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Deliverable 2.2

Systemic and cross-sectorial issues pertaining to the Clean Energy Transition objectives

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EXECUTIVE SUMMARY

Policymaking needs to be strategic, coordinated and have a clear vision. Isolated policies may provide a solution relevant in a specific field but fail to achieve a transformation of the system. The Clean Energy Transition requires to be approached in a holistic way, with policy interventions and regulations aiming at transforming the relevant system as a whole. Such approach implies examining different parts of the system in their interconnection, without separating technological domain from social and environmental ones.

The purpose of this deliverable is to draw a "Template for identification and categorisation of cross-cutting issues in energy" offering a coordinated input to decision-makers for addressing systemic and cross-sectorial solutions in the energy sector to support the Clean Energy Transition. The template will set a framework for defining and classifying identified cross-cutting issues.

Deliverable 2.2 builds upon the analysis and findings of Deliverable 1.6 “Interim report & recommendations on cross-cutting and interdisciplinary activities relevant to the SET Plan” aimed at providing an initial mapping of existing cross-cutting and interdisciplinary topics – both technological and non-technological - and related activities in the SET Plan Implementation Plans (IPs).

The deliverable will provide:

1) A state-of-the-art on present cross-cutting issues identified in the SET Plan Implementation Plans and in the National Energy Climate Plans;
2) A forward-looking overview on ways to classify and define the identified cross-cutting issues;
3) Suggestions on missing elements in the used description of the cross-cutting topics.
4) The implementation of the template is part of Task 2.2., and the following main steps have been followed:
5) Initial identification of existing cross-cutting topics and activities in the IPs and NECPs that can support the Clean Energy Transition;
6) Dialogue and presentation to the EERA JPCs meeting held on 3 June 2021 of the identified topics.

A follow-up discussion on the topics and related activities, proposed prioritization, and recommendations on enabling factors to support the Clean Energy Transition could be undertaken at a later SUPEERA workshop. The workshop will be planned in connection to other tasks and will involve EERA JPCs (and other Joint Programme members, when relevant)

and other relevant stakeholders (e.g. ETIPs, KIC InnoEnergy and other industry-driven platforms, consumer groups, citizens' organisations).

Deliverable 2.2 is one of the outputs of Task 2.2 “Systemic and cross-sectorial solutions pertaining to the Clean Energy Transition objectives” aimed at providing coordinated input to decision makers on systemic and cross-sectorial solutions to support the Clean Energy Transition.

The task is part of Work Package 2 “Accelerating innovation and uptake by industry” and is carried out in coordination with Task 1.3 "Cross-cutting and interdisciplinary activities", 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 “Translating new EU policies into concrete actions for the EERA and SET-Plan community”.

The output of Deliverable 2.2, the “Template for identification and categorisation of cross-cutting issues in energy", will feed the Task 2.4 (Recommendations) and the Work Package 3, providing input to enabling policies in support of R&I relating to the Clean Energy Transition.

LIST OF TABLES AND FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

AC(s)	Associated Countries
BTI	Breakthrough Technolgies for Industries
CCS	Carbon Capture and storage
CCU	Carbon Capture and Utilization
CETP	Clean Energy Transition Partner
CEM	Clean Energy Ministerial
CESEC	Central and South-eastern Europe Energy Connectivity
CSP	Concentrated Solar Power
EC	European Commission
EE	Energy Efficiency
EERA	European Energy Research Alliance
EM4I	Energy Material for Innovation
ERA-NET	European Research Area Net
ESI	Energy System Integration
ETIP	European Technology and Innovation Platform
EU	European Union
FP	Flagship Project
IEA	International Energy Agency
IP	(SET Plan) Implementation Plan
IRE	Integrated Reional Energy
IWG	Implementation Working Group
JP	(EERA) Joint Programme
JPC(s)	Joint Programme Coordinator(s)
MS(s)	Member State(s)
MMIPs	Multi-annual Mission Oriented Innovation Programs
NECP(s)	National Energy and Climate Plan(s)
NEEAP(s)	National Energy Efficiency Action Plans
NEIS	National Energy Independence Strategy
NER	Nordic Energy Research
PED	Positive Energy Districts
PV	Photovoltaics
RE	Renewable Energy
R&D	Research and Development
R&I	Research and Development and Innovation
SET Plan	Strategic Energy Technology Plan
SDGs	Sustainable Development Goals

SGEM	Smart Grid Energy Market
SETIS	Strategic Energy Technology Information Plan
SRIA	Strategic Research and Innovation Agenda
SUPEERA	Support to the coordination of national research and innovation programmes in areas of activities of the European Energy Research Alliance
TKIs	Top Consortia for Knowledge and Innvovation

I INTRODUCTION

The document provides a "Template for identification and categorisation of cross-cutting issues in energy" offering a coordinated input to decision-makers for addressing systemic and cross-sectorial solutions in the energy sector to support the Clean Energy Transition.

