connected with digitalisation.

Concerning the transformation of the energy ecosystem to become renewables-based, most of the technologies will be based on digital tools. For instance, the management and monitoring of renewable energy plants, risk surveillance, emergency handling, matching of the load, production and demand profiles, and even billing operations are mainly conducted via digital tools.

From a related perspective, technological advances also bring new digital players to the energy ecosystem. These are mainly machines, commonly in the form of AI-based automated decision and control systems that support humans in managing the energy ecosystem.

Although the digitalisation of the energy ecosystem primarily relates to the technology aspect, the most efficient contribution of digitalisation to the energy transition depends on adequately managing this digitalisation. This, in turn, requires the consideration of the multiple facets of digitalisation, including the social, environmental, economic, cultural, and policy-relevant impacts. As well as providing economic benefits, better decisions, and faster and more efficient operations, these impacts are also related to challenges for the stakeholders. For instance, with the rollout of smart meters, households need to adapt and/or develop their skill sets to analyse the data from the smart meters and change their energy-related decisions, possibly even their lifestyles accordingly. On the other hand, the system operators need to be able to cooperate with the machine agents of the energy ecosystem. Individuals that participate in a community energy cooperative need to keep track of their facilities' financial and operational progress. Policymakers need to formulate policies to ensure that the integration of renewables into the energy ecosystem can be realised without issues such as public resistance against technological investments.

Accordingly, steering the digitalisation of the energy ecosystem while fostering technological developments and innovations on the one hand, and balancing the impacts of digitalisation on the other hand, requires the explicit consideration of many aspects in the domain of SSH (Social Sciences and Humanities).

To this end, the Subprogramme on Social Science and Humanities in Digitalization for Energy aims to contribute to the energy transition by addressing the SSH-relevant aspects of digitalisation in the energy ecosystem. In doing so, the Subprogramme on Social Science and Humanities in Digitalization for Energy will conduct research to frame the pathways to manage these aspects and provide policy suggestions.

Objectives

1. Identifying the impacts of digitalisation on the energy ecosystem

Identifying the impacts brought about by the rapid changes in the energy ecosystem, characterised mainly by replacing existing mechanisms with digital counterparts and emerging new digital processes, is a prerequisite to addressing these impacts.
The Subprogramme on Social Science and Humanities in Digitalization for Energy will follow an approach based on the critical dimensions of SSH relevant to the digitalisation of the energy ecosystem.

2. Social acceptability of technological developments and digitalisation of the energy ecosystem

As with any endeavour pertaining to society, the digitalisation of the energy ecosystem cannot be successful without ensuring its social acceptability. However, social acceptability is sophisticated, varies with geography (locality), and depends on a broad spectrum of factors, including the sociodemographic factors, energy profile of the society, and level of trust within the society.
The Subprogramme on Social Science and Humanities in Digitalization for Energy aims to utilise the SSH approach to analyse the dynamics of social acceptance of digitalisation of the energy ecosystem.

3. A human-centric approach to the digitalisation of the energy sector

The SSH approach to digitalising the energy ecosystem is based on the human-centric viewpoint. This viewpoint is also inherent in the energy transition that relies on empowering individuals in the energy ecosystem.
Accordingly, the Subprogramme on Social Science and Humanities in Digitalization for Energy will develop a framework that prioritises a human-centric approach to the digitalisation of the energy sector.

4. FAIR data and digitalisation

Digitalisation of the energy ecosystem calls for integrating an increasing number and variety of machine-based agents into the energy systems' decision-making, management, and operation. Clearly, these new participants of the energy system require structured and well-defined data for fulfilling their part of the related processes. For this purpose, the energy data needs to be designed, created, captured, processed and shared based on the FAIR (Findable, Accessible, Interoperable, and Reusable) data principles.
The Subprogramme on Social Science and Humanities in Digitalization for Energy aims to identify a roadmap for implementing FAIR data principles in energy digitalisation.

5. Digital Tools for behavioural change

As with any change, the energy transition also calls for behavioural change, both for stimulating and adapting to the change.

The Subprogramme on Social Science and Humanities in Digitalization for Energy aims to analyse the role of one of the core topics of SSH, behavioural change, and its relation to the digitalisation of the energy ecosystem. This objective's primary focus will be identifying how digitalisation can support behavioural change for the energy transition.

The Subprogramme draws on a broad range of conceptual and methodological approaches, including qualitative and quantitative analysis, mixed methods, discourse analysis, coding, bibliometric analysis, desk research, literature reviews, surveys, semi-structured interviews, focus groups, case studies and workshops.

Thematic Groups

Thematic Group on Education and Skills

Description & Scope

The Thematic Group (TG) on Education and Skills under EERA JP e3s has been initiated to fill a strategic gap in JP's working topics. The group aims to foster research on:

- Aligning workforce competencies with energy transition needs.
- Broadening education and training focus beyond technical fields, to also include societal and behavioural dimensions.
- Engaging a diverse range of societal actors, including those representing the government, industry, education and training, labour and civil society, at local, national and regional levels.

Background and challenges

According to the International Renewable Energy Agency (IRENA), a Paris Climate Agreement-compliant pathway has the potential to create around 30 million jobs within the renewable energy sector by 2030, as well as 77 million jobs in other transition-related sectors, e.g., energy efficiency, power grids & energy flexibility, and hydrogen[2]. The IEA's World Energy Employment 2025 report[3] points out that demand for workers is increasing across all part of the energy system, across all scenarios. Skilled worker shortages and an aging energy workforce are reported issues collected as part of an IEA survey sent out to more than 700 energy firms, trade unions and educators worldwide. Aging is also identified as a relevant factor for Europe, and a recent study on labour market scenarios for Germany concluded that its aging population will lead to a decrease of employment, unless employment rates increase and/or migration increases (Löffler, Konstantin; presentation under the NTNU Energy Transition Week 2026 on "How does a lack of skilled workforce impact the German and European Energy Transition?")[4].

Besides the expected increased global demand for workforce, ongoing technological advancements in domains such as digitalisation or artificial intelligence, will require "upskilling" and "reskilling" of workers in existing energy industries.

Given the current context, the Thematic Group on Education and Skills acknowledges the following challenges for education and skills for the energy transition:

- **Access to skilled workforce** will potentially impact the roll-out and speed of the energy transition and play a role in the achievement of energy and climate goals.
- **Increased digitalisation and AI will require reskilling** of the existing working force. At the same time, these technologies may help creating opportunities for bridging this gap by enhancing productivity, enabling predictive maintenance, and creating personalized training.
- **Fragmentation of competences:** existing training initiatives are not sufficiently connected, and there is limited interdisciplinarity (e.g., technical versus non-technical issues) in education, training programmes and academic degrees.
- **Professional training courses** are usually very topic oriented and focusing almost exclusively on technical aspects.
- **Weak connection with industry and governments:** current collaboration between academia, research, industry and the public sector is insufficient to anticipate and meet skills demand.

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[2] https://www.irena.org/Education/Call-to-Action-on-Skilling

[3] https://www.iea.org/reports/world-energy-employment-2025/executive-summary

[4] https://www.ntnu.edu/energytransition/joint-eera-and-ecmf-workshop

- **Skills gap not fully recognised:** relevant strategic planning tools to deliver a fair, resilient, and climate-neutral Europe, such as the National Energy and Climate Plans, do not explicitly mention social aspects and overlook the mismatch between workforce skills and labour market needs. There is a need to develop appropriate methodologies to identify and quantify these gaps.
- **Gender issues:** there is a persistent underrepresentation of women in technical energy and STEM (Science, Technology, Engineering and Mathematics) fields ('leaky pipeline'), as well as within vocational studies, which show even stronger imbalances. Gender will be addressed by the TG on Gender Perspective, but it is also of high relevance for this TG.
- **Sustainability/climate reporting requirements are increasingly important for companies,** requiring knowledge on methods such as GHG accounting, Life Cycle Assessment (ISO 14040 and 14044 Standards) other Environmental Assessment tools - these should be more systematically included in higher education curricula related to the energy transition.

Topics

TG Education and Skills aims at addressing the following topics:

- **Understanding how access to skilled workforce** may impact the roll-out and speed of the energy transition in Europe, and ultimately the achievement of energy and climate goals in the region;
- Better understand **how increased digitalisation and AI tools** will create a need for upskilling in the existing working force in Europe, as well as the potential these technologies can play in achievement of European energy transition goals.
- Understanding how higher education institutions in Europe can achieve a **better integration of technical and non-technical fields (such as SSH),** as part of study programmes, academic degrees, etc. This could be e.g., increased cross-department collaborations, cross department supervision of MSc and PhD thesis, etc. A recent example of a step in the direction of increased cross department collaboration is the NTNU Unified Campus 2015-2030 project[5], which will co-locate academic communities in a unified campus in Trondheim, *"lowering the threshold for working across disciplines and different academic groups"*.
- Likewise, increase awareness on **the importance of including training on sustainability, circularity**, as part of engineering and other technical degrees.
- **Raise awareness on the establishment of partnerships** addressing skilling for the energy transition, which include academic/research sectors and training providers, governments, industry, youth organizations, trade unions, civil society and other local and international stakeholders.
- **Collaboration with TG Gender Perspectives on Gender aspects** within education and skills for the energy transition.

[5] https://www.ntnu.edu/campusdevelopment/about-campus-development

Thematic Group on Gender Perspectives in the Energy Transition

Description & Scope

The Thematic Group on Gender Perspectives in the Energy Transition aims to ensure that gender perspectives are better/more meaningfully and systematically integrated into research agendas and energy policies. The thematic group operates transversally across the other EERA JP e3s subgroups. By establishing a dialogue with other subgroups as well as thematic groups, it identifies where and how gender perspectives are relevant.

The group brings together researchers from different disciplines. On a general level, we aim to strengthen an understanding of why it is important to mobilize gender perspectives in the energy transition and how this can be done in practice. Finally, given the group's interdisciplinarity, we desire the group to function as a platform for knowledge exchange. In the spirit of interdisciplinary gender studies, we do not aim to limit the scope of the group but rather welcome new lines of inquiry and approaches under the umbrella of 'gender', including new insights on emerging energy topics with potential gender implications, such as automation and energy flexibility.

Background and challenges

Given the diversity of the group and the breadth of 'gender perspectives,' one of the challenges is how to prioritize relevant issues. On the one hand, there are ways in which gender becomes a relevant axis of difference to consider, often in relation to other axes of difference (for example, race, age, ability, and income-level), in research design, policy development, and the representation of women at different levels and positions in the field of energy.

On the other hand, we aim to understand the ways in which a feminist/feminist technoscience lens can lead to a problematizing of knowledge production (whose knowledge counts? whose knowledge is visible?). A feminist lens also shifts the focus from purely technical (or economic) considerations of the energy transition to a power-aware approach based on the understanding that energy systems and their futures are often designed around masculinist, neo-colonial, and industrial-capitalist structures.

The group also aims to contribute to ongoing strategic thinking about future research agendas with gender-disaggregated data needs, methodological considerations, and emerging gender-relevant issues such as flexibility, automation, and the increasing burden of energy-related behavioural expectations.

Topics

Gender and Energy Access & Consumption:

- Gender-blind policies (both on access and production sides, e.g., wage gaps, sectoral effects) and energy poverty.
- Symbolic dichotomy between "male" (production/technology) and "female" (consumption/care) energy roles, such as structures of energy labour markets, including renewable energy, storage, and digital systems.
- Impact of gender-biased data and AI-driven models and institutional best practices.
- Climate risks and disproportionate impacts on women/vulnerable groups.
- Gendered experiences in emerging topics: demand flexibility, automation, and gendered burdens in households.

Knowledge Production, Data Generation, Methodologies and beyond:

- Need for: Gender-disaggregated data, intersectional indicators, and robust frameworks.
- Identification of vulnerable groups and analysis of the structural inequalities they face
- Feminist technoscience and intersectional methodologies.

- Combining qualitative and quantitative methods.
- Data management and sensitivity issues.
- Transdisciplinary research teams and better integration of gender perspectives from the outset.
- Gender and diversity in energy knowledge communities (communities composed of researchers, academics, practitioners, and other experts who build knowledge on the different aspects of energy systems, ranging from engineering topics to social science perspectives)

Actions

This section identifies possible streams of activities that could be considered over the next years to address the topics identified. These actions are:

- Building a gender-sensitive methodology toolkit for research practitioners coming from different fields and disciplines
- Building a network around particular topics listed above, such as gender and climate, energy poverty, etc.
- Performing a critical analysis of EU /energy and R&I policies through a gender lens
- Strengthening the link between energy and welfare/gender policy and research domains through participatory activities (deliberative arenas...)

Thematic Group on Societal Readiness

Description & Scope

The EU defines Societal Readiness as an indicator of R&I results that reflects the extent to which different societal needs and concerns have been considered, thereby increasing the potential for societal uptake and supporting the transition towards societal adaptation.

In line with this perspective, European Union institutions, particularly through Horizon Europe calls and the SET Plan, place strong emphasis on participation, inclusiveness, and the alignment of scientific research with societal needs. The "Societal Readiness Thinking Tool" developed by AIT provides an important conceptual foundation in this debate (Bernstein et al. 2022).

Building on this background, the SR Thematic Group focuses on advancing the conceptual and methodological understanding of Societal Readiness and exploring ways to make this concept more operational in R&I activities. Thus, it aims to translate this perspective into practical approaches and collaborative activities that strengthen the societal relevance and impact of research. Ultimately, this group seeks to position JP e3s as a reference point for SR, contributing to a fair, inclusive, and effective clean energy transition.

Several target groups make part of this general scope:

- Research & Innovation actors in energy, SSH, and interdisciplinary projects;
- Policymakers and regulators shaping European and national energy frameworks;
- Industry stakeholders (technology providers, utilities, SMEs);
- Citizens, households, and communities as end-users and co-creators;
- Education and training institutions, supporting skills and capacity-building for societal engagement.

The more specific scopes of the SR Thematic Group are:

1. Positioning societal readiness as a strategic pillar
2. Developing a shared framework for societal readiness levels
3. Operationalizing SR concepts across sectors
4. Measuring SR
5. Embedding societal needs and values in research and innovation
6. Enhancing knowledge production and learning infrastructure
7. Gaining policy relevance and long-term ambition

Background and challenges

Societal Readiness (SR) has been proposed to define the skills of research and innovation (R&I) initiatives to account for and respond to societal needs, values, concerns, and expectations throughout the lifecycle of a project, moving beyond purely technological considerations to include ethical, cultural, and inclusive dimensions (Steinbeis Europa Zentrum, 2025).

Unlike Technology Readiness Levels (TRLs) – which are focused on the technical maturity of solutions – the concept of SR stresses the anticipatory thinking about how technologies and innovations interact with real-world contexts and the people affected by them (Bernstein et al. 2022). If we consider the *Societal Readiness Thinking Tool*, for example, it has been proposed to help researchers reflect on potential societal implications and integrate relevant strategies into R&I projects early on (NewHoRRIzon ,2019).

In the European Union, SR has been introduced as a pilot requirement in specific Horizon Europe Cluster 5 calls on climate, energy, and mobility, where proposals are expected to address societal considerations systematically and report publicly on their progress (European Commission Work Programme, 2025).

Topics

The following priority topics will be part of the SR Thematic Group's mission:

- **Contribute to prepare a COST Action** proposal on SR within e3s and, more specifically, within the e3s Sub-Programme 2 – Just Transition and Governance of the Energy Transition.
- **Define and operationalize SRLs (Societal Readiness Levels)** aligned with but distinct from TRLs.
- **Find metrics & measurement tools** with attention to cross-sectoral approaches (e.g. households, industry, policy).
- **Propose a sector-specific application of** SR concepts to selected SET Plan sectors (e.g. PV, storage, buildings)., with attention to the perspective of multiple stakeholders (citizens, companies, public institutions).
- **Favor a knowledge sharing & learning infrastructure** inspired by past ERA-NET Smart Energy Systems experience.

Impacts

The impact of JP e3s is conceived as a progressive and cumulative process unfolding across both science-oriented and policy-oriented dimensions and across a broad range of stakeholder groups. It represents the final stage of the intervention logic underpinning this SRIA: the **strategic challenges** identified in the European energy transition landscape define the areas where change is needed; the **research priorities** identify the corresponding knowledge needs; and the **Sub-Programmes and Thematic Groups** generate the knowledge, tools, evidence and collaborative activities required to address them. The resulting outputs and outcomes are expected, over time, to contribute to the systemic changes required to respond to the initial strategic challenges and advance the objectives of JP e3s.
JP e3s supports the research community by reinforcing coordination and excellence in SSH research. It strengthens EERA by embedding a more systemic and interdisciplinary perspective across Joint Programmes. Moreover, JP e3s provides policymakers at European, national and local levels with robust, evidence-based insights to support policy design and implementation.

In addition, JP e3s contributes to industry by improving the understanding of market and societal dynamics and the conditions for the successful deployment of clean energy solutions, while ultimately empowering citizens by fostering participation, inclusiveness and energy citizenship.

Through this multi-level and multi-actor approach, JP e3s aims to ensure that its impacts extend beyond knowledge production and contribute to tangible progress towards a Clean Energy Transition that is effective, secure, competitive, environmentally sustainable and socially just.

Identifying the target groups

The Clean Energy Transition is shaped by a broad stakeholder ecosystem operating across policy, research, innovation, industry and society. JP e3s aims to interact with and generate relevant impact on these actors, with the objective of strengthening the integration of SSH expertise into European energy research and policy processes and supporting a more just, sustainable and effective transition.
The main stakeholder groups expected to be most directly impacted by JP e3s activities include:

- **EERA ecosystem:** the EERA Secretariat, Joint Programmes, Task Forces, transversal initiatives and EERA members.
- **SET Plan and energy research and innovation networks:** Implementation Working Groups (IWGs) and European Technology and Innovation Platforms (ETIPs).
- **Research networks and scientific communities:** SSH research networks, energy transition research communities, and communities working on modelling, sustainability assessment and societal readiness.
- **Policy and governance actors**, including:
    - EU policymakers, in particular the European Commission, including DG RTD, DG ENER, DG CLIMA and the Joint Research Centre;
    - national authorities;
    - regional and local authorities;
    - public administrations and regulatory bodies.
- **Industry and market actors.**
- **Civil society and citizens:** NGOs, civil society organisations, consumer organisations, energy communities and other relevant societal actors.

Defining the impact chain

The impact of JP e3s on its stakeholder groups is structured across three interconnected levels, as illustrated in the table below.

In the **short term**, the Joint Programme generates tangible outputs in the form of new knowledge, analytical tools, methods, evidence and collaborative networks, strengthening the evidence base on the social, economic, institutional and environmental dimensions of the energy transition.

These outputs provide the foundation for **medium-term outcomes**, including enhanced stakeholder capacities, stronger interdisciplinary integration, improved practices in policy design and implementation, and a better understanding of the societal, market and institutional conditions affecting the Clean Energy Transition.

Over the **longer term**, these effects are expected to contribute to systemic impacts and thereby to addressing the strategic challenges identified in this SRIA. These include accelerating the deployment of clean energy technologies, strengthening energy security and strategic autonomy, supporting competitiveness and circularity, reducing energy demand, improving affordability and consumer protection, strengthening governance capacity, and ensuring that the transition is just, inclusive and societally legitimate.

The impact chain therefore does not imply a linear or one-to-one relationship between individual activities and strategic challenges. Rather, the different Sub-Programmes and Thematic Groups generate complementary outputs and outcomes that interact and jointly contribute to the achievement of JP e3s objectives and to the wider transformation of the European energy system.

Stakeholder	Short-term outputs	Medium-term outcomes	Long-term impacts	SP involved
Research networks and scientific communities	Joint research proposals, publications, shared datasets	Stronger coordination of SSH research, reduced fragmentation Contributions to and definition of EU research agenda in energy-SSH	European leadership in SSH energy transition research	All SPs and TGs
EERA ecosystem	SSH expertise inputs to JPs and policy processes	Enhanced interdisciplinary integration across JPs Consolidating the policy support function of EERA	Stronger positioning of EERA as systemic research actor in EU policy	All SPs and TGs

Policy and governance actors	Policy briefs, analytical tools, evidence-based insights	Improved policy design, implementation and evaluation capacity	More effective, inclusive and resilient energy and climate policies	SP1, SP2 and SP5 and TGs
Industry and Market actors	Insights on user behaviour, acceptance, and market barriers	Better investment strategies and reduced social risks	Competitive, innovation-driven and socially embedded clean energy sector	SP3, SP4, TG on Skills, TG on Societal Readiness
SET Plan and energy research and innovation networks	SSH expertise inputs, analytical tools, evidence-based insights	Enhanced interdisciplinary, Improved policy design, implementation and evaluation capacity	na	All SPs
Civil society and citizens	Participation tools, engagement processes, knowledge	Increased energy literacy and participation	Active energy citizenship and a just, inclusive transition	SP1, SP2, TG on Societal Readiness, TG on Gender Perspectives

Contribution to the Cross-Cutting Strategic Objectives

The impacts generated across the different JP e3s target groups constitute a key mechanism for achieving the three **Cross-Cutting Strategic Objectives**. Scientific and research impacts, together with impacts within the wider EERA community, contribute directly to **integrating knowledge** by strengthening connections among social, economic, institutional, environmental and technological perspectives, promoting common conceptual and methodological approaches and facilitating the circulation of SSH expertise across energy research domains. At the same time, the development of interdisciplinary networks, shared competences, joint research activities and stronger interactions among JP e3s Sub-Programmes, Thematic Groups, other EERA Joint Programmes and external research communities contributes to **coordinating and building capacity**, reducing fragmentation and strengthening the collective ability to address the systemic challenges of the Clean Energy Transition. Policy, industry, market and societal impacts are particularly important for **translating knowledge into impact**, as they enable scientific evidence, analytical tools and interdisciplinary expertise to inform policy design and implementation, innovation and market practices, stakeholder strategies and societal engagement. These dimensions are closely interconnected: stronger knowledge integration enhances the quality of research and evidence; improved coordination increases the capacity to generate and mobilise such knowledge; and engagement with policymakers, industry, civil society and citizens enables its effective uptake and valorisation. In this way, the impacts generated by JP e3s connect knowledge production, research coordination and capacity building with concrete changes in decision-making, innovation processes and societal practices, supporting the implementation of the Clean Energy Transition.

Contribution to the strategic challenges

The expected impacts of JP e3s can be related to the strategic challenges identified at the beginning of the SRIA through four closely interconnected dimensions.

Supporting an effective, secure and sustainable transformation of the energy system - By improving knowledge of socio-technical transition pathways, sustainability, energy demand, market dynamics and policy options, JP e3s contributes to creating the conditions for accelerated renewable energy deployment and fossil fuel phase-out. Integrated sustainability assessment, modelling and evidence on resource dependencies, circularity and resilience also support efforts to strengthen energy security and European strategic autonomy and to embed circularity across energy-system and clean-technology value chains.

Supporting a competitive and affordable Clean Energy Transition. - Research on markets, business models, policy frameworks, demand-side behaviour and technology uptake contributes to understanding how decarbonisation can be combined with European industrial competitiveness and effective investment. At the same time, evidence on market design, tariffs, energy demand and distributional impacts can support affordability and effective consumer protection, while helping policymakers identify and manage possible trade-offs between economic efficiency, competitiveness, social equity and environmental sustainability.

Supporting a just, inclusive and demand-conscious transition - JP e3s contributes to addressing the challenges of reducing energy demand and delivering a just and inclusive transition by generating evidence on efficiency, sufficiency, behavioural and organisational change, energy poverty, affordability, participation and unequal access to technologies. Through research on energy citizenship, engagement and empowerment, it also supports the development of transition pathways in which citizens and communities can participate actively and in which costs, benefits and decision-making opportunities are more fairly distributed.

Strengthening governance, societal readiness and implementation capacity - By providing interdisciplinary evidence, analytical tools and participatory approaches, JP e3s supports more effective multilevel governance and strengthens the capacity of European, national, regional and local actors to design, implement and evaluate transition policies. At the same time, its integration of SSH perspectives, Responsible Research and Innovation and Societal Readiness contributes to reorienting research and innovation towards solutions that are not only technically robust, but also socially legitimate and institutionally implementable.

These four dimensions are mutually reinforcing and reflect the systemic nature of the Clean Energy Transition. In particular, they give operational meaning to **RP1 – Socio-technical pathways for accelerating the Clean Energy Transition**, which provides the overarching perspective through which technological deployment, societal change, institutional transformation, market evolution and changing patterns of energy demand are considered together.

Scientific and research impact

JP e3s contributes to strengthening the European research landscape by structuring and mobilising Social Sciences and Humanities (SSH) expertise across countries, disciplines and institutional contexts. By bringing together complementary research capacities from diverse national energy systems, it enables comparative analysis, fosters mutual learning, and facilitates the identification and transfer of best practices across Europe.

In doing so, JP e3s plays a key role in reducing the fragmentation that has traditionally characterised SSH research in the energy domain, while enhancing coordination and critical mass at the European level. Through its activities, the Joint Programme also increases the visibility and participation of SSH research in European funding frameworks and promotes the systematic integration of social science perspectives into energy research and innovation. This integration is essential to address the complex and systemic nature of the Clean Energy Transition, ensuring that technological developments are aligned with societal needs, behaviours and institutional dynamics.

Impact within EERA

JP e3s plays a strategic role within EERA by complementing the predominantly technology-oriented Joint Programmes with Social Sciences and Humanities expertise, thereby enabling a more systemic understanding of the energy transition.

By integrating societal, economic and governance dimensions into EERA's research activities, the Joint Programme contributes to bridging the gap between technological development and real-world implementation, ensuring that innovation pathways are aligned with societal needs and institutional contexts. Through its cross-cutting nature, JP e3s also fosters stronger collaboration among Joint Programmes, promoting interdisciplinarity and facilitating knowledge exchange across domains.

In addition, JP e3s strengthens EERA's contribution to European policy processes by providing robust, evidence-based insights on the non-technical dimensions of the transition. In doing so, it reinforces EERA's role as a key scientific partner for European institutions, supporting the implementation of strategic frameworks such as the SET Plan and broader mission-oriented research and innovation agendas.

Policy impact

Supporting evidence-based policymaking lies at the core of JP e3s' mission, reflecting the increasing need for robust, interdisciplinary knowledge to design, implement and evaluate complex energy and climate policies. By integrating behavioural, institutional, economic and environmental perspectives, the Joint Programme provides a comprehensive understanding of the drivers and barriers shaping the Clean Energy Transition.

Through this integrated approach, JP e3s contributes to reducing uncertainty in policy decision-making, enabling policymakers to better anticipate societal responses, assess trade-offs and design more coherent policy mixes. It also supports greater consistency and alignment between policy instruments across governance levels, while facilitating the implementation of key European frameworks, including the European Green Deal, the SET Plan and the Just Transition agenda.

In the long term, these contributions support the development of energy and climate policies that are more effective, socially acceptable and equitable, thereby reinforcing the EU's capacity to achieve its climate neutrality objectives in an inclusive and sustainable manner.

Industry and market impact

The transition towards decentralised and user-centred energy systems introduces new challenges for industry, particularly in relation to social acceptance, behavioural dynamics and the emergence of local resistance to energy projects. In this evolving context, technological feasibility alone is no longer sufficient to ensure successful deployment, and a deeper understanding of societal and market conditions becomes essential.

JP e3s contributes to addressing these challenges by providing critical insights into consumer behaviour, community engagement and participatory approaches, helping industry actors to better anticipate and respond to societal expectations.

At the same time, it supports the identification of market barriers and opportunities across different regional and institutional contexts, enabling a more nuanced understanding of the conditions under which energy innovations can be successfully deployed. By integrating these insights, JP e3s also contributes to the development of socially robust and inclusive business models that are better aligned with the realities of decentralised energy systems.

Societal impact and just transition

Recognising that the success of the transition ultimately depends on societal acceptance and active engagement, the Joint Programme adopts a people-centred approach that considers citizens not only as end-users, but also as participants and co-creators of energy systems. In this context, JP e3s promotes innovative forms of citizen engagement, including energy communities, co-creation processes and living labs, which foster dialogue, trust and collective ownership of the transition.

At the same time, it contributes to addressing key societal challenges such as energy poverty and social inequalities, ensuring that vulnerable groups are adequately considered in policy design and implementation.

By advancing knowledge on behavioural change and supporting the development of energy literacy, JP e3s also enables individuals and communities to actively participate in shaping more sustainable energy practices.

In the long term, these efforts contribute to the emergence of active forms of energy citizenship, characterised by increased participation, empowerment and shared responsibility. They also strengthen trust in public institutions and enhance the legitimacy of energy policies, which are essential conditions for their effectiveness.

Governance and rules

The JP governance (organisation and internal rules) has been conceived to make the JP able to jointly pursue three main objectives:

- guaranteeing the smooth coordination of the JP's activities;
- Strengthening the relationships with the other EERA JPs, the SEC and the EERA central working groups:
- Fostering the involvement of e3s members.

JP bodies and roles

The JP's governance relies on the following bodies:

- Joint Programme Coordinator;
- Vice coordinators;
- Management Board;
- Sub-Programmes coordinators and co-coordinators;
- Temporary thematic groups coordinators;
- General Assembly (associate and full members);
- Steering Committee (full members only);
- e3s ambassadors;

Joint Programme Coordinator (JPC)

The JPC chairs the Joint Programme Management Board, performs key administration duties and coordinates the existing and potential members of the programme. The EERA JPCs meet physically twice a year and also hold periodic online calls when required.

JPC's tasks and responsibilities include:

- Coordination of JP members;
- Interaction with other JPCs, the SEC and the ExCO;
- Facilitating interaction among Sub-Programmes leaders;
- Establishment and coordination of temporary workgroups;
- Coordinate the planning process;
- Discussions with potential EERA members and introduction of new members.

Elected by the Steering Committee (see below), the JPC's term of office is four years.

Vice coordinators (VC)

JPs vice coordinators support JPC in the whole coordination tasks and are specifically responsible to maintain a continuous liaison with the EERA central working groups: the Policy Working group and the Communication Working group. The VC responsible for the Policy working group will be asked to periodically report about the relevant changes that might affect the JP's activities while the VC responsible for the Communication working group will coordinate with the SPCs to strengthen the JP's relationships beyond EERA.

Elected by the Steering Committee (see below) the VC's term of office is four years (to be renovated together with the JPC). If needed, e.g., in case of change of job etc., SPs coordinators may be substituted in advance.

Management Board (MB)

The Management Board is composed of min 6 and max 11 members:

- Joint Programme Coordinator;
- Five Sub-Programme Coordinators;
- Max 2 JP vice coordinators (among the SP or vice SPs coordinators - optional);
- Max 5 SPs vice coordinators (optional).

The main MB tasks are:

- Financial, contract and Intellectual Property (IP) management;
- Monitoring of Sub-Programmes activities and support to their objectives;
- Monitoring of progress of JPs Yearly Work Plan (YWP, see section 2 below) and other activities;
- Research planning and strategy;
- Liaison with relevant initiatives within and beyond EERA;
- Preparation of progress reports to the EERA ExCo.

Temporary Thematic Groups Coordinators can be invited to take part in MB meetings while the activity they are responsible for are running.

Elected by the Steering Committee (see below) the MB term of office is four years.

Sub-Programme Coordinators (SPCs)

It is recommended but not mandatory that each of the five Sub-Programmes is led by two coordinators:
The 2 SPCs are responsible for coordinating the collaborative research activities in their respective Sub-Programme and for the implementation of the YWP. SPCs oversee the overall progress of the SPCs activity (organising workshops, monitoring progress of combined research efforts and delivering the workshop reports and other milestones), take part to the release of the YWP and promote e3s communication and collaboration beyond EERA (with other R&I networks, ETIPs, etc.).
Elected by the Steering Committee (see below) the SPCs term of office is four years.

General Assembly (GA)

The SC is composed by a representative from each participant member and is the main decision-making body of JP e3s. Participation and voting rights in the GA are determined by the type of membership fee yearly paid by members which is € 2,000 for full members and € 1,000 for associate members. Full and associate members have the right to participate and take part in the discussion, only the full members have the right to vote.

Steering Committee (SC)

Is the body composed exclusively of full members, who have voting rights and are therefore eligible to vote and stand for election

JP Ambassadors

In order for the JP e3s to be bridged with the other JPs one member will be identified as the main contact for e3s and will be entitled to maintain a continuous interaction with a specific JP (through mail contacts, participation upon invitation to JPs MB and SC, etc).
Any of the e3s members can be appointed as ambassadors upon his/her voluntary candidature but in order to facilitate the interaction, priority is given to e3s members that have multiple membership in the two JPs to be connected.
Nominated by the Steering Committee (see below), no term of office is foreseen for the Ambassadors.

Temporary thematic groups and Temporary thematic groups Coordinators
When in the YWP a specific task is identified that involve the JP as a whole and cannot be assigned to a specific Sub-Programme, a temporary thematic group is built and a coordinator identified among the e3s (associate and full) members who is responsible for the smooth implementation of the activity and the reporting to the MB.

JPs decision making and Yearly Work Plan (YWP)

All the JP e3s (associate and full) members are asked to actively take part in the decision making process through their participation in the discussion and through the sharing of their ideas, proposals and specific issues that need to be mandatorily taken into account by the JP bodies.
Only the full members are entitled to be a candidate as JPC and to be part of the MB and have the right to vote.
Decisions are normally taken through a voting procedure in the correspondent JP bodies' periodic meetings as summarised in the table below:

Body	Meeting	Voting rules	Note
Management Board	Monthly	Majority of the participants	Vote is allowed if at least 50% of the MB members are present
Steering Committee at General Assembly	Half Yearly	Majority of the full members participants	Vote is allowed if at least 50% of the full JP members are present

When participation in meetings is below 50% of the body's members, the voting procedure will be conducted by email.

By the end of December each year, a **Yearly Work Plan** is delivered and approved by the SC.
The YWP reports the activities foreseen for the following year and, for each of them, a short description where needed, a timeline and the assignment of responsibilities. Not all SPs will be active in the YWP every year; a rotation principle is applied to concentrate JP efforts and resources on a narrower set of feasible tasks.
The YWP may contain a range of items:

- (mandatory) General Assemblies, venue and provisional dates;
- (mandatory) Brokerage Events,

- Workshops and Seminars, with a short description;
- Publications;
- Other tasks.

Interaction with SEC, central working groups and the other JPs

JP e3s is strongly committed to maintaining and reinforcing communication and interaction with other working groups focused on energy transition research within and beyond EERA.

Within EERA, the JPC, supported by the VCs, maintains regular links with the SEC and the central working groups on Policy and Communication, while the Ambassadors ensure continuity with the other EERA JPs and report the most relevant updates at the quarterly meetings coordinated by the JPC.

Beyond EERA, the JPC, supported by the VC responsible for liaison with the EERA Communication group, works with the SPCs to engage other R&I networks relevant to the specific SP domains, as described in the Sub-Programme sections.

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ANNEXES

Annex 1 - Membership

#	Member	Affiliation
1	AIT	Full
2	BERA	Full
3	CEA	Full
4	CIEMAT	Full
5	CIRCE	Associate
6	CyI	Full
7	CNR	Associate
8	DTU	Full
9	EGE	Associate
10	EI-JKU	Associate
11	ENEA	Full
12	HU	Associate
13	IEN	Associate
14	IFPEN	Full
15	IREC	Associate
16	IRMO	Invited Associate
17	IUE	Associate
18	KHAS	Associate
19	KIT	Full

20	METU	Full
21	NTNU	Full
22	SINTEF Energy	Full
23	SSSA	Full
24	TECNALIA	Full
25	TNO	Full
26	TUD	Full
27	UKERC	Full
28	UG	Associate
29	UNIBO	Associate
30	UNIBZ	Associate
31	UNIPD	Full
32	UNIROMA La Sapienza	Associate
33	UNIROMA 3	Associate
34	UNITO	Full
35	UVAASA	Full
36	VTT	Full

Annex 2 - Roles Assignment

	Role	Name	Organization
Management Board	JP Coordinator	Alessandro Sciullo	UNITO
	JP Vice Coordinator - Responsible liaison with Policy Group	Tiina Koljonen	VTT
	JP Vice Coordinator - Responsible liaison with Comm Group	Izaskun Jimenez Iturriza	TECNALIA
	SP1 coordinator	Mara Thiene	UNIPD
	SP1 co-coordinator	Ezilda Costanzo	ENEA
	SP2 coordinator	Manfred Paier	AIT
	SP2 co-coordinator	Izaskun Jimenez Iturriza	TECNALIA
	SP3 coordinator	Daniel Garrain	CIEMAT
	SP3 co-coordinator	Witold Roger Poganietz	KIT
	SP4 coordinator	Eleonora Annunziata	SSSA
	SP4 co-coordinator	Ramazan Sari	DTU
	SP5 coordinator	Raquel Santos Jorge	NTNU
	SP5 co-coordinator	Tiina Koljonen	VTT
Ambassadors	JP AMPEA	Eleonora Annunziata	SSSA
	JP Digital for Energy	Efe Mehmet Biresselioglu	IUE
	JP Smart Cities	Gulben Calis	EGE
	JP Ocean Energy	Izaskun Jimenez Iturriza	TECNALIA
	JP Smart Grid	Izaskun Jimenez Iturriza	TECNALIA
	JP Energy System Integration	Johannes Reichl	EI-JKU
	JP Photovoltaic Solar Energy (PV)	Pinar Derin-Güre	METU
	JP Energy Storage	Yolanda Lechon	CIEMAT
	JP Concentrated Solar Power		
	JP Bioenergy		
	JP Nuclear Materials		
	JP Wind		
	JP Hydropower	Michael Belsnes	SINTEF Norway
	JP Geothermal	Fabio Iannone	SSSUP