Project Number: 949125

Start Date of the Project: 01 January 2020

Duration: 42 months

Deliverable 1.7

Final report & recommendations on cross-cutting and interdisciplinary activities relevant to the SET-Plan

DISSEMINATION LEVEL	**Public**
DUE DATE OF DELIVERABLE	31/12/2022
ACTUAL SUBMISSION DATE	20/12/2022
WORK PACKAGE	WP1 - Facilitating the execution of the SET Plan
TASK	Task 1.3 – Cross-cutting and interdisciplinary activities.
TYPE	Report
NUMBER OF PAGES	65
AUTHORS' NAMES AND AFFILIATIONS	Emily E. Riley, DTU Stine Work Brodersen, DTU Lars Brückner, DTU Lone Falsig Hansen, DTU
REVIEWERS' NAMES AND AFFILIATIONS	Ivan Matejak, EERA Ganna Gladkykh, EERA Mónica de Juan González, EERA Spyridon Pantelis, EERA
KEYWORDS	SET Plan, Implementation Plans, Implementation Working Groups, Cross-cutting and Interdisciplinary Topics, SETIS, SUPEERA

The SUPEERA project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 949125.

Version	Date	Description
0.1	08.12.2022	The first draft
0.2	13.12.2022	First revision
0.3	14.12.2022	Second revision
0.4	19.12.2022	First final version
1	20.12.2022	Final and submitted version

Disclaimer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 949125.

Table of contents

EXECUTIVE SUMMARY

The purpose of this document is to provide a mapping of existing cross-cutting and interdisciplinary topics – both technological and non-technological - and related activities in the updated SET Plan Implementation Plans (IPs).

Based on the feedback received from the EERA Joint Program Coordinators (JPCs) and the conclusions from the desktop analysis the following steps are now taken into consideration for drafting the Deliverable 1.7 “Final report & recommendations on cross-cutting and interdisciplinary activities relevant to the SET Plan”:

- Analysis of the latest versions of the IPs. It provides an updated mapping of cross-cutting topics and related activities covered by the new IPs, and the identification of synergies. With Deliverable 1.6, the development of the cross-cutting issues in the latest versions is also included. In the present deliverable, the analysis focuses more on the relevance of the identified topics and the presence of a dedicated funding mechanism in the Member States and Associated Countries, and on identifying research and technology needs to support the identified topics and activities and facilitate the scale-up to commercial size.
- Follow-up discussions on the identified topics and related activities that took place in various communication means with the Joint Programme Coordinators and other stakeholders (e.g. ETIPs, EC, industry, national representatives in the SET Plan etc.). Major discussions on these topics include the EERA Annual Strategy Meeting and the latest Joint Programme Coordinators’ meeting that reflected upon several cross-cutting issues, raising also other relevant topics that were marginally addressed in the previous deliverable.
- Follow up on the first workshop on "Energy Materials for Innovation (EM4I)” organised by the EERA JP on Advanced Materials and Processes for Energy Applications (JP AMPEA), together with the EERA Joint Programme on Nuclear Materials (JP NM) and the transversal Joint Programme Digitalisation for Energy (JP DfE). The workshops covered the integral stages of materials research, from discovery to scale-up productions, device development, industrial integration and sustainability, as well as cross-cutting technologies supporting these actions.

The task is carried out in coordination with Task 2.2. "Systemic and cross-sectorial issues pertaining to the Clean Energy Transition objectives", Task 2.3. "Dialogue for transnational collaboration with industry in support of the NECPs", particularly on facilitating a cross-sectorial dialogue for systemic solutions, and Task 3.2 on policy recommendations.

The outcome will serve as input to discussions with the EERA JPCs and other stakeholders on how to enhance added-value links across the IPs, and support possible synergies and mutual learning.

LIST OF ACRONYMS

AC	Associated Countries
AC/DC	Alternating Current/Direct Current
ADEME	Agency for Ecological Transition
B€	Billion €
BIPV	Building Integrated PV
BMBF	Federal Ministry of Education and Research
CCS / CCU	Carbon Capture and Storage / Carbon Capture and Use
CETP	Clean Energy Transition Partnership
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CEF	Connecting Europe Facility
DC	Direct Current
EC	European Commission
ECTP	European Construction Technology Platform
EE	Energy Efficiency
EERA	European Energy Research Alliance
EFSI	European Fund for Strategic Investments
EIA	Environmental Impact Assessments
EIB	European Investment Bank
EIT	European Institute of Technology
EM4I	Energy Materials for Innovation
ENEN AISBL	European Nuclear Education Network non-profit association
ERA-MIN	ERA-Net Cofund on Raw Materials
ERA-NET	European Research Area Network
ERDF	European Regional Development Fund
ESA	European Space Agency
ESARDA	European Safeguards Research and Development Association
ESI	Energy Systems Integration
ESIF	European Structural and Investment Funds
ETIP	European Technology and Innovation Platform
ETS	Emissions Trading System
EU	European Union
EUA-EPUE	European University Association Energy & Environment Platform
EV	Electric Vehicles
F4E	Fusion for Energy
FAIR	Findability, Accessibility, Interoperability, and Reusability
FP	Framework Programme
H2	Hydrogen
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
INCO	International Cooperation
InnovFin-EDP	InnovFin Energy Demonstration Projects
IP	(SET Plan) Implementation Plan
IPCEI	Important Projects of Common European Interest

ISPT	Institute for Sustainable Process Technology
IWGs	Implementation Working Groups
JP	(EERA) Joint Programme
JP AMPEA	Joint Programme Advanced Materials and Processes for Energy Applications
JP Bio	Joint Programme Bioenergy
JP CCS	Joint Programme Carbon Capture and Storage
JP CSP	Joint Programme Concentrated Solar Power
JP DfE	Joint Programme Digitalisation for Energy
JP E3S	Joint Programme Economic, Environmental and Social Impacts
JP EEIP	Joint Programme Energy Efficiency in Industrial Processes
JP ES	Joint Programme Energy Storage
JP ESI	Joint Programme Energy Systems Integration
JP FCH	Joint Programme Fuel Cells and Hydrogen
JP HP	Joint Programme Hydropower
JP NM	Joint Programme Nuclear Materials
JP OE	Joint Programme Ocean Energy
JP PV	Joint Programme Photovoltaic Solar Energy
JP SC	Joint Programme Smart Cities
JP SG	Joint Programme Smart Grids
JP Wind	Joint Programme Wind Energy
JPC	Joint Programme Coordinator
JPI	Joint Programming Initiative
KIC	Knowledge and Innovation Community
KPI	Key Performance Indicators
LCA	Life Cycle Analysis
Li	Lithium
LIFE	L'Instrument Financier pour l'Environnement
M€	Million €
MS	Member States
NECP	National Energy and Climate Plans
O&M	Operation and Maintenance
ORC	Organic Rankine Cycle
PED	Positive Energy Districts
PV	Photovoltaics
R&I	Research & Innovation
RE	Renewable Energy
RHC	Renewable Heating and Cooling
RIA / IA	Research & Innovation Actions / Innovation Actions
RVO	Netherlands Enterprise Agency
SCADA	Supervisory Control and Data Acquisition
SET Plan	Strategic Energy Technology Plan
SETIS	SET Plan information system
SUPEERA	Support to the coordination of national research and innovation programmes in areas of activities of the European Energy Research Alliance
TBD	To be determined

TRL	Technology Readiness Levels
TWG	Temporary Working Groups
USA	United States of America

LIST OF TABLES AND CHARTS

I INTRODUCTION

The document updates the Deliverable 1.6 which provides a mapping of existing cross-cutting and interdisciplinary topics - both technological and non-technological - and related activities described in the updated EU's Strategic Energy Technology Plan (SET Plan) Implementation Plans (IPs). As well as an analysis of the feedback received from the EERA Joint Programme Coordinators (JPCs).

In 2008, the European Commission launched the SET Plan, as an instrument to boost R&I in the field of low carbon technologies. Building on the SET Plan 10 priorities, 14 IPs were written to cover all the Energy Union R&I priority areas, and Implementation Working Groups (IWGs) were put in charge of executing the R&I activities listed under the IPs.

The SET Plan aims at giving all stakeholders a clear overview of the current energy research challenges and priorities for the European Union and at displaying a set of targets, consistent with the objective of the Clean Energy Transition. By establishing a long-term framework for collaboration, the SET Plan facilitates the coordination across borders, structures European and national research programmes, and triggers investments in common priorities in low-carbon technologies. Several supporting initiatives (e.g. various Horizon 2020 projects that aim to support the implementation of the SET Plan) added that the SET Plan enables the inclusion of those parties who do not usually participate directly in the policy-making process of the European Union. One of the perceived added values of the SET Plan as a collaborative tool is its role in accelerating technology deployment by closing the gap between R&I and the market.

Each IWG comprises national governments, industry representatives and research institutions and is led (or co-led) by one (or two) SET Plan countries. The goal of the IPs is to translate the SET Plan key actions into specific recommendations for R&I engagements and/or policy measures related to innovation, identifying strategy and R&I activities that need to be implemented to reach targets set in the Declaration of Intent, coordinating R&I activities and stimulate joint actions by funding actors, also considering international cooperation.

The IWGs have the task of advancing the respective implementation plans, collectively reaching the agreed technological targets. In its yearly report, SETIS also assesses the relevance of the Implementation Plans and their targets and activities according to current technological and political priorities, collects potential needs of revision of these targets and activities, displays a non-exhaustive list of ongoing R&I project and their funding sources, and analyses ongoing collaborations or potential synergies between IPs.

There are no new updates on the SETIS report since the 2020 analysis (published in 2021), where it was reported that between 2019 and 2020, "all IWGs were advancing with the implementation plans". Indeed, amongst the 143 activities identified across all IPs, an increasing number of them have ongoing projects, reaching 74% in 2020 (vs 46% in 2019). The corresponding 1203 projects reported by the IWGs to SETIS have mobilised €13.2 billion since 2017, funded by national, regional, transnational, and/or EU funds. SETIS report officially signed the beginning of the revision of the SET Plan (“revamp”), which will better align the Plan and its stakeholders (including the EERA community) in support of EU political, energetic and industrial priorities,

The document, Deliverable 1.7, is a final report and will collate both the analysis of the latest versions of the IPs and discussion with the EERA JPCs and other stakeholders on enhancing added-value links across the IPs and supporting possible synergies and mutual learning.

II METHODOLOGY

The mapping stems from the cross-cutting and interdisciplinary topics and activities identified in Deliverable 1.6 (Table 3 for technological cross-cutting topics and Table 7 for non-technological cross-cutting topics) and their presence in the IPs (Table 1 below) published by SETIS.

Mapping includes both technological and non-technological cross-cutting topics as needs and requirements (technological and non-technological) that are common to multiple sectors and activities. The analysis includes related activities/projects and budget when present in the IPs. A number of topics have been identified as enablers, i.e. relevant topics but without a dedicated budget.

Table 1: Implementation plans (2021-2022) retrieved from SETIS website. The plans shaded green are updated versions of the plans analysed in Deliverable 1.6.

Implementation Plan (IP)	Abbreviation
Implementation plan on High voltage direct current (HVDC) & direct current (DC) technologies	IP HVDC & DC
Implementation plan on batteries	IP Batteries
Implementation Plan on energy efficiency in industry	IP EE for Industry
Implementation plan on renewable fuels and bioenergy	IP Bio
Implementation plan on offshore wind	IP Wind
Implementation plan on nuclear safety	IP Nuclear
Implementation plan on deep geothermal energy	IP Geothermal
Implementation plan on positive energy districts	IP PED
Implementation plan on solar photovoltaics	IP PV
Implementation plan on ocean energy	IP Ocean

The analysis of the IPs conducted by SUPEERA is structured in two main parts, related to technological and non-technological topics, and includes the following aspects:

1) In how many and in which IPs are the previously identified cross-cutting topics present
2) Specifics of the activities, i.e. description of related needs, R&I activities (undertaken or foreseen) and, when available, allocated budget
3) Potential synergies between the IPs
4) The relevance of the identified topics in the Member States and Associated Countries (ACs) and the presence of a dedicated funding mechanism

5) Identification of research and technology needs to support the above topics and activities and to facilitate the scale-up to commercial size.

For points 1-3, the topics identified in Deliverable 1.6 have been considered. In addition, after the REPowerEU plan was announced, further emphasis has been placed on the analysis of security issues and on the shortages of the qualified workforce. Security & Safety has been added as a technological cross-cutting issue and an extra subheading to Education & training, a non-technological cross-cutting topic, to cover skilling and reskilling aspects of the workforce. In addition, the definition of High temperature & advanced materials has been broadened following the recommendation in Deliverable 1.6.

For points 4 and 5, the analysis in Deliverable 1.6 has been expanded with the following additions:

a) The starting point is an initial discussion on the funding required, implementation instruments (past, present, and future), and the MS and AC involved across all the IPs.
b) The discussion has been separated into cross-cutting topics with activities and that only describe the cross-cutting topic as an enabler or as a small sub activity in a wider activity. This identifies IPs where only an enabler is listed to gain inspiration and work synergistically with IPs where there is an activity.
c) In the annexes, each of the activities has been listed with their TRL progression, where possible. This identifies cross-cutting activities that have similar TRL progression for synergies as well as cross-cutting activities with TRL progression higher that can facilitate scale-up to commercial size.
d) Summary of the cross-cutting activities facilitated by EERA, and discussions between Joint Programme Coordinators and other representatives participating in these activities.

III COUNTRIES AND FUNDING

It is noted that there are no IPs or activities that are limited to specific MS and AC, ensuring that all activities are relevant and open to interested parties across Europe while recognising that the needs of different countries will differ. This is also reflected in the budgets of many of the activities that specify that there are a number of different technologies and projects required to reach the targeted impacts.

In Table 2, the IWGs associated with the creation of the IP is recorded, where given, to demonstrate which countries will have the closest connection to the identified research and technology needs. The stated budgets and identified funding sources complement this list of countries. It is observed that there is a strong need across IPs for funding from both MS, AC and EU to meet the R&I needs.

Table 2: Implementation plans listed with MS and AC involvement given by two-letter country codes together with total budget and implementation instruments for financing.

IP	MS and AC involvement	Budget and implementation instruments
IP HVDC & DC	IT, LT, TR, SE, CY, ES, SK, BE, DE, IE, NO, CZ, IS, TR, RO, HU	**Total budget:** Not stated **Implementation instruments:** Connecting Europe Facility (CEF), Framework Programmes (FPs), specific national and international projects are listed from e.g. Innovation Fund Denmark (DK), Energy Transition Fund (BE), Italian Ministry of Economic Development (IT), Nordic Energy Research (Nordics), Federal Ministry of Education and Research (DE)
IP Batteries	AT, BE, EE, FR, DE, IT, NO, ES, SE, TR, UK	**Total budget:** Not stated **Implementation instruments:** EU MS, European Institute of Technology on Raw Materials (EIT-Raw Materials), ERA-Net Cofund on Raw Materials (ERA-MIN), National science organisations, local government organisations
IP EE for Industry	FI, NL, AT, PT, CH, SE, ES, TR, IT, BE, CY, CZ, FR, LV, NO, SI, PL, DE	**Total budget:** Not stated **Implementation instruments:** Mix of private equity/debt and public (national and European) grants/loans/ guarantees. Funds at EU level should be guaranteed to achieve true cross-sectorial EU dimension of technologies development and demonstration (e.g. Horizon Europe, notably the Processes4Planet partnership, Clean Steel partnerships, Circular Economy; the Innovation Fund). Other complementary funds or tools could cover specific territorial interests (e.g. national or regional funds such as ADEME (FR), BMBF (DE),

		ISPT and RVO (NL), Agentschap ondernemen (BE)) or support deployment (e.g. Investment and financial instruments from EIB, Innovation Fund, InnovFin Energy Demonstration Projects (InnovFin-EDP)). Some regional/local funding will be needed to ensure logistics for the interaction between CO_2 capture and CO_2 use partners.
IP Bio	IT, FI, FR, AT, BE, CY, DE, ES, NL, PT, SE, TR	**Total budget:** Estimated 107 B€. The magnitude of investment is understood as cumulative until 2030, and a split of 73% corporate R&D (78 B€), 21% national (22 B€) and 6% EU (7 B€) funding is assumed. **Implementation instruments:** Framework Programme (FP) RIA, European Partnership Initiatives, MS R&I programs, non-public cofounding, equity, commercial loans, Risk Finance, Innovation Fund, EFSI, ESIF, FP IA & Innovfin, European Partnership Initiatives, other, EIB, CEF Transport, CEF Energy
IP Wind	NL, BE, DE, EE, ES, FR, IT, NO, TR, UK	**Total budget:** Not stated **Implementation instruments:** Next Generation EU (800 B€), Horizon Europe (95,5 B€), Connecting Europe Facility (22,4 B€), Just Transition Fund (17 B€), InvestEU (2,8 B€)
IP Nuclear	**Chair and vice chairs:** UK, FR, BE (other members not stated) **Endorsed by:** BE, CH, CZ, ES, FI, FR, HR, HU, IT, LT, NL, PL, RO, SI, SK, TR, UK	**Total budget:** Not stated **Implementation instruments:** Increased cooperation between Member States, Public and Private investments involving industry, research centres, academia and technical safety organisations. Euratom, European Regional Development Fund (ERDF), EIB loans, Euratom loans, InnovFin, EFSI, European Fusion Joint Programme on R&D, F4E Joint Undertaking, EC Joint Research Centres (JRCs), European Safeguards and Research and Development Association (ESARDA), European Nuclear Education Network non-profit association (ENEN AISBL), The European Fusion Education Network (Fusenet Association), major infrastructure operated in the framework of international cooperation and bilateral agreements
IP Geothermal	**Chair and vice chairs:** CH, NL, NO, IT, (other	**Total budget:** Estimated overall investment of 936,5 M€ needs to be mobilised over the next 5-8 years, sourced as follows: 456 M€ from the industry (private funds - 49% of the total); 342 M€ from national

	members not stated)	programmes (36,5% of the total); 138,5 M€ from EU funds (14,5% of the total) **Implementation instruments:** Dedicated industry investment (private funds), National funding incl. bi- or multilateral projects (FR, IS, IT, PT, TR, DE, CH), CETP, GEOTHERMICA, Horizon Europe
IP PED	NO, SK, SE, FI, UK, PT, ES, FR, IT, CZ, TR, DE, DE, NL, AT, LV	**Total budget:** The total envisaged budget involved is of a magnitude of 0.74 B€ in R&I funding throughout 2018-2025. In the majority of participating countries national public research funding, especially innovation funds, need to be matched by contributions of the beneficiaries. On average, the beneficiaries will contribute approximately at least 30% (150 M€ out of 500 M€) of public funding (depending on the national funding rules). The investments on the ground can be estimated at a minimum of 100 B€. **Implementation instruments:** PED Labs: 20 M€ of transnational R&I funding through JPI Urban Europe (and EC) and 100 M€ through alignment of national R&I funding, Innovation Actions: 80 M€ of transnational R&I funding and 300 M€ through alignment of national R&I funding, PED Knowledge Diffusion and experiences: 7 M€ through alignment of national R&I funding/programmes, cash and in-kind personnel contributions for management efforts by participating countries, national R&I funding programmes of participating countries, FPs, Climate-KIC, KIC InnoEnergy, Digital Innovation Hubs, private funding, ERDF, LIFE, National Smart Cities programs, EIB, RHC ETIP members' own resources, Transnational R&I funding
IP PV	BE, CY, EE, FR, DE, IT, NL, NO, ES, TR	**Total budget:** Not stated **Implementation instruments:** European funding, National funding (1003 - Primary Subjects R&D Funding Program and 1511 - Research & Technology Development and Innovation Program (TR), Innovative Technologies for Modern Utility-Scale PV – part b (IT), TKI Urban Energy program (NL)) and industry resources, Flagship projects, joint R&I activities between SET Plan countries (EUREKA, EUROGIA, Solar ERA-NET, Solliance), EU level (Framework Program)

IP Ocean	IE, ES, UK, DK, FI, PT FR, IT, SE, BE, NL, DE, CY	**Total budget:** Current estimate for funding levels is 1 B€ between 2021 and 2025, sourced as follows 335 M€ from the industry (private funds - 33% of the total); 400 M€ from national/regional programmes - (40% of the total); 271 M€ coming from EU funds (27% of the total – mainly from Horizon Europe and the ETS Innovation Fund)" **Implementation instruments:** Important Projects of Common European Interest (IPCEI), ERDF, EFSI, InnovFin-EDP, Innovation Fund

IV CROSS-CUTTING TOPICS – TECHNOLOGICAL

Table 3 below shows the technological cross-cutting topics defined in Deliverable 1.6. Safety & security (shaded in green) has been added based on REPowerEU plan. Additionally, the definition of subtopics within High temperature & advanced materials has been expanded based on the conclusions within Deliverable 1.6.

Table 3: Technological cross-cutting topics (identified in D1.6) with green shading for added topics based on REPowerEU and D1.6.

Technological cross-cutting topics SET Plan IPs	
Energy efficiency	In buildings: cost reduction and increase in efficiency of micro combined heat and power/combined cooling heat and power plants
	In industry: energy efficiency of cross-sector industrial components
Energy systems integration	Integration of renewable fuels/bioenergy in different energy systems - e.g. power-to-gas, power-to-liquid, use of biomass-based energy generation and renewable hydrogen in heating, cooling, and electricity networks; synergies with renewable hydrogen and CO_2 streams
	Synergies with building and transport/e-mobility: development of photovoltaic technologies in combination with efficient building materials (Building-Integrated PV); production, consumption and storage of renewable energies in buildings in integration with electromobility infrastructures
	Improving system integration, optimal design, intelligent and flexible operation; integrated energy system design providing an efficient and flexible energy infrastructure
	Hybrid and flexible systems able to integrate different sources of energy (grid dispatchability)
High temperature & advanced materials	Development of affordable high-temperature, corrosion-resistant materials or new alloys resistant to extreme conditions for renewable fuels/sustainable transport
	Development of materials processing techniques and components for fast industrialization compatible with current mass production lines in batteries
	Development of effective materials to reduce issues connected with scaling and corrosion, both for low- and high-temperature geothermal applications

	Research on innovative materials and their degradation/failure mechanisms leading to the development of new and improved materials for offshore wind
	For buildings: cost-efficient, intelligent, flexible heat pumps (also thermally-driven) and heat pumps for high temperatures
	Research on advanced materials and their manufacture for energy conversion and storage devices
Energy storage	New design for high temperature thermal energy storage
	Development of compact thermal energy storage materials, components and systems
	Storage and heat exchange of solar energy
	Hybridisation of battery systems for stationary energy storage, integration with other renewable energy systems
	Renewable energy storage
	Development of local storage solutions for energy districts
	Development of a European CO_2 Storage Atlas identifying and characterising all recognised prospective storage sites on a consistent basis - to facilitate site comparison, ranking, and integrated regional and national storage planning and transport development
Digitalisation	Systemic and socio-economic impact of digitalisation in the energy system
	Internet of Things, smart cities & connection with e-mobility
	Data management/data unification issues (information platform, creation of standards and common data models at EU level)
	Topic linked to non-technological cross-cutting topics such as policy & regulation, standardisation, data management, socioeconomic policies & measures
Security & safety	Security of supply via diversification of energy and raw material use
	Safety - inspection, equipment, processes
	Cybersecurity & resilience against cyber-attacks (including identification and real-time counteracting)

	Topics linked to the defence of critical infrastructure

As in Deliverable 1.6, synergies exist across the technological and non-technological cross-cutting topics. This is also true for the added cross-cutting topic, Security & safety, where there are overlaps with technological cross-cutting topics such as High temperature & advanced materials and Digitalisation, and non-technological cross-cutting topics such as Policy & regulation and Standardisation.

4.1 Technological cross-cutting activities

As shown in Table 4 below, each of the cross-cutting topics has at least one activity in an IP related to it and each IP has at least one activity that relates to a cross-cutting topic. However, there are 7 IPs for which the cross-cutting topics are mentioned without any associated activity – and hence with no associated funding.

Table 4: Outline of technological cross-cutting topics identified in the IPs. The number of technological cross-cutting activities in each IP is indicated in the rightmost column, and the number of activities within each technological cross-cutting topic

IP	Energy efficiency	Energy systems integration	High temperature & advanced materials	Energy storage	Digitalisation	Security	Total Activities
IP HVDC & DC		3	1	E	1	E	5
IP Batteries	E	1	1	2	E		4
IP EE for Industry	6	2			1	E	9
IP Bio	3	4	1	4			12
IP Wind		2	2		7		11
IP Nuclear	1		1		E	1	3
IP Geothermal	1	1	1	E	E		3
IP PED	2	1		E	5		8
IP PV	E	1	2		1		4
IP Ocean	E	2		E	2	E	4
Total Activities	**13**	**17**	**9**	**6**	**17**	**1**	

Table 4 shows that Security & safety, High temperature & advanced materials, and Energy storage are the least represented across the IPs, while Digitalisation, Energy Efficiency, and Energy systems integration are the best represented and therefore synergies across the IPs should be possible to identify. Some comments on the topics are as follows:

- **Energy Efficiency:** This topic has 13 activities in covering co-generation opportunities for heating and industrial use and in renewable heating and cooling in PEDs. Most of the activities are within IP EE for Industry and activities only cover 5 IPs: IP EE for Industry, IP Bio, IP Nuclear, IP Geothermal, and IP PED. The 13 activities in cover co-generation opportunities for heating, energy, and industrial use, as well as renewable heating and cooling in PEDs. Energy efficiency is further mentioned in IP Batteries, IP PV, IP Bio, and IP Ocean as efficiency targets within each of their technologies. For

example, in IP batteries there are efficiency targets for kW/kg and kW/L, and in IP Bio there are net process efficiency targets. There are strong synergies here for the co-generation of heat & power as well as the use of waste heat. Additionally, potential synergies have been noted between digitalisation within industry and PEDs.

- **Energy System Integration:** This is the most recurrent topic with 17 activities across 9 IPs. This cross-cutting topic covers the most IPs, with only IP Nuclear not having any activities in this topic. However, this topic has strong synergies with energy efficiency where IP Nuclear does have one activity. This is the most common cross-cutting topic reflecting that the evolution of the energy system will be consisted by a variety of different renewables and the importance of ensuring that new technologies are integrated into the energy systems. As this builds resilience and security, this topic also has links to Security & safety.
- **High Temperature & Advanced Materials:** With the expanded definition (see Table 4), there are 9 activities across 7 IPs and it is the second most common cross-cutting topic across the IPs. IP Ocean, IP PED, and IP EE for Industry are the 3 IPs that do not have activities relating to advanced materials. However, this does not preclude them from being able to exploit synergies. For example, IP Ocean has an activity called "Application of innovative materials from other sectors" where there would be an overlap with IP EE for Industry with innovative construction materials beyond the scope of the definition of this cross-cutting topic.
- **Energy Storage:** This topic has 6 activities across 2 IPs (IP Batteries with 2 activities and IP Bio with 4 activities) and is an enabling factor with sub activities in 4 further IPs (IP HVDC & DC, IP Geothermal, IP PED, and IP Ocean). In both IP Batteries and IP Bio, the topic is mostly related to the specifics of their respective technologies and in developing energy storage and renewable energy carriers to facilitate energy systems integration. There are 3 activities related to energy carriers in IP Bio, where energy carriers are an intermediary for future conversion along the value chain.
- **Digitalisation:** This topic has the second largest number of related activities with 17 activities across 6 IPs. It is also mentioned as an enabler or sub activity in 3 IPs. It is only not mentioned in IP Bio, where one would foresee synergies related to industry 4.0 and digital twins. There are clear synergies between this topic and the recent draft legislation on open data[1], there are specific activities related to open data in IP Ocean, IP Wind, IP Geothermal, and IP PED.
- **Security & safety:** All the IPs were written before Russia's invasion to Ukraine. However, there are still activities and enablers mentioning the topics of Security & safety. Following Action 4 in the SET Plan ("Increase the resilience and security of the energy system"), 7 IPs cite the security of energy supply as key drivers for technology development. IP Nuclear has a strong focus on integrated safety-security-safeguard methods and concepts as expected in this IP there is an R&I activity related to the topic and the topic is listed as a "Key enabling condition". Security aspects are also seen as sub-activities within IP HVDC & DC, IP Ocean, and IP EE for Industry.

[1] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12111-Open-data-availability-of-public-datasets_en

Table 4 is complemented by Table 5, below, which provides an overview of the technological cross-cutting topics, the related activities and, when specified in the IPs, of the associated budget/resources.

Table 5: Activities identified within the technological cross-cutting topics.

Technological cross-cutting topic	IP	Related Activities	Allocated budget / resources
Energy efficiency	IP EE for Industry[2]	Activity 1.1: Heat upgrade from low to high grade - Heat pumps	7-8 M€ per project.
		Activity 1.2a: Use of low/medium temperature waste heat (120 - 350ºC) to generate electrical power at high efficiency	TRL 1-4: 3 M€ per project; TRL 4-7: 14 M€ per project
		Activity 1.2b: High temperature waste heat recovery to generate electrical power at high efficiency	80 M€
		Activity 1.3: Waste and renewable heat to cold generation	TRL 4-5: 2 M€; TRL 5-7: 14 M€
		Activity 1.4a: Hybrid plants for waste heat upgrade integrating renewable energy into industrial plants and processes	TRL 5-7: 30 M€
		Activity 1.4b: Advanced compact Combined Heat and Power - plants of industry scale	TRL 3-5: 3 M€; TRL 5-7: 7 M€
	IP Bio	Activity 8: Develop high efficiency large scale biomass cogeneration of heat and power	0.5 B€
		Activity 9: Demonstrate high efficiency large scale biomass cogeneration of heat and power	0.8 B€
		Activity 10: Scale-up high efficiency large scale biomass cogeneration of heat and power	10 B€
	IP Nuclear	Activity 9: Cogeneration of heat and electricity	20 M€/year (2017-2020) for 10 to 20 year
	IP Geothermal	Activity C: Improvement of overall geothermal energy conversion performance for electricity generation, and heating & cooling	21 M€

[2] *For all activities it is stated that additional budget is required to achieve TRL8 and 9*

	IP PED	Activity 11: RHC-ETIP – Industry support	7 M€
		Activity 12: Euroheat & Power – Industry support	0.5 M€ over the course of 8 years
Energy systems integration	IP HVDC & DC	Activity ST-CP-1: Multi-vendor interoperability - first European full-scale implementation of Multi-Vendor Multi Terminal Voltage Source Converters	TBD €
		Activity ST-CP-2: Grid forming capabilities offered by HVDC systems	
		Activity ST-P-1: Methods and tools for combined system (HVAC & HVDC) expansion	
	IP Batteries	Activity 3.2: Second use and smart integration into the Grid	15 M€
	IP EE for Industry	Activity 2.1: Industrial Symbiosis: between energy intensive industries to valorise energy losses streams and better manage energy globally	4-5 M€ for low TRL 15-20 M€ for high TRL
		Activity 2.2: Non-conventional energy sources in the process industry including carbon capture and use	TRL 4-6: 20–30 M€ per project; TRL 6-9: 10-20 M€ per project. - 200 M€ for electric furnaces and crackers each - 50 M€ per CCU demonstration plant (TRL7-8)
	IP Bio	Activity 4: Develop other renewable liquid and gaseous fuels (excluding hydrogen) through thermochemical/ chemical/ biochemical /electrochemical transformation of energy neutral carriers with renewable energy	0.2 B€

		Activity 5: Demonstrate other renewable liquid and gaseous fuels (excluding hydrogen) through thermochemical/ chemical/ biochemical/electrochemical transformation of energy neutral carriers with renewable energy	0.4 B€
		Activity 6: Scale-up other renewable liquid and gaseous fuels (excluding hydrogen) through thermochemical/chemical/biochemical/electrochemical transformation of energy neutral carriers with renewable energy	10.08 B€
		Activity 7: Production of renewable hydrogen from water electrolysis and renewable electricity	0.41 B€
	IP Wind	Activity 2.1 Offshore wind farms & systems integration: Design and control of wind power plants and HVDC grids for power system with zero CO_2 emissions	TBD €
		Activity 2.3 Offshore wind farms & systems integration: Sustainable hybrid solutions, storage, and power to X	
	IP Geothermal	Activity B: Integration of geothermal heat and power in the energy system and grid flexibility	11,5 M€
	IP PED	Activity 9: ECTP – From Positive Energy Blocks to Districts	12 M€
	IP PV	Activity 1: PV for BIPV and similar applications	Specific R&D into the integration topics and production technologies, related to specific market segments, would require around 5 M€/year to reach critical mass and EU cooperation. For joint demonstration and feasibility projects close to the market one would need an additional 2-5 M€/year in total

	IP Ocean	Activity 1.11: Developing and demonstrating near-commercial application of ocean energy in niche markets and hybrid systems	100 M€ for 10 medium sized projects and a few large projects
		Activity 1.12: Quantifying and demonstrating grid-scale benefits of ocean energy	6 M€ for a few small projects
High temperature & advanced materials	IP HVDC & DC	Activity ST-T-3: Further development of Wide Bandgap (WBG) materials	TBD €
	IP Batteries	Activity 2.1: Foster development of materials processing techniques and components for fast industrialization compatible with present mass production lines.	50 M€ (4-year projects, 5 projects)
		Activity 2.2: Foster development of cell and battery manufacturing equipment	TBD €
	IP Bio	Activity 4: Develop other renewable liquid and gaseous fuels (excluding hydrogen) through thermochemical/ chemical/ biochemical /electrochemical transformation of energy neutral carriers with renewable energy	0.2 B€
		Activity 9: Demonstrate high efficiency large scale biomass cogeneration of heat and power	0.8 B€
	IP Wind	Activity 1.4: Next generation wind turbine technology: New and smart materials	TBD €
		Activity 6.3: Basic wind energy sciences: Material science for sustainability	
	IP Nuclear	Activity 7: Innovative materials to improve plant safety and efficiency, and qualification for operation under Gen-IV conditions	50 M€/year (2017-2021) for 10 to 20 years
	IP Geothermal	Activity E: Sustainable and efficient production technologies	25.6 M€
	IP PV	Activity 3: New technologies & materials	For each main topic (multijunction devices on Si or CIGS and CPV) is in the range of 15–50 M€
		Activity 5: Manufacturing technologies	Each equipment topic is in the range of 10–50 M€
Energy storage	IP Batteries	Activity 1.3: Advancement of batteries for stationary energy storage	TRL3-7: 50 M€; TRL7-9: 15 M€

			6-8 M€ per project
		Activity 3.1: Hybridisation of battery systems for stationary energy storage	25 M€
	IP Bio	Activity 5: Demonstrate other renewable liquid and gaseous fuels (excluding hydrogen) through thermochemical/ chemical/ biochemical /electrochemical transformation of energy neutral carriers with renewable energy	0.4 B€
		Activity 11: Develop solid, liquid and gaseous intermediate bioenergy carriers through biochemical / thermochemical/ chemical conversion from sustainable biomass	0.5 B€
		Activity 12: Demonstrate solid, liquid and gaseous intermediate bioenergy carriers through biochemical / thermochemical/ chemical conversion from sustainable biomass	1 B€
		Activity 13: Scale-up solid, liquid and gaseous intermediate bioenergy carriers through biochemical / thermochemical/ chemical conversion from sustainable biomass	9 B€
Digitalisation	IP HVDC & DC	Activity ST-O-1: Development and integration of advanced software tools in SCADA systems for AC/DC hybrid systems	TBD €
	IP EE for Industry	Activity 2.3: Digitalisation: Further integration in process and plant management including plant/process design phase and processing plant retrofit	20 M€ per project and > 50 M€ for projects at TRL8
	IP Wind	Activity 2.2: Offshore wind farms & systems integration: Increases performance of wind power and grid via digitalisation	TBD €
		Activity 3.3: Floating offshore wind & wind energy industrialisation: Enable digital transformation in wind energy system O&M	
		Activity 4.2: Wind energy operation, maintenance & installation: Next generation of wind farm control (wake, cluster layout etc.)	
		Activity 4.3: Wind energy operation, maintenance & installation: Enable digital transformation in wind energy system O&M	
		Activity 4.4: Wind energy operation, maintenance & installation: Sensor systems and data analytics for health monitoring	
		Activity 6.2: Basic wind energy sciences: Digital turbine and data analytics	

		Activity 6.4: Basic wind energy sciences: Open access database for research validation (FAIR data)	
	IP PED	Activity 2: JPI Urban Europe – PED Labs and Innovation Actions	635 M€
		Activity 4: EERA JP SC - Diffusion of knowledge and experiences	18 M€ (4 years)
		Activity 9: ECTP – From Positive Energy Blocks to Districts	12 M€
		Activity 10: ECTP – ESA – Digital Modelling of Cities	27 M€
		Activity 11: RHC-ETIP – Industry support	7 M€ (8 years)
	IP Ocean	Activity 1.10: Instrumentation for condition monitoring and predictive maintenance	25 M € for a few medium sized projects and around 5 small projects
		Activity 1.14 Open-data repository for ocean energy operation and performance	10 M€ for a few medium sized projects and around 5 small projects
Security & safety	IP Nuclear	Activity 1: Plant safety, risk assessment and severe accidents, integrity assessment of systems, structures and components	250 M€/year (2017-21)

4.2 Technological cross-cutting enablers

As shown in Table 3, all IPs, except IP Bio and IP Wind, have identified enablers or sub activities within technological cross-cutting topics where they do not have wider activities. All technological cross-cutting topics are listed as enablers in at least one IP except for Energy systems integration and High temperature & advance materials, likely due to the high number of activities spread across the IPs. Notably, IP Nuclear does not have any activity or enabler in Energy systems integration and Energy storage, two closely connected technological cross-cutting topics.

Counting both activities and enablers, Digitalisation is as well covered as Energy Systems Integration, with only IP Bio without a discussion on Digitalisation. Energy Storage is identified only as an enabler across 4 IPs, without activities and Energy Efficiency, Digitalisation, and Security are identified in 3 IPs without activities either.

Table 3 is complemented by Table 6, below, which provides an overview of the technological cross-cutting topics and the discussion as a related enabler within the IPs.

Table 6: Enablers and sub-activities identified within the technological cross-cutting topics.

Technological cross-cutting topic	IP	Comments and sub activities within the IP
Energy efficiency	IP Batteries	Targets in Activity 1.1 and 1.4 to increase energy efficiency in terms of Wh/kg and Wh/l of traction batteries for advanced Li batteries and beyond Li batteries respectively are included.
	IP PV	Targets in R&I Activity 1, 3, and 5 to increase PV module efficiency compared to different technologies and different timepoints are included.
	IP Ocean	Targets to increase the efficiency of the converter are included in Activity 1.3
Energy storage	IP HVDC & DC	With the increasing penetration of power-electronic-interfaced devices and renewable energy sources due to HVDC system, new requirements regarding voltage level, current ratings, and integration of energy storage, among others, shall be addressed by new technological developments.
	IP Geothermal	Within R&I Activity B - Showcasing geothermal energy storage integrated with district heating networks and dedicated equipment (heat pumps, ORC turbo-expanders, and heat exchanger networks) with hot and cold reservoirs able to cover variable demand of heating, cooling, and electricity.
	IP PED	Storage of heat and electricity: effective batteries, H_2, high thermal inertia of floor and ceiling, electric vehicles, power-to-gas is identified as a key research field of technological innovations needed for deploying PED
	IP Ocean	Within Activity 1.1, there is a sub activity to Demonstrate delivery of grid-compliant power including short-term energy storage solutions to smooth power output when needed, and within Activity 1.12, there is a sub activity to Quantify the benefits in terms of reduced requirements for transmission infrastructure, demand response and storage, due to variability that is out-of-phase and correlated to solar and wind power. Provide estimates of the cost of energy that account for this benefit of ocean energy. Previous and ongoing projects combining multiple renewable energy sources as well as storage assets should be included for an up-to-date approach to this issue, including virtual power plant applications where appropriate.
Digitalisation	IP Batteries	Within R&I Activity 2.2, there is a sub activity for standardization for digitalization of equipment across the whole production chain (Industry 4.0) to increase quality and reduce rejects. standards and smart data; incl. identification of key parameters and tracking strategies for failures identification across the production chain with high impact on electrochemical cell properties -> 2025.
	IP Nuclear	Within the scope of 2, research programmes will enable the development of digital twins for the major components such as reactor cores or steam generators.

	IP Geothermal	The recommendation of an open-access policy to geothermal information (including standard exchange formats) is identified as a cross-cutting issue without any associated activity or budget.
Security & safety	IP HVDC & DC	Within Activities ST-CP-3 and ST-O-1, there is a sub-activity for the estimation of the current system state and its security assessment, via the development of online and real-time capable algorithms and tools that enable optimal operation of the hybrid AC/DC system (e.g. avoidance of circular flows) and to support security analyses. Within Activity ST-P-1, reliability and resilience methodologies are included to set a framework for adequately addressing security and adequacy issues and criteria via not only deterministic but also probabilistic (e.g. Monte-Carlo) methods.
	IP EE for Industry	Within Activity 2.3, there is a sub activity for increasing resilience against cyber-attacks including identification and real-time counteracting.
	IP Ocean	Within Activity 1.12, a sub activity for Quantifying benefits in terms of grid resilience in general and security threats in particular should be considered.

V CROSS-CUTTING TOPICS – NON-TECHNOLOGICAL

Table 7 below shows the non-technological cross-cutting topics defined in Deliverable 1.6. The definition of subtopics within Education & training has been expanded based on REPowerEU.

Table 7: Non-technological cross-cutting topics (identified in D1.6) with green shading for added topics based on REPowerEU.

Non-technological cross-cutting topics SET Plan IPs	
Circular economy	Broad remit, including LCA and sustainable waste management
Education & training	Incl. best practices exchange, dissemination of knowledge and experiences (including digital modelling of cities)
	Skilling and Re-skilling of the workforce towards the skills required for the clean energy transition
Policy & regulation	Incl. market design, support to the stable, long-term R&I policy framework, pan-European procurement models
	Topic linked to Standardisation, Digitalisation, R&I funding
R&I funding programmes & measures	Incl. access to finance/ad hoc financial schemes (& related risk management), shared certification and shared data models
	Incl. support to industry & large scale deployment initiatives
	Topic linked to Policy & regulation
Social awareness, acceptance, engagement	Incl. Living Labs, energy technologies & solutions for decarbonized European districts and cities (incl. development of novel economic schemes and social acceptance models)
	Incl. architecture & urban planning
	Incl. development of KPIs to measure consumer benefits
	Topic linked to Education & training, Policy & regulation, R&I funding, Socio-economic policies and measures
Standardisation	Incl. analysis of socio-economic motivations for investing in technologies/solutions
	Incl. social, environmental and legal aspects re to infrastructure development
	Topic linked to Social awareness/engagement, Policy & regulation, Education & training

International cooperation	Broad remit, incl. knowledge transfer between academia and companies, capacity building, best practices exchange across countries

5.1 Non-technological cross-cutting activities

As shown in Table 8, each of the cross-cutting topics has at least three activities in an IP related to it. The majority of IPs have at least one activity that relates to a cross-cutting topic, however two have no activities within the identified cross-cutting topics. However, there are 6 IPs for which the cross-cutting topic is mentioned as an enabler or part of a larger activity, without any associated activity. This is particularly clear for IP HVDC & DC and IP Bio which do not have any associated activities in any of the cross-cutting topics and they are only identified as enablers.

Table 8: Outline of non-technological cross-cutting topics identified in the IPs. The number non-technological cross-cutting activities in each IP is indicated in the rightmost column, and the number of activities within each non-technological cross-cutting topic is indicated in the bottom row. "E" signifies that the topic has been identified as an enabler where it is part of a larger activity or discussed in detail within the IP.

IP	Circular economy	Education & training	Policy & regulation	R&I funding programmes & measures	Social awareness, acceptance, & engagement	Standardisation	Socio-economic policies & measures	International cooperation	Total Activities
IP HVDC & DC	E		E		E		E		0
IP Batteries	1	E	E		E	E	E		1
IP EE for Industry	7	1							8
IP Bio	E		E	E			E		0
IP Wind	1	1			1	1	3		7
IP Nuclear	3	1		2	1	1		1	9
IP Geothermal	1		1	1	1		1	E	5
IP PED		E	E	E	E		1	1	2
IP PV							1	1	2
IP Ocean	E	E	2	4		2	1	E	9
Total Activities	**13**	**3**	**3**	**7**	**3**	**4**	**7**	**3**	

Table 8 shows that Education & training, Policy & regulation, Social awareness, acceptance & engagement, Standardisation and International cooperation are the least represented across the IPs, and Circular economy, R&I funding programmes & measures and Socio-economic policies & measures are the best represented and therefore synergies across the IPs should be identifiable. Some comments on the topics:

- **Circular economy** is the most common topic in terms of activities with 13 activities within the IPs Batteries, EE for Industry, Wind, Nuclear and Geothermal. The topic is included in three additional IPs as enabling factors or sub activities; HVDC & DC, Bio and Ocean. Several of the IPs note that the development of technology should be encouraged to incorporate the principles of circular economy and account for the life cycle of components, i.e. availability of raw materials (mining, recycling/reuse, alternative feedstock), the energy consumption of components and their manufacturing as well as end-of-life recovery and re-use. These are principles that hold true across

technologies and can contribute to ensuring access to raw materials, including critical raw materials.

- **Education & training** is present in 3 activities within IP EE for Industry, IP Wind and IP Nuclear. The topic is included in 3 additional IPs as enabling factors or sub-activities; Batteries, PED and Ocean. To increase competitiveness of the EU and ensure capacity-building among researchers, the needed workforce and civil society, education and training are key cross-cutting elements. This includes technological, economic, behavioural and social knowledge as well as cross-sectoral collaboration. For PED, engagement with civil society requires research on their expectations, which may factor into the development of supplying technologies.
- **Policy & regulation** includes 3 activities within IP Geothermal and IP Ocean. The topic is included in 4 additional IPs as enabling factors or sub activities; HVDC & DC, Batteries, Bio and PED. Identified needs include the establishment of long-term stable policy and regulatory frameworks, facilitation of cross-border trade and transmission of electricity as well as adaptations that might be needed with further HVDC development. Specifically for the marine area, spatial planning should ocean energy, as well as adaptation of the EU Environmental Impact Assessment Directive to include offshore windfarm cables. For batteries, considerations could include enforcing declaration of environmental impact, removing double grid fees and using CO_2 emission limits to regulate consumer behaviour.
- **R&I funding programmes & measures** includes 7 activities within IP Nuclear, IP Geothermal and IP Ocean. The topic is included as enabling factors or sub activities in the IPs Bio and PED. Identified needs across IPs are stable financial instruments, funding sources (EU, national, regional and private) as well as schemes to reduce financial risks, such as the creation of an EU Insurance and Guarantee Fund, which is indicated in the IP on Ocean Energy. This is necessary to support demonstration and innovation projects.
- **Social awareness, acceptance, engagement** includes 3 activities within IP Wind, IP Nuclear and IP Geothermal. The topic is included as enabling factors or sub activities in the IPs HVDC & DC, Batteries and PED. The future power system should be technically sound as well as sustainable and accepted by the public. Therefore, solutions should adhere to the principles of circular economy. Activities focus on engaging the public, in cooperation with infrastructure operators, construction industry, real estate developers, research organisations and citizen organisations. The need for analysis of existing and new business models to facilitate introduction of battery storage in electrical transport and static storage is noted for IP Batteries.
- **Standardisation** is mentioned in 4 activities within IP Wind, IP Nuclear and IP Ocean. The topic is included as enabling factors or sub-activities in the IP Batteries. This cross-cutting topic identifies a need for harmonisation of licencing, certification and standardisation. Structures to enable the digital transformation is noted for IP Wind but could also apply to other IPs.
- **Socio-economic policies & measures** is highly relevant as evidenced by identified activities and enabling factors across almost all IPs, e.g. 7 activities within the IPs Geothermal, Ocean, PED, PV and Wind and sub activities within IPs Batteries, Bio and

HVDC & DC. For the future EU-wide energy grid with multiple energy sources and interconnections between countries, regulation of access priority and dispatch needs to be agreed upon. The socio-economic policy ecosystem, i.e. systems integration (markets and financial implications), political and public support as well as social impact and capacity building, should be considered. It is recommended to improve knowledge of the value chains by analysing existing, and proposing new, business and contracting models. These should incorporate organisational, financial, legislative, social and technological barriers. To fully achieve the targets, further investments and funding instruments are needed, especially in connection to demonstration and market deployment of technologies.

- **International cooperation**: The potential for synergies and added value of international cooperation within research and innovation is less addressed across IPs with 3 identified activities within IPs Nuclear, PED and PV and 2 sub activities within IPs Geothermal and Ocean. International cooperation can contribute to meeting the EU's international commitments in energy, climate and health development. It is noted that synergies can be exploited by building upon the knowledge generated by existing international collaboration entities (for example EERA, ETIP, ERA Net and others) and strengthening collaboration between national research capacities. IP PED seeks to start a pilot collaboration with China and to assess additional possibilities for international collaboration. IP Nuclear notes the benefits of enhanced cooperation between MS as well as with third countries in key areas, namely China, Japan, South Korea and USA.

Table 8 is complemented by Table 9, below, which provides an overview of the non-technological cross-cutting topics, the related activities and, when specified in the IPs, the associated budget/resources.

Table 9: Activities identified within the non-technological cross-cutting topics.

Non-technological cross-cutting topic	IP	Related Activities	Allocated budget / resources
Circular economy	IP Batteries	Activity 1.5: Develop circular economy and de-bottleneck availability of critical raw materials	75 M€ required for TRL5-7 and 25 M€ required for subsequent TRL7-9
	IP EE for Industry	Activity 3.1: Resource efficiency	TBD €
		Activity 3.3: CCS/CCU in the cement sector	
		Activity 4.3: Plastic waste as an alternative feedstock	
		Activity 4.4: CO_2 / CO as an alternative feedstock	

		Activity 4.5: Biomass as an alternative feedstock	
		Activity 5.5: Carbon Capture and Usage	For trial and operational testing: 164 M€ For upscaling and operating: 500 M€
		Activity 5.6: Circular economy	TBD €
	IP Wind	Activity 5.4: Ecosystem, social impact & human capital agenda: Circular economy and availability of materials	TBD €
	IP Nuclear	Activity 4: Geological Disposal	150 M€/year (2016-2020) for 10 to 20 years
		Activity 5: Spent fuel and radioactive waste management, decommissioning	100 M€/year (2017-2020) for 5 to 20 years
		Activity 6: Partitioning and Transmutation, nuclear fuel reprocessing, and qualification of new fuel for demonstrators	100 M€/year (2017-2025) for 10 to 30 years
	IP Geothermal	Activity D: Full reinjection of electric heating and cooling plants integrated into the circular economy	123.4 M€
Education & Training	IP EE for Industry	Activity 2.4: Knowledge exchange, training and capacity-building: Improving the exchange of technological, economic, behavioural and social knowledge; training, capacity building and dissemination, to enhance sustainable energy management	1 and 2 M€ per project/deliverable (4 total)
	IP Wind	Activity 5.3: Ecosystem, social impact & human capital agenda: Increase workforce for offshore wind by continuing education and training	TBD €
	IP Nuclear	Activity KEC4: ETKM Education and Training	50 M€/year (2015-2020) for 5 to 10 years
Policy & regulation	IP Geothermal	Activity NTBE A: Involving the public in sustainable geothermal development (Part B)	21 M€ (Parts A&B)
	IP Ocean	Activity 2.2: Promoting Ocean Energy in Marine Spatial Planning	3 M€
		Activity 3.5: Support the development of novel mechanisms to close funding gaps (such as a Public Procurement of Innovative Solutions)	40 M€
R&I funding programmes & measure	IP Nuclear	Activity KEC 2: Stable and predictable investment conditions	10 M€/year (2015-2020) for 5 to 20 years

		Activity KEC5: Supporting Infrastructures	300 M€/year (2014-2021) for 5 to 20 years
	IP Geothermal	Activity NTBE B: Risk mitigation (financial/project)	177 M€
	IP Ocean	Activity 3.1: Dedicated revenue support for the first wave & tidal demonstration farms	circa 225 €/MWh depending on technology and project expect several pre-commercial demonstration arrays
		Activity 3.2: Creation of an investment fund for ocean energy farms	200-300 M€ of private/public investment funding (this is to be outside of contributions from EU, MS and partnering non-EU countries which are in actions 1.1 to 1.6 which totals almost 800 M€)
		Activity 3.3: Creation of an EU insurance and Warranty fund to underwrite various project risks.	50-70 M€ public or private insurance funds – Outside of the 800 M€ from MS, partnering non-EU countries, Regions and EU in actions 1.1 - 1.6.
		Activity 3.4: Funding from EU, national, regional & private sector to support demonstration and innovation projects	1 B€ for Actions 1.1-1.15 and Actions 3.1-3.6
Social awareness, acceptance & engagement	IP Wind	Activity 5.5: Ecosystem, social impact & human capital agenda: Empowering citizens and increasing public engagement	TBD €
	IP Nuclear	Activity 3: Effects of low doses of ionising radiation	150 M€/year (2015-2020) for 10 to 20 years
	IP Geothermal	Activity NTBE A: Involving the public in sustainable geothermal development (Part A)	21 M€ (Parts A&B)
Standardisation	IP Nuclear	Activity KEC3: Harmonization of licensing rules, certification, and standards	10 M€/year (2016-2020) for 10 years

	IP Wind	Activity 3.3: Floating offshore wind & wind energy industrialisation: Enable digital transformation in wind energy system O&M	TBD €
	IP Ocean	Activity 1.15: Standardisation and certification	10 M€ required for 5 small projects
		Activity 2.1: De-risking of environmental consenting through an integrated programme of measures.	7.2 M€ required
Socio-economic policies & measures	IP Wind	Activity 2.4: Offshore wind farms & systems integration: Markets & financing	TBD €
		Activity 5.1: Ecosystem, social impact & human capital agenda: Nature-inclusive wind energy (and multi-use)	
		Activity 5.2: Ecosystem, social impact & human capital agenda: Assessment methods to quantify/qualify the impact of research projects	
	IP Geothermal	Activity NTBE B: Risk mitigation (financial/project)	177 M€
	IP PED	Activity 7: EUA-EPUE – Capacity Building	5 M€
	IP PV	Activity 4: Operation and diagnosis of photovoltaic plants	60 M€
	IP Ocean	Activity 2.3: Promoting political support and public backing for ocean energy	3 M€
International cooperation	IP Nuclear	Activity KEC6: INCO[3] International cooperation	10 M€/year (2015-2020) for 5 to 20 years
	IP PED	Activity 1: JPI Urban Europe –European Positive Energy Cities	2 M€ from participating countries over 8 years
		Activity 4: EERA JP SC - Diffusion of knowledge and experiences	18 M€ (4 years)
		Activity 8: JPI Urban Europe – International Cooperation	35 M€
	IP PV	Activity 6: Cross-sectoral research at lower TRL	Reallocation of resources for national labs

[3] https://cordis.europa.eu/article/id/7743-inco-cooperation-with-third-countries-and-international-organizations

5.2 Non-technological cross-cutting enablers

As shown in Table 7, 6 IPs have identified enablers or sub-activities within non-technological cross-cutting topics where they do not have wider activities. IPs without any identified enabling non-technological cross-cutting topics are IP EE for Industry, IP Wind, IP Nuclear and IP PV. For IP Wind, and IP Nuclear this is most likely due to the high number of topics already covered by activities, whereas IP EE for Industry and IP PV only cover two non-technological cross-cutting topics each.

Counting both activities and enablers Circular economy and Socio-economic policies & measures are the most well covered by the IPs. All non-technological cross-cutting topics are mentioned as an enabler in at least one IP. Policy & regulation is the most common with 4 IPs identifying Policy & regulation as an enabler and Standardisation is the least common as it is only 1 IP identifying Standardisation as an enabler.

Table 9 is complemented by Table 10, below, which provides an overview of the technological cross-cutting topics and the discussion as a related enabler within the IPs.

Table 10: Enablers and sub activities identified within the non-technological cross-cutting topics.

Non-technological cross-cutting topic	IP	Comments and sub activities within the IP
Circular economy	IP HVDC & DC	The IWG notes that it is a purpose of the IWG to stimulate the development of technology which respects the circular economy principles and so there will be the need to investigate and account life cycle environmental impact of this kind of structures, such as the raw materials mining and treatment (before installation), energy consumption from components and equipment manufacturing, soil occupation (during installation and use); equipment disassembly, components end-of-life recovery (e.g. reuse or recycling). Furthermore, The Environmental Impact Assessment Directive, which obliges Environmental Impact Assessments (EIAs) to be carried out before projects that are likely to have an impact on the environment are approved, is noted.
	IP Bio	The IWG identifies support of sustainable feedstock mobilisation as a key enabler. The development and use of currently unexploited sustainable waste, biomass and land resources to supply advanced technologies, with particular emphasis on applying principles of circular economy.
	IP Ocean	Within Activity 2.1, there is a sub activity encouraging a circular economy approach in the design of ocean energy technologies).
Education & Training	IP Batteries	Cross-functional activity without funding on “Improving technological, economic, behavioural and social knowledge; training, capacity building and dissemination”. Regarding training, this covers both workers and researchers needed to increase competitiveness in the EU.

	IP PED	Capacity building, education and training is noted as a key challenge and requirement for deployment of PED and as such is included within Activity 7 as “Capacity building and engagement with civil society”. It is noted that capacity building should undertake a comparison of the Universities’ curricula to agree upon a common workflow (e.g. concept of Collaborative Innovation Networks). Furthermore, engaging with civil society requires research on their expectations which are often unknown or heterogeneous.
	IP Ocean	Within Activities 1.1 and 1.2, there is a sub activity for facilitation of knowledge and cross-sector collaboration.
Policy & regulation	IP HVDC & DC	Non-technical challenges have been identified. These cover i) the legal framework, which needs to be adapted to facilitate the development of a meshed offshore electricity grid; ii) network codes, which serve specifically to facilitate cross-border trade and transmission of electricity and may need to be altered with further HVDC developments; and iii) the EIA directive, which covers on- and offshore windfarms but not yet the offshore underground cables.
	IP Batteries	The need to establish an enabling regulatory framework for competitiveness in the batteries field is noted. This covers: i) tightening recycling norms with possibilities of enforcing declaration of environmental impact of battery production for battery producers and importers should be considered; ii) harmonisation of the different regulations concerning the transportation of dangerous goods to facilitate second use of EV batteries; iii) removing barriers for storage expansion within the context of the new Electricity Market Directive and Regulation take effect, which notably concerns the removal of double grid fees which are badly affecting the expansion of battery-based storage; iv) encourage MS to exempt users from taxation on energy losses from charging/discharging batteries when applying the Energy Taxation Directive at national level; v) using legislation on CO_2 emission limits as a tool to encourage e-mobility uptake by consumers; and vi) introducing CO_2 limits for "yellow machines" and other non-regulated sectors should be carefully considered.
	IP Bio	A successful outcome of this IP will depend on enablers and barriers alike. Enablers include the creation of a long-term stable policy framework and well-established, transparent and agreed framework on sustainability criteria for all feedstocks from agriculture, forestry as well as for biological and municipal waste.
	IP PED	Within Activity 4, there is a sub activity to suggest revising the regulatory framework. This means identification and documentation of barriers, challenges and opportunities in existing PED projects. This would explore the main causal mechanisms that either enable or inhibit the successful diffusion of PED innovation, systems, or policies, and how PED innovations can be scaled up both within the EU and beyond.
R&I funding programmes & measures	IP Bio	It is noted that further investments, funding sources and financial instruments will be needed to fully achieve the targets, especially in connection to demonstration, first-of-a-kind plants and market deployment of technologies including socio-economic aspects.
	IP PED	Within Activity 2, there is a sub activity for: i) the preparation of the implementation of the Strategic R&I Plan into a series of transnational calls; ii) Planning and execution of calls towards PED Labs and

		Innovation Actions for PEDs; and iii) facilitation of transnational collaboration regarding the alignment of national programmes and R&I funding calls towards PEDs.
Social awareness, acceptance & engagement	IP HVDC & DC	As a non-technical challenge, it is noted by the IWG that the future (HVDC based) power system should not only be technically sound, but also be a sustainable and socially acceptable solution. As such, solutions need to adhere to circular economy principles and be well accepted by communities.
	IP Batteries	Within "Statement on improving technological, economic, behavioural and social knowledge; training, capacity building and dissemination", analysis of existing, and proposals for new business and contracting models, considering organisational, financial, legislative, social and technological barriers are listed as a sub-activity. This would contribute to optimising the introduction of battery storage applications in electrical transport and static renewable electricity storage in cooperation with energy regulators.
	IP PED	Within Activity 1, there are identified sub activities to mobilise cities with an ambition to develop: i) "Positive Energy Districts for sustainable urbanization" for a European city-driven networking activity in cooperation with public utilities, infrastructure operators, construction industry, real estate developers, research organisations and citizen organisations, and ii) PED Labs: repairing and setting up PED Labs using a placed-based perspective and experience with new digital planning, permit giving, construction, and building management standards, regulatory innovation zones, new technologies, sector coupling, stakeholder involvement, etc.) Within Activity 4, there are identified sub-activities to: i) develop and scientifically validate PED definition and boundary conditions; ii) define, plan and execute the RDI needed to move from PED to Positive Energy Cities and Societies, in line with new knowledge and ambitions on an international, EU and national scale; iii) use own facilities as living labs (our own campuses, research and work facilities, cities); and iv) support development of existing and new PED Labs to function as open innovation playgrounds.
Standardisation	IP Batteries	As a non-R&I enabler, establishing an enabling regulatory framework for competitiveness in the batteries field is listed as a key cross-functional activity. This covers: i) harmonisation of safety requirements; ii) real-life representative application-based duty cycle standards, testing standards and performance certificates; and iii) best practices for battery connection rules for providing different grid services.
Socio-economic policies & measures	IP HVDC & DC	As a non-technical challenge, market rules are noted by the IWG. The priority access and dispatch rules reduce the risk on investments for RES, as the certainty that the generated electricity can be sold on the market increases when the access to the grid is prioritised. However, in a meshed offshore grid where the connection of on- and off- shore energy is mixed with interconnection between countries, clear agreements have to be made. For example, it should be decided whether the full capacity of the cable is available for transportation of the offshore generated electricity (which means that this electricity always has priority access), or whether part of the cable is separated in some way and reserved for interconnection.

	IP Batteries	Within improved knowledge of the value chain, a recommended enabling activity is the analysis of existing, and proposals for new, business and contracting models, considering organisational, financial, legislative, social and technological barriers. This would contribute to optimising the introduction of battery storage applications in electrical transport and in static renewable electricity storage where cooperation with energy regulators is also key.
	IP Bio	As stated in "R&I funding programmes & measures", further investments, funding sources and financial instruments will be needed to fully achieve the targets, especially in connection to demonstration, first-of-a-kind plants and market deployment of technologies including socio-economic aspects.
International cooperation	IP Geothermal	Seven key international cooperation for identified and related to activities in the IP: GEMex, IEA-Geothermal TCP, GGDP, Global Geothermal Alliance, GEOTHERMICA, EERA JP Geothermal, ETIP Deep Geothermal. These organisations have been given alongside which activities they are linked to. This allows synergies to be exploited across activities and international organisations.
	IP Ocean	Within Activity 1.5, it is noted that the identification of novel concepts should use internationally agreed evaluation criteria via structured product verification approaches that build on prior knowledge and experience (e.g. a stage-gate approach).

VI INPUT FROM EERA JOINT PROGRAMME COORDINATORS ON CROSS-CUTTING TOPICS

6.1 JPs input on the SET Plan revamp

EERA is structured in 18 thematic JPs covering various low-carbon technologies and systemic areas of the clean energy transition. For the purpose of this analysis, EERA JP Coordinators were asked to provide inputs for the cross-cutting areas that corresponded to their areas of expertise. Below, is the list of the cross-cutting areas and topics identified in this analysis juxtaposed to the EERA JPs who provided their contributions for defining the list of the topics for each of the cross-cutting areas.

Table 12 below is complemented with information from the Deliverable 1.3 were almost all EERA JPs contributed to a survey concerning the revamping process of the SET Plan. In that survey, among other, they were asked to indicate the three most relevant non-technological cross-cutting topics of their domain.

Table 11: Technological cross-cutting topics identified by EERA Joint Programme Coordinators

Technological cross-cutting topics	Contributing EERA JPs
Energy efficiency	JP Energy Efficiency in Industrial Processes, JP Wind
Energy systems integration	JP Energy System Integration, JP CCS
High temperature & advanced materials	JP AMPEA
Energy storage	JP Energy Storage
Digitalisation	Transversal JP on Digitalization of Energy
Security & safety	No contribution from the JPs

Table 12: Non-technological cross-cutting topics identified by EERA Joint Programme Coordinators

Non-technological cross-cutting topic	Contributing EERA JPs
Circular economy	JP Wind, JP E3S, JP Nuclear Materials, JP CCS
Education & Training	JP E3S, JP Nuclear Materials, JP PV, JP EEIP, JP DfE, JP Wind, JP Geothermal, JP Ocean, JP Smart Grids, JP Energy Storage
Policy & regulation	JP Wind, JP E3S, JP CSP, JP Nuclear Materials, JP Smart Cities, JP Bio, JP AMPEA, JP Geothermal, JP Ocean, JP Smart Grids

R&I funding programmes & measures	JP Nuclear Materials, JP Wind, JP EEIP, JP AMPEA, JP PV, JP Hydro, JP DfE, JP CSP
Social awareness, acceptance & engagement	JP Wind, JP E3S, JP CSP, JP DfE, JP Nuclear Materials, JP PV,
Standardisation	JP AMPEA , JP Wind, JP DfE, JP ES
Socio-economic policies & measures	JP E3S, JP Smart Cities, JP Hydro
International cooperation	JP Wind, JP PV, JP Energy Storage, JP EEIP, JP Bio, JP AMPEA, JP Geothermal, JP Ocean

6.2 Discussions during EERA Annual Strategy Meeting (22-23 June 2022) and JPCs meeting (6-7 December 2022)

Discussions on cross-cutting topics (both technological and non-technological) were facilitated in the framework of the EERA Annual Strategy Meeting (ASM) that took place in Prague (22-23 June 2022), and the EERA Joint Programme Coordinators' meeting that took place in Brussels on 6-7 December 2022. The issues and topics that were addressed during these meetings are categorised per cross-cutting topic in the Table 13 below:

Table 13: Cross-cutting topics discussed during the EERA ASM and JPC meetings.

Technological and non-technological cross-cutting topics	Topics addressed during EERA ASM, and EERA JPCs meetings
Energy efficiency	ASM: Discussion on amendment to the Recovery Resilience Fund on Energy efficiency in buildings and the decarbonisation of industry JPC: The importance of the heating sector on the overall primary energy consumption
Energy systems integration	ASM: Integration of wind and solar energy should create win-win situations with the other sectors (e.g. agriculture) JPC: Heating as an enable of energy system integration
High temperature & advanced materials	JPC: Overall, materials' research agenda is hugely underfunded by the EC, especially since the Russian invasion
Energy storage	ASM: Short, but also long-term energy storage is crucial for a more flexible and decarbonised energy system; JPC: Importance of seasonal heating storage to match the seasonality of demand and supply from renewables
Digitalisation	-
Security & safety	ASM: Main powers of the REPowerEU is to develop the access and the use of EU's resources that will bring more autonomy, security, and competitiveness. JPC: Europe should start producing PV modules domestically, since it is already a mature technology; Critical dependencies on raw materials for low carbon technologies' manufacturing; current electricity market might cause an underinvestment in the energy system that could hinder its reliability.
Circular economy	ASM: The critical role of developing sustainable supply chains.
Education & Training	ASM: Identification of bottlenecks in the REPowerEU relevant to the lack of skills to support the clean energy transition (including new skills for regulators and legal workers);

Policy & regulation	ASM: The main topic of discussion was the REPowerEU plan. JPC: EERA community will support the Secretariat on setting up periodic scientific events on key X-cutting topics, relevant to major EU policies; National policy knowledge to be brought to the EERA policy working group.
R&I funding programmes & measures	ASM: JPC: Common proposal with the participation of all JPs on sharing energy research infrastructure; Presentation on the European Centre of Excellence on Wind Energy; Towards an increased role of researchers in the EU Innovation Fund projects
Social awareness, acceptance & engagement	JPC: The restructuring of the JP E3S will see the participation of all JPs that will facilitate their collaboration on topics relevant to SSH, More information on CCS acceptance is available
Standardisation	JPC: Metadata standards as a way to encourage researchers to use the same standards;
Socio-economic policies & measures	JPC: Wind: interest in sustainability assessment for wind technology;
International cooperation	ASM: Discussion about the role of EERA on mediating for improved participation of EU-13 countries to the SET Plan and R&I funding schemes JPC: CEP-NM: co-funded European partnership on nuclear materials will be in operation soon.

6.3 Collaboration on cross-cutting topics in the framework of the JP E3S

In the framework of the Joint Programmes and particularly the JP E3S, a substantial collaboration of EERA members on cross-cutting activities is implemented by enlarging the scope and influence of the. The JP E3S promotes an energy transition where people and society are at the heart of solving the climate and ecological challenges. JP E3S's structure is currently under revision with the objective to identify synergies in the domain of social sciences and humanities with other EERA Joint Programmes. More precisely the restructuring plan foresees the following activities: a) the establishment of a new sub-programme with a focus on SSH; b) organization of a joint workshop with the Joint Programme Photovoltaic Solar Energy to address topics related to socio-economic sustainability; c) organization of a joint workshop with the COST Action on Geothermal District 12.

During the JPC meeting, the revision process of the JP was discussed, showing the interest of the most JPs on having an ambassador in the JP E3S that will facilitate the connection with their JP on relevant issues, but also identify any possible collaborations with other JPs. For instance, some initial thoughts indicate that the following tasks could be performed by the members of the JP E3S: a) stakeholder analysis and engagement, b) strengthening the SSH aspects of the JPs and identify common non-technological areas for collaboration.

6.4 Input from materials workshop on cross-cutting topics

The conclusions from the material workshop on cross-cutting topics reflect the importance of bringing materials science to the forefront of Europe's energy research landscape, including the SET Plan, if we are to achieve the net-zero objectives.

On July 1st 2022, EERA and its Joint Programmes on Nuclear Materials (JPNM), Advanced Materials and Processes for Energy Applications (JP AMPEA), and Digitalisation for Energy (DfE) kicked off its virtual workshop series Energy Materials for Innovation (EM4I). In this inauguration workshop dedicated to materials discovery and development, nine invited speakers from energy research and industrial communities across Europe presented a wide range of overarching issues for enabling accelerated materials research at the centre of Clean Energy Transition.

As main conclusions, the experts participating in the workshop arrived at the following takeaways:

- The European Commission's proposal to cut greenhouse gas emissions by at least 55% by 2030 sets Europe energy research and technology development on an accelerated path. Advanced materials are a backbone of innovation for achieving climate neutrality by 2050 while ensuring a safer, healthier, and more resilient and prosperous lifestyle for all.
- Such accelerated materials and technology development requires a systemic, cross-cutting approach that considers the whole value chain from basic research to scale-up production, market acceptance, cost performance, and durability.
- The need for fast and efficient energy materials development is quickly transforming the way research is practiced.
- High throughput materials design has seen great success due to numerical tools such as artificial intelligence. The AI-assisted simulations are powerful in analysing and screening experimental data where physical models (analytical) lack, enabling fast and efficient screening of candidates via the elimination of less promising materials or discovering novel ones with theoretically interesting properties.
- For numerical simulations (AI-assisted or not) to function, the availability of large sets of experimental data with specific choices of material properties is crucial. High-throughput approaches, such as combinatorial characterization and the use of miniaturized samples, have demonstrated their effectiveness in this regard.
- Experimental data on microstructures and under in-situ/operando conditions are also important for improving models (numerical or analytical) since the properties of the materials are often dependent on such parameters.
- A continuous feedback loop between real data and simulations is the key to delivering breakthrough energy materials and technology on time.
- Once the TRL 5/6 is reached, the materials exploitation issues are no longer technical but socio-economic hinders. This fact underlines the importance of a systems approach.

VII CONCLUSIONS AND RECOMMENDATIONS

The document represents the final report and provides a mapping of existing cross-cutting and interdisciplinary topics – both technological and non-technological - and related activities described in the EU's Strategic Energy Technology Plan (SET Plan) Implementation Plans (IPs).

The document starts by outlining the technological cross-cutting topics identified in the IPs and by presenting the number of IPs that mention a given topic and identifying synergies across these topics, both technological and non-technological; e.g. that Energy System Integration has ties to other technological topics like Energy Storage and Digitalisation.

The second section describes the non-technological cross-cutting topics identified in the IPs, namely: Circular Economy, Education & Training, Policy & Regulation, R&I Funding Programmes assures, Social Awareness-Acceptance-Engagement, Standardisation, Socio-economic Policies & Measures, and International Cooperation.

The conclusions and recommendations are based on the following aspects:

- Template provided to the IWGs for drafting the IPs
- Identified technological cross-cutting issues
- Identified non-technological cross-cutting issues
- Input received by the EERA Joint Programmes Coordinators via several activities and meetings
- Follow up on the series of workshops on materials

7.1 Recommendations/Template for drafting IPs

The template provided has not changed between the creation of the new IPs, and a similar lack of consistency has been pointed out across the IPs. The information collected and the activities addressed by the IWGs appeared to be quite different. This makes it difficult for both IWGs and relevant stakeholders to identify synergies across the respective IPs.

It is recommended that the template should be clearer and more detailed, in order to collect uniformised and comparable data between different IPs. Specifically for cross-cutting topics, there should be a clear definition of cross-cutting issues (both technological and non-technological) to have a common understanding of which activities could be relevant and the level of detail that should be collected. These aspects should not be underestimated taking into consideration the role played by the IPs in accelerating the energy transition.

Beyond cross-cutting topics, there is a variety of specifications regarding the budgets and TRLs associated with each activity. Some IPs give no information on budgets and TRLs, some give very wide estimations, and other more detailed IPs give budgets with their expected number of projects. In all cases, there is no information on the progress of a specific activity. This is both regarding what financing has been secured and whether the technology is on track to reach its projected targets. This makes it challenging to determine what future financing is required and, in particular for technological cross-cutting topics, where synergies can be best exploited in line the TRL of the activity.

7.1.1 Technological cross-cutting issues

By analysing collected data for the technological cross-cutting topics the main conclusions are as follows:

1. **Energy Efficiency.** Energy efficiency aspects are only included in half of the IPs, even though the Union's energy efficiency targets are essential towards the low-carbon economy. Energy efficiency is seen important in relation to buildings and industry, even if it should be considered in all IPs.
2. **Energy System Integration.** Energy system integration as a horizontal topic to all IPs is present in nearly all IPs (missing from IP Nuclear), and synergies between different technologies are identified. This will ensure the EU energy system is sufficiently flexible to accommodate renewable energy sources (excluding nuclear). Energy system integration aspects should be covered in IP Nuclear to integrate nuclear energy. It is further proposed that cooperation across the IPs should be included in the integration activities.
3. **High Temperature & Advanced Materials.** On the one hand, development of materials for energy applications plays an important role in the IPs where activities have been identified in 7 of the 10 analysed IPs. The applications differ from IP to IP, but the cooperation on materials development could produce technological benefits for several IPs. Synergies here are more prevalent at low-mid TRL, encompassing the research and development of new materials and building the supply chain/manufacturing processes. On the other hand, the SET Plan is currently working to extend its ambition in terms of the objectives and targets to enhance EU competitiveness in clean energy technologies in light of the launch of the Fit for 55 packages in order. The main take aways from the series of workshops that will be carried out under the initiative named Energy Materials for Innovation (EM4I) could be used as feedback for expanding its scope to include emerging technologies identified by experts on these topics.
4. **Energy Storage.** Energy storage includes activities in 2 of the 10 analysed IPs and is identified as an enabler in a further 4 IPs. Energy storage represents a key technology for enabling renewable energies and synergies between different IPs should be exploited. It is a weaker area than previously, where there were several technologies; material, component and system development needs were well mentioned. However, as the topic has strong links with Energy systems integration, where synergies could be exploited across the identified activities in both of the tightly connected technological cross-cutting topics.
5. **Digitalisation.** Digitalisation is much more frequently identified by the IPs than the previous categories. This reflects that the IWGs recognise that digital technologies such as AI, blockchain and internet of things are key technologies driving the next wave of the digital transformation and could enhance existing processes, create entirely new business models, and develop innovative products and services for a new generation of consumers.
6. **Security & safety.** This topic is the least covered by the IPs and has strong links to digitalisation, via cyber security, as well as links to topics that address the security of supply such as Energy efficiency, Energy systems integration, and Energy storage. For

better coverage of this topic in future implementation plans, IWGs can include the security priorities mentioned in REPowerEU and the Security & safety issues in the IPs listed as activities or enablers.

7.1.2 Non-technological cross-cutting issues

As far as collected data for the non-technological cross-cutting topics regards, the main conclusions are:

1. **Circular Economy.** The IPs without funding associated with circular economy activities should consider doing so, in particular considering the new circular economy action plan (CEAP)[4] where the objectives (make sustainable products the norm in the EU; empower consumers and public buyers; focus on the sectors that use most resources and where the potential for circularity is high such as electronics and ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food, water and nutrients; ensure less waste; make circularity work for people, regions and cities; and lead global efforts on the circular economy) cover all technologies.
2. **Education & Training.** Despite many IPs are mentioning Education and Training it is not always clear which type of activities are implemented, moreover in most cases, there is no funding tied to this activity – there are only 3 activities across the IPs identified in this topic. Given the recent council adoption of "recommendation to stimulate learning for the green transition and sustainable development"[5], it is key to quickly recognise necessary skills and synergies. It could be relevant to, e.g., map education and skills needed in evolving energy fields, and to address the education gaps. All IPs that have activities within Education & Training, or have identified it as an enabling topic, also explicitly include the re-skilling of workers towards green technologies.
3. **Policy & Regulation.** Most IPs mention the presence of regulatory bottlenecks at both EU and National levels. However, there are only 2 IPs with associated activities. IPs should consider what activities would create a transparent and stable regulatory environment guaranteeing investors' confidence as a necessary condition to achieve the identified targets.
4. **R&I Funding Programmes and measures.** The allocation of R&I Funding and a budget is a necessary precondition for addressing many of the activities indicated in the IPs. Information such as the implementation instruments (funding programmes) to be mobilised and their associated indicative financing contribution to support R&I activities should be mentioned in the Implementation Plans by their corresponding Implementation Working Groups. This is a complex exercise since there is a variety of funding opportunities available at European, national and regional levels. Therefore, this information is scattered through different funding agencies and databases, resulting in partial and non-uniformised information across the different Implementation Plans. A common database including information about the most relevant programmes

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN
[5] https://data.consilium.europa.eu/doc/document/ST-9242-2022-INIT/en/pdf

at European, national and regional level would be of great interest and added value for the whole SET-Plan community. Additionally, one instrument mentioned in several IPs for the alignment of public and private financing is the creation of public-private partnerships. Eventually, risk financing is also identified as a common barrier in several Implementation Plans. Development of ad-hoc financial schemes could be promoted to improve access to loans for R&D projects with high uncertainty/risk. As already described above, it would also be useful for IPs to identify funding spent, funding secured, and funding needed along the development pathways, as well as estimations for the funding required at critical timepoints or key TRLs in the IPs.

5. **Social Awareness-Acceptance-Engagement.** To achieve the EU goals towards a climate-neutral future for Europe in terms of speed, effectiveness and equality, specific actions to engage with citizens in novel ways and improve societal relevance and impact are needed. Therefore, any revisions to the IPs should have dedicated sections related to Social Sciences and Humanities (SSH), including tangible recommendations. IP Wind, IP Nuclear, and IP Geothermal could be used as examples as they include specific activities in SSH research and innovation. In addition, they should move beyond social awareness/ acceptance/ engagement and consider all relevant aspects of SSH, such as early participation of stakeholders in meaningful ways; learning from innovative bottom-up approaches, and the recognition of the important roles of professionals in the energy system (not just 'end-users')[6].
6. **Standardisation.** By documenting and sharing information on state-of-the-art technology and providing a framework for technology-related policies, standardisation represents an essential tool for policy-makers in defining and supporting national legislation and regulation for renewable energy. There are 4 IPs with related activities and a different IP identifies Standardisation as an enabler. This topic has strong links to Policy & regulation, and IP EE for Industry and IP PV do not have activities or identified enablers in either of the topics. An explicit requirement for the IWGs to address this point would be relevant.
7. **International cooperation.** International cooperation is seen as having a key role in contributing to the implementation mechanisms indicated in the IPs. However, there are few related activities and very few note international cooperation as an enabler (beyond the funding mechanisms). As International cooperation is a broad term, it could be more effective for the achievement of the actions described in the IP, if references to the specific types and scales of collaborations are included: e.g. transnational, European, bilateral, gov-to-gov collaboration/exchange.

[6] https://energy-shifts.eu/

ANNEX 1

SUPEERA task 1.3 Cross-cutting and interdisciplinary activities, Technological

EERA Joint Programmes: AMPEA: Advanced Materials and Processes for Energy Applications, Bio: Bioenergy, CCS: Carbon Capture and Storage, CSP: Concentrated Solar Power, DfE: Digitalisation for Energy, e3s: Economic, Environmental and Social Impacts, EEIP: Energy Efficiency in Industrial Processes, ES: Energy Storage, ESI: Energy Systems Integration, FCH: Fuel Cells and Hydrogen, Geothermal: Geothermal, HP: Hydropower, NM: Nuclear Materials, OE: Ocean Energy, PV: Photovoltaic Solar Energy, SC: Smart Cities, SG: Smart Grids, Wind: Wind Energy

Technological cross-cutting topic	IP and country composition of IWG	Related Activities	Allocated budget / resources	TRL progression	Relevant JP(s)	Other potentially interested JP(s) and related IP(s)
Energy efficiency	IP EE for Industry[7]	Activity 1.1: Heat upgrade from low to high grade - Heat pumps	7-8 M€ per project.	5→7 (≤250°C) 3→6 (≥250°C)	JP EEIP	JP AMPEA
		Activity 1.2a: Use of low/medium temperature waste heat (120 - 350ºC) to generate electrical power at high efficiency	TRL 1-4: 3 M€ per project; TRL 4-7: 14 M€ per project	1/4→4/7 (small systems) 4→7 (large systems)	JP EEIP	
		Activity 1.2b: High temperature waste heat recovery to generate electrical power at high efficiency	80 M€	4→7	JP EEIP	
		Activity 1.3: Waste and renewable heat to cold generation	TRL 4-5: 2 M€; TRL 5-7: 14 M€	4→7	JP CSP, JP EEIP	

[7] *For all activities it is stated that additional budget is required to achieve TRL8 and 9*

		Activity 1.4a: Hybrid plants for waste heat upgrade integrating renewable energy into industrial plants and processes	TRL 5-7: 30 M€	4→7	JP CSP, JP EEIP	JP Bio, JP ESI
		Activity 1.4b: Advanced compact Combined Heat and Power - plants of industry scale	TRL 3-5: 3 M€; TRL 5-7: 7 M€	3→5 5→7	JP CSP, JP EEIP	JP ESI
	IP Bio	Activity 8: Develop high efficiency large scale biomass cogeneration of heat and power	0.5 B€	2/3→5	JP Bio	JP AMPEA, JP EEIP
		Activity 9: Demonstrate high efficiency large scale biomass cogeneration of heat and power	0.8 B€	Not specified	JP Bio	JP EEIP
		Activity 10: Scale-up high efficiency large scale biomass cogeneration of heat and power	10 B€	7/8→9	JP Bio	JP EEIP
	IP Nuclear	Activity 9: Cogeneration of heat and electricity	20 M€/year (2017-2020) for 10 to 20 year	Not specified	NM	JP EEIP
	IP Geothermal	Activity C: Improvement of overall geothermal energy conversion performance for electricity generation, and heating & cooling	21 M€	5/6→7/8	JP Geothermal	JP EEIP
	IP PED	Activity 11: RHC-ETIP – Industry support	7 M€	7-9	JP SC, JP EEIP	JP DfE?
		Activity 12: Euroheat & Power – Industry support	0.5 M€ over the course of 8 years	7-9	JP SC, JP EEIP	JP DfE?
Energy systems integration	IP HVDC & DC	Activity ST-CP-1: Multi-vendor interoperability - first European full-scale implementation of Multi-Vendor Multi Terminal Voltage Source Converters	TBD €	6-7	JP ESI, JP SG	Potentially all IPs

		Activity ST-CP-2: Grid forming capabilities offered by HVDC systems		4-6	JP SG	Potentially all IPs
		Activity ST-P-1: Methods and tools for combined system (HVAC & HVDC) expansion		2-5	JP SG	JP DfE
	IP Batteries	Activity 3.2: Second use and smart integration into the Grid	15 M€	Products: 7→9 System: 6→8	JP SG	JP DfE, JP SC, JP ESI
	IP EE for Industry	Activity 2.1: Industrial Symbiosis: between energy intensive industries to valorise energy losses streams and better manage energy globally	4-5 M€ for low TRL 15-20 M€ for high TRL	4/5→7/8	JP EEIP, JP ESI	JP DfE
		Activity 2.2 - Non-conventional energy sources in process industry including carbon capture and use	TRL 4-6: 20–30 M€ per project; TRL 6-9: 10-20 M€ per project. - 200 M€ for electric furnaces and crackers each	4→6→9 (sector dependent)	JP EEIP, JP ESI	JP: AMPEA, JP Bio, JP CSP, JP ES

			- 50 M€ per CCU demonstration plant (TRL7-8)			
	IP Bio	Activity 4: Develop other renewable liquid and gaseous fuels (excluding hydrogen) through thermochemical/ chemical/ biochemical /electrochemical transformation of energy neutral carriers with renewable energy	0.2 B€	2/3→5	JP Bio, JP ESI, JP SG	JP AMPEA, JP ES
		Activity 5: Demonstrate other renewable liquid and gaseous fuels (excluding hydrogen) through thermochemical/ chemical/ biochemical/electrochemical transformation of energy neutral carriers with renewable energy	0.4 B€	6/7→8	JP Bio, JP ESI, JP SG	JP ES
		Activity 6: Scale-up other renewable liquid and gaseous fuels (excluding hydrogen) through thermochemical/chemical/biochemical/electrochemical transformation of energy neutral carriers with renewable energy	10.08 B€	7/8→9	JP Bio, JP ESI, JP SG	JP CSP, JP DfE, JP ES
		Activity 7: Production of renewable hydrogen from water electrolysis and renewable electricity	0.41 B€	2→9	JP Bio, JP ESI, JP FCH, JP SG	JP CSP, JP ES IP Wind IP HVDC & DC
	IP Wind	Activity 2.1 Offshore wind farms & systems integration: Design and control of wind power plants and HVDC grids for power system with zero CO_2 emissions	TBD €	Medium	JP SG, JP Wind	JP AMPEA, JP DfE, JP OE, JP ESI IP HVDC & DC
		Activity 2.3 Offshore wind farms & systems integration: Sustainable hybrid solutions, storage, and power to X		High	JP SG, JP Wind	JP DfE, JP ES, JP ESI, JP OE

						IP HVDC & DC
	IP Geothermal	Activity B: Integration of geothermal heat and power in the energy system and grid flexibility	11.5 M€	4/5→7/9	JP Geothermal, JP SG	JP DfE, JP ESI, JP SC IP HVDC & DC
	IP PED	Activity 9: ECTP – From Positive Energy Blocks to Districts	12 M€	7-9	JP SC, JP SG	JP Bio? JP DfE, JP e3s, JP EEIP, JP ESI IP Batteries, IP PV IP HVDC & DC
	IP PV	Activity 1: PV for BIPV and similar applications	Specific R&D into the integration topics and production technologies, related to specific market segments, would require around 5 M€/year to reach critical mass and EU cooperation. For joint demonstration and feasibility projects close to the market one would need	3 (PoC) to 7 (technology dependent)	JP PV	JP SG, JP SC IP Batteries, IP PED IP HVDC & DC

			additional 2-5 M€/year in total			
	IP Ocean	Activity 1.11: Developing and demonstrating near-commercial application of ocean energy in niche markets and hybrid systems	100 M€ for 10 medium sized projects and a few large projects	7-9	JP OE	IP HVDC & DC
		Activity 1.12: Quantifying and demonstrating grid-scale benefits of ocean energy	6 M€ for a few small projects	7-9	JP OE, JP SG	JP DfE IP HVDC & DC
High temperature & advanced materials	IP HVDC & DC	Activity ST-T-3: Further development of Wide Bandgap (WBG) materials	TBD €	4-6		
	IP Batteries	Activity 2.1: Foster development of materials processing techniques and components for fast industrialization compatible with present mass production lines.	50 M€ (4-year projects, 5 projects)	Assembling: 9→10 Materials: 5→8 Recipe: 5/7→8 Cell: 6→9		JP AMPEA, JP ES, JP ESI
		Activity 2.2: Foster development of cell and battery manufacturing equipment	TBD €	Production process: 4→7		
	IP Bio	Activity 4: Develop other renewable liquid and gaseous fuels (excluding hydrogen) through thermochemical/ chemical/ biochemical /electrochemical transformation of energy neutral carriers with renewable energy	0.2 B€	2/3→5	JP Bio	JP AMPEA, JP ES, JP ESI IP PED IP Offshore Wind
		Activity 9: Demonstrate high efficiency large scale biomass cogeneration of heat and power	0.8 B€	Not specified	JP Bio	JP ESI

						IP PED
	IP Wind	Activity 1.4: Next generation wind turbine technology: New and smart materials	TBD €	Medium	JP Wind	JP AMPEA
		Activity 6.3: Basic wind energy sciences: Material science for sustainability		Low	JP Wind	Potentially all IPs with activities within materials
	IP Nuclear	Activity 7: Innovative materials to improve plant safety and efficiency, and qualification for operation under Gen-IV conditions	50 M€/year (2017-2021) for 10 to 20 years	Not specified	JP NM	JP AMPEA
	IP Geothermal	Activity E: Sustainable and efficient production technologies	25.6 M€	2/4→6/9	JP Geothermal	
	IP PV	Activity 3: New technologies & materials	For each main topic (multijunction devices on Si or CIGS and CPV) is in the range of 15–50 M€	3-7	JP PV	JP AMPEA, JP ES
		Activity 5: Manufacturing technologies	For each equipment topic is in the range of 10–50 M€	R&I: 6/7→8/9 Applied: 3/5→5/7	JP PV	
Energy storage	IP Batteries	Activity 1.3: Advancement of batteries for stationary energy storage	TRL3-7: 50 M€; TRL7-9: 15 M€ 6-8 M€ per project	3→7 7→9	JP ES	IP PED IP PV
		Activity 3.1: Hybridisation of battery systems for stationary energy storage (ESS)	25 M€	3→7	JP ES	JP PV, JP Wind

						IP PED, IP PV
	IP Bio	Activity 5: Demonstrate other renewable liquid and gaseous fuels (excluding hydrogen) through thermochemical/ chemical/ biochemical /electrochemical transformation of energy neutral carriers with renewable energy	0.4 B€	6/7→8	JP Bio	JP ES IP PED, IP Offshore Wind
		Activity 11: Develop solid, liquid and gaseous intermediate bioenergy carriers through biochemical / thermochemical/ chemical conversion from sustainable biomass	0.5 B€	2/3→5	JP Bio	JP ES
		Activity 12: Demonstrate solid, liquid and gaseous intermediate bioenergy carriers through biochemical / thermochemical/ chemical conversion from sustainable biomass	1 B€	6/7→8	JP Bio	JP ES
		Activity 13: Scale-up solid, liquid and gaseous intermediate bioenergy carriers through biochemical / thermochemical/ chemical conversion from sustainable biomass	9 B€	7/8→9	JP Bio	JP ES IP PED, IP Offshore Wind
Digitalisation	IP HVDC & DC	Activity ST-O-1: Development and integration of advanced software tools in SCADA systems for AC/DC hybrid systems	TBD €	5-8	JP DfE	
	IP EE for Industry	Activity 2.3: Digitalisation: Further integration in process and plant management including plant/process design phase and processing plant retrofit	20 M€ per project and > 50 M€ for projects at TRL8	4/5→8	JP DfE	JP EEIP
	IP Wind	Activity 2.2: Offshore wind farms & systems integration: Increases performance of wind power and grid via digitalisation	TBD €	Medium/high	JP DfE, JP SG, JP Wind	JP OE, JP ESI IP HVDC & DC

		Activity 3.3: Floating offshore wind & wind energy industrialisation: Enable digital transformation in wind energy system O&M		Medium	JP DfE, JP Wind	JP OE
		Activity 4.2: Wind energy operation, maintenance & installation: Next generation of wind farm control (wake, cluster layout etc.)		High	JP DfE, JP Wind	
		Activity 4.3: Wind energy operation, maintenance & installation: Enable digital transformation in wind energy system O&M		Medium	JP DfE, JP Wind	
		Activity 4.4: Wind energy operation, maintenance & installation: Sensor systems and data analytics for health monitoring		High	JP DfE, JP Wind	IP Geothermal, IP Ocean, IP Nuclear
		Activity 6.2: Basic wind energy sciences: Digital turbine and data analytics		Low/medium	JP DfE, JP Wind	
		Activity 6.4: Basic wind energy sciences: Open access database for research validation (FAIR data)		N/A	JP DfE, JP Wind	
	IP PED	Activity 2: JPI Urban Europe – PED Labs and Innovation Actions	635 M€	2-7	JP SC, JP DfE	JP Bio, JP EEIP, JP PV, JP SG, JP Wind IP Batteries, IP PV
		Activity 4: EERA JP SC - Diffusion of knowledge and experiences	18 M€ (4 years)	5-7	JP SC	
		Activity 9: ECTP – From Positive Energy Blocks to Districts	12 M€	7-9	JP SC, JP DfE	JP Bio, JP EEIP, JP ESI, JP Wind

						IP Batteries, IP PV
		Activity 10: ECTP – ESA – Digital Modelling of Cities	27 M€	4-6 (new technologies) 8 (access portal)	JP SC, JP DfE	
		Activity 11: RHC-ETIP – Industry support	7 M€ (8 years)	7-9	JP SC, JP DfE	JP EEIP
	IP Ocean	Activity 1.10: Instrumentation for condition monitoring and predictive maintenance	25 M € for a few medium sized projects and around 5 small projects	4-6	JP OE	IP Geothermal, IP Wind, IP Nuclear
		Activity 1.14 Open-data repository for ocean energy operation and performance	10 M€ for a few medium sized projects and around 5 small projects	High	JP OE	JP DfE
Security & safety	IP Nuclear	Activity 1: Plant safety, risk assessment and severe accidents, integrity assessment of systems, structures and components	250 M€/year (2017-21)	Not specified	JP NM	IP Geothermal, IP Ocean, IP Wind

ANNEX 2

SUPEERA task 1.3 Cross-cutting and interdisciplinary activities, Non-technological

JP: EERA Joint Programme, AMPEA: Advanced Materials and Processes for Energy Applications, Bio: Bioenergy, CCS: Carbon Capture and Storage, CSP: Concentrated Solar Power, DfE: Digitalisation for Energy, e3s: Economic, Environmental and Social Impacts, EEIP: Energy Efficiency in Industrial Processes, ES: Energy Storage, ESI: Energy Systems Integration, FCH: Fuel Cells and Hydrogen, Geothermal: Geothermal, HP: Hydropower, NM: Nuclear Materials, OE: Ocean Energy, PV: Photovoltaic Solar Energy, SC: Smart Cities, SG: Smart Grids, Wind: Wind Energy

Non-technological cross-cutting topic	IP	Related Activities	Allocated budget / resources	TRL progression	Relevant JP(s)	Other potentially interested JP(s) and related IP(s)
Circular economy	IP Batteries	Activity 1.5: Develop circular economy and de-bottleneck availability of critical raw materials	75 M€ required for TRL5-7 and 25 M€ required for subsequent TRL7-9	5→7 7→9		JP e3s IP PED
	IP EE for Industry	Activity 3.1: Resource efficiency	TBD €	Not specified		JP e3s, JP SC
		Activity 3.3: CCS/CCU in Cement sector		Not specified		JP SC
		Activity 4.3: Plastic waste as an alternative feedstock		Not specified		JP e3s, JP SC
		Activity 4.4: CO_2 / CO as an alternative feedstock		Not specified		
		Activity 4.5: Biomass as an alternative feedstock		Not specified		JP Bio, JP SC IP Bioenergy
		Activity 5.5: Carbon Capture and Usage	For trial and operational testing: 164 M€ For upscaling and operating: 500 M€	8 (by 2050)		JP Bio, JP ES IP Bioenergy

		Activity 5.6: Circular economy	TBD €	Not specified		JP Bio, JP e3s, JP EEIP, JP SC
	IP Wind	Activity 5.4: Ecosystem, social impact & human capital agenda: Circular economy and availability of materials	TBD €	Low/medium	JP Wind	JP e3s, JP SC
	IP Nuclear	Activity 4: Geological Disposal	150 M€/year (2016-2020) for 10 to 20 years	Not specified	JP NM	JP e3s
		Activity 5: Spent fuel and radioactive waste management, decommissioning	100 M€/year (2017-2020) for 5 to 20 years	Not specified	JP NM	
		Activity 6: Partitioning and Transmutation, nuclear fuel reprocessing, and qualification of new fuel for demonstrators	100 M€/year (2017-2025) for 10 to 30 years	Not specified	JP NM	
	IP Geothermal	Activity D: Full reinjection electric heating and cooling plants integrated in the circular economy	123.4 M€	5/6→6/7	JP Geothermal	JP SC IP PED
Education & Training	IP EE for Industry	Activity 2.4: Knowledge exchange, training and capacity-building: Improving exchange of technological, economic, behavioural and social knowledge; training, capacity building and dissemination, to enhance sustainable energy management	1 and 2 M€ per project / deliverable (4 total)	5→7 5→9 (training and capacity building)		JP e3s
	IP Wind	Activity 5.3: Ecosystem, social impact & human capital agenda: Increase workforce for offshore wind by continuing education and training	TBD €	Medium	JP Wind	
	IP Nuclear	Activity KEC4: ETKM Education and Training	50 M€/year (2015-2020) for 5 to 10 years	Not specified	JP NM	
Policy & regulation	IP Geothermal	Activity NTBE A: Involving the public in sustainable geothermal development (Part B)	21 M€ (Parts A&B)	Not applicable	JP Geothermal	JP e3s IP PED

	IP Ocean	Activity 2.2: Promoting Ocean Energy in Marine Spacial Planning	3 M€	6→9	JP OE	
		Activity 3.5: Support the development of novel mechanisms to close funding gaps (such as a Public Procurement of Innovative Solutions)	40 M€	6→8	JP OE	JP e3s
R&I funding programmes & measure	IP Nuclear	Activity KEC 2: Stable and predictable investment conditions	10 M€/year (2015-2020) for 5 to 20 years	Not specified	JP NM	
		Activity KEC5: Supporting Infrastructures	300 M€/year (2014-2021) for 5 to 20 years	Not specified	JP NM	
	IP Geothermal	Activity NTBE B: Risk mitigation (financial/project)	177 M€	Not applicable	JP Geothermal	
	IP Ocean	Activity 3.1: Dedicated revenue support for the first wave & tidal demonstration farms	circa 225 €/MWh depending on technology and project expect several pre-commercial demonstration arrays	1→8	JP OE	
		Activity 3.2: Creation of an investment fund for ocean energy farms	200-300 M€ of private/public investment funding (this is to be outside of contributions from EU, MS and partnering non-EU countries which are in actions 1.1 to 1.6 which totals almost 800 M€)	7→9	JP OE	JP Wind?
		Activity 3.3: Creation of an EU insurance and Warranty fund to underwrite various project risks.	50-70 M€ public or private insurance funds – Outside of the 800 M€ from MS, partnering	8→9	JP OE	

			non-EU countries, Regions and EU in actions 1.1 - 1.6.			
		Activity 3.4: Funding from EU, national, regional & private sector to support demonstration and innovation projects	1 B€ for Actions 1.1-1.15 and Actions 3.1-3.6	Not applicable	JP OE	
Social awareness, acceptance & engagement	IP Wind	Activity 5.5: Ecosystem, social impact & human capital agenda: Empowering citizens and increasing public engagement	TBD €	Medium	JP e3s, JP Wind	JP SC IP PED
	IP Nuclear	Activity 3: Effects of low doses of ionising radiation	150 M€/year (2015-2020) for 10 to 20 years	Not specified	JP NM	
	IP Geothermal	Activity NTBE A: Involving the public in sustainable geothermal development (Part A)	21 M€ (Parts A&B)	Not applicable	JP e3s, JP Geothermal	JP SC IP PED
Standardisation	IP Nuclear	Activity KEC3: Harmonization of licensing rules, certification, and standards	10 M€/year (2016-2020) for 10 years	Not specified	JP NM	
	IP Wind	Activity 3.3: Floating offshore wind & wind energy industrialisation: Enable digital transformation in wind energy system O&M	TBD €	Medium	JP Wind	JP DfE?
	IP Ocean	Activity 1.15: Standardisation and certification	10 M€ required for 5 small projects	Not applicable	JP OE	
		Activity 2.1: De-risking of environmental consenting through an integrated programme of measures.	7.2 M€ required	1→9	JP OE	
Socio-economic policies & measures	IP Wind	Activity 2.4: Offshore wind farms & systems integration: Markets & financing	TBD	Low/medium	JP e3s, JP SG, JP Wind	JP OE
		Activity 5.1: Ecosystem, social impact & human capital agenda: Nature-inclusive wind energy (and multi-use)		Medium	JP e3s, JP Wind	JP SC IP PED

		Activity 5.2: Ecosystem, social impact & human capital agenda: Assessment methods to quantify/qualify the impact of research projects		High	JP e3s, JP Wind	JP SC
	IP Geothermal	Activity NTBE B: Risk mitigation (financial/project)	177 M€	Not applicable	JP Geothermal	
	IP PED	Activity 7: EUA-EPUE – Capacity Building	5 M€	6-8	JP SC	
	IP PV	Activity 4: Operation and diagnosis of photovoltaic plants	60 M€	6-7	JP PV	
	IP Ocean	Activity 2.3: Promoting political support and public backing for ocean energy	3 M€	6→9	JP OE	JP e3s
International cooperation	IP Nuclear	Activity KEC6: INCO International cooperation	10 M€/year (2015-2020) for 5 to 20 years	Not specified	JP NM	
	IP PED	Activity 1: JPI Urban Europe –European Positive Energy Cities	2 M€ from participating countries over 8 years	8-9	JP SC	JP e3s, JP ES, JP ESI, JP PV
		Activity 4: EERA JP SC - Diffusion of knowledge and experiences	18 M€ (4 years)	5-7	JP SC	
		Activity 8: JPI Urban Europe – International Cooperation	35 M€	2-8	JP SC	JP e3s
	IP PV	Activity 6: Cross-sectoral research at lower TRL	Reallocation of resources for national labs	3-6 (topic dependent)	JP PV	