Deliverable 2.2 builds upon the analysis and findings of Deliverable 1.6 “Interim report & recommendations on cross-cutting and interdisciplinary activities relevant to the SET Plan” aimed at providing an initial mapping of existing cross-cutting and interdisciplinary topics – both technological and non-technological - and related activities in the SET Plan Implementation Plans (IPs).

The main goal of analysing cross-cutting topics is to help to improve a conceptual framework for planning technological solutions for the Clean Energy Transition.

Cross-cutting issues provide a context for the Clean Energy Transition planning beyond specific technologies. Therefore, addressing and design of the cross-cutting issues for technological and policy planning is crucially important to ensure that the clean energy transitions are designed with the systems-thinking, holistic optics. The latter is prerequisite for socio-technical transformations needed to achieve the net-zero society.

An emphasis on the cross-cutting dimension of the technological planning for the Clean Energy Transition is in line with the current European and global agendas. Both the European Grean Deal[1] and the Sustainable Development Goals[2] (SGDs) define sets of ambitious goals which would be impossible to achieve with a purely techno-centric mindset and without taking into consideration the cross-cutting aspects.

The way templates, guidelines, communications, are designed by policymakers and the expected requirements described in documents like the SET Plan Implementation Plans (IPs), and the National Energy Climate Plans (NECPs), defines eventually the quality of the plans produced by a different group of stakeholders and the range of different aspects included.

In most of the mentioned documentation, there are no specific references to cross-cutting issues and when they are indicated there is no distinction between technological and non-technological

[1] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[2] https://sdgs.un.org/goals

cross-cutting issues. This practice can potentially lead to overlooking the important cross-cutting components, especially those that are non-technological ones.

The work conducted by SUPEERA addresses the gaps in designing templates and guidelines by explicitly separating technological and non-technological cross-cutting issues and suggesting a topics' classification principle within each of these two categories. The work on the cross-cutting issues conducted by SUPEERA is inspired by and builds on the results of work of SET Plan IWGs, ERA-NETs, EERA JPs and the EU MSs' representatives within the collaborative writing process of the CETP SRIA Input Papers[3].

The template provided in this document does not aim to serve as an exhaustive list of the technological and non-technological cross-cutting topics. Instead, it is seen as a preliminary exercise that can be elaborated further to eventually provide a universal template that can be used for developing energy and climate transition plans and which will serve as a guidance for include the key action points essential for achieving net-zero goals in an environmentally, socially and economically sustainable way.

II METHODOLOGY

To achieve the objectives of T2.2, i.e. to provide coordinated input to decision-makers on systemic and cross- sectorial solutions to support the Clean Energy Transition, a three-fold methodology was followed in preparing this deliverable (D2.2):

1) Desk analysis of the SET Plan Implementation Plans (Deliverable 1.6 "Interim report & recommendations on cross-cutting and interdisciplinary activities relevant to the SET Plan) (see table1) and of targeted National Energy Climate Plans (NECPs) (see table 2) in order to identify potential overlaps and complementarities among the different technological and non-technological cross-cutting activities addressed by the two sets of documents;

Implementation Plan (IP)[4][5]	Abbreviation
IP Bioenergy & Renewable Fuels for Sustainable Transport	IP Bio
IP Initiative for Global Leadership in Photovoltaics	IP PV
IP Initiative for Global Leadership in Concentrated Solar Power	IP CSP

[3] https://www.eera-set.eu/news-resources/2623-video-the-key-role-played-by-eera-in-the-development-of-the-strategic-research-agenda-of-the-clean-energy-transition-partnership.html
[4] https://setis.ec.europa.eu/implementing-actions/set-plan-documents_en#ecl-inpage-50
[5] Nuclear Safety IP is not included in the analysis since their responsible IWG was adopted after the project approval

IP Batteries - Become competitive in the global battery sector to drive e-mobility and stationary storage forward	IP Batteries
IP Deep Geothermal	IP Geothermal
IP Positive Energy Districts - Europe to become a global role model in integrated, innovative solutions for the planning, deployment, and replication of Positive Energy Districts	IP PED
IP Increase the resilience and security of the energy system	IP Energy System
IP Ocean - Initiative for Global Leadership in Ocean Energy	IP Ocean
IP EE for Buildings - Energy Efficiency Solutions for Buildings	IP EE for Buildings
IP CCS & CCU	IP CCS & CCU
IP Wind - Global Leadership in Offshore Wind	IP Wind
IP Energy Consumers - Smart solutions for energy consumers	IP Energy Consumers
IP Make EU industry less energy intensive and more competitive	IP Industry

Table 1: List of Implementation Plans (IPs) and related abbreviation.

No	Region	NECP - Example Countries
1	Central Europe	Austria (with comparison to Belgium, France, Germany and the Netherlands)
2	Southern Europe	Bulgaria (with comparison to Malta)
3	Nordic Countries	Denmark (with comparison to Finland and Sweden)
4	Baltic Countries	Latvia & Lithuania

Table 2: List of the target NECPs and regions covered in this deliverable

2) Development of a list of categories and sub-categories for classifying in a more specific way the cross-cutting issues. The categories and the relevant descriptions will provide policymakers throughout institutions and countries a coordinated input on systemic and cross-sectorial solutions to support the Clean Energy Transition. The process of defining specific cross-cutting topics to use for this analysis was informed by the results of the previous work, namely the work on the Cross-Cutting Challenges[6] and the Storage

[6] https://www.eera-set.eu/component/attachments/?task=download&id=518:CETP_Input_Paper_Crosscutting_final

Systems and Fuels[7] Input Papers for the CETP SRIA as well as the EERA White Paper on the Clean Energy Transition[8].

3) Feedback from the EERA Joint Programme Coordinators (JPCs) has been implemented in the "Template for identification and categorisation of cross-cutting issues in energy" (See paragraph 5).

III DESK ANALYSIS OF THE IPs and NECPs

The desk analysis of the IPs (published by SETIS[9,10]and endorsed in the period 2017-2019) and NECPs (submitted at the end of 2019 by the Member States for the period 2021-2030) was done based on the cross-cutting technological and non-technological topics identified by SUPEERA and already part of D.1.6 (see table 3) and Deliverable 2.1 "Consolidated common and regional pathways in NECPs and stakeholders mapping." The categories identified for the IPs were then applied in the analysis of the selected NECPs mentioned above (see Table 2). The topics identified are present in at least two IPs.

Technological cross-cutting topics	Non-Technological cross-cutting topics
Energy efficiency	Education & training
Energy System Integration	Policy & regulation
High temperature & advanced materials	R&I funding programmes & measures
Energy storage	Social awareness, acceptance, engagement
Digitalization	Standardisation
	International cooperation

Table 3: Technological and non-technological cross-cutting topics

The mapping took also into consideration the following documents to understand if specific requirements for addressing cross-cutting issues appear:

- The General Framework for integrated National Energy and Climate Plans[11], defining the template and requirements for drafting the NECPs;

[7] https://www.eera-set.eu/component/attachments/?task=download&id=520:CETP_Input_Paper_Storage_and_Fuels_final
[8] EERA White Paper on the Clean Energy Transition will be available online in September 2021. Before then, draft of the paper can be provided upon request (email: g.gladkykh@eera-set.eu).
[9] https://setis.ec.europa.eu/implementing-actions/set-plan-documents_en#ecl-inpage-50
[10] https://setis.ec.europa.eu/implementing-actions/set-plan-documents_en
[11] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999&from=EN

- The document "Common principles guiding temporary Working Groups to prepare Implementation Plans" provided by the SET Plan -Secretariat 8 June 2016 to the Working groups for drafting the IPs.

It is relevant to mention that the analysis of the IPs showed that the word cross-cutting is only mentioned in the following cases:

- *In IP Batteries.* It is mentioned one time when referring to the development of "New battery materials design (electrodes, electrolytes, separators and current collectors) with excellent kinetic characteristics, high safety, strong chemical bonds and excellent thermal performance".
- *In IP EE IND.* It is mentioned in the context of Petroleum Refineries sector benefiting from cross-cutting technologies, few times as a general priority, in relation to R&I activity on System integration, and R&I targets.
- *In IP OCEAN*. It is mentioned in relation to the impact on the overall ocean energy sector (e.g. environmental consenting procedures, the creation of an EU Insurance and Guarantee Fund).
- *IP Geothermal*. It is mentioned as a title (as also a title on Non-technical barriers/enablers) and then when presenting knowledge transfer, training and open-access policy.

In the NECP Template provided by the Commission[12] in 2018, there is no mentioning of the cross-cutting issues as such or any guidance on how to include them or any definition either. The word “cross-cutting” as such is not included in the NECP template. The word is used in the final NECPs by:

- *Austria*, 6 times: equality between genders as a cross-cutting issue; storage systems as a cross-cutting issue; other cross-cutting technology;
- *Belgium*, 28 times: for example cross-cutting areas identified for funding needs; energy and climate policy as a cross-cutting theme; cross-cutting measures, such as the development of the circular economy and the promotion of urban agriculture; cross-cutting strategic action programmes; cross-cutting policies and measures;

[12] CELEX_32018R1999_EN_TXT.pdf, REGULATION (EU) 2018/ 1999 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL - of 11 December 2018 - on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663 / 2009 and (EC) No 715 / 2009 of the European Parliament and of the Council, Directives 94/ 22/ EC, 98/ 70/ EC, 2009/ 31/ EC, 2009/ 73/ EC, 2010/ 31/ EU, 2012/ 27/ EU and 2013/ 30/ EU of the European Parliament and of the Council, Council Directives 2009/ 119/ EC and (EU) 2015/ 652 and repealing Regulation (EU) No 525 / 2013 of the European Parliament and of the Council (europa.eu)

- *Czech* (5 times: cross-cutting targets in energy security; cross-cutting measures; cross-cutting target on education, training and awareness-raising; cross-cutting and sectoral criteria);
- *France*,3 times: public policy guidelines, both cross-cutting and sectoral in nature
- *The Netherlands*,1 time: cross-cutting themes such as the labour market & education, spatial integration, finance and innovation.

The chosen topics were then grouped by SUPEERA into categories and subcategories that provided a more clear and detailed way for classifying the cross-cutting issues (see paragraph 5).

The desktop analysis has the following limitations:

- Only topics appearing in at least two IPs have been selected (D1.6), leaving out relevant topics considered as cross-cutting in only one IP. This is the case for example of IP EE IND[13], where the following cross-cutting topics are identified:
    - Industrial components (boilers, pumps, valves, compressors, fans, conveyors… all of which systems typically contain motors and drives)
    - Heat pump technologies
    - Industry 4.0: digitalisation and machine learning
    - System integration
    - Industrial symbiosis
    - Renewable energy systems (e.g. Solar thermal, hydrogen, nuclear)

SUPEERA intends to address this limitation in the work that will be performed in D1.7 "Final report & recommendations on cross-cutting and interdisciplinary activities relevant to the SET Plan". The deliverable builds upon the D1.6.

- More focus should be given to enablers and non-technical barriers since technological innovations are often more obvious and receive funding, but in order to benefit most of the techniques, also the enablers should be exploited, non-technical barriers identified and taken into consideration. Cooperation between different technologies on cross-cutting issues should ease this. A comment on this has been received from one JPC mentioning what indicated in Action 6 - IP EE IND:
    - Enablers:
        - Electrification, low carbon gases, infrastructure, Circularity
    - Non-technical barriers:
        - Tension between incremental efficiency improvements and radical transformation in line with climate neutrality and the European Green Deal

[13] https://setis.ec.europa.eu/system/files/2021-04/set_plan_ee_in_industry_implementation_plan.pdf

- Rebound effects: something that is low/zero carbon may still be energy inefficient: e.g. hydrogen
- Carbon leakage risk, leading to underinvestment
- Lack of market differentiation between "energy-intensive" and "energy efficiently" produced variants of the same product. Or customer indifference?
- Lack of a market for low-carbon/energy efficient products
- High capex / opex
- Financial and administrative barriers
- Economic feasibility (return on investment, or payback period)
- Information asymmetry, lack of knowledge about solutions
- Lack of access to new workforce skills relevant to new EE technologies
- Absence of standardisation (digital)
- Lead markets

- The analysis does not take into consideration areas specific documents and the National Energy Efficiency Action Plans (NEEAPs). The NEEAPs detail national energy consumption estimates and the strategies that the Member State will use to achieve reduction targets.

3.1 CROSS-CUTTING ISSUES IN THE IPs

The mapping is part of D1.6 “Interim report & recommendations on cross-cutting and interdisciplinary activities relevant to the SET Plan” (see Annex I). It stems from the cross-cutting and interdisciplinary topics and activities identified in the IPs published by SETIS[9,10] and includes both technological and non-technological cross-cutting topics as needs and requirements (technological and non) that are common to multiple sectors and activities. The topics included are present in at least two IPs.

3.2 CROSS-CUTTING ISSUES IN THE NECPs

As mentioned earlier, in the NECP Template provided by the Commission[12] in 2018 there are no requirements for the MS to address and describe cross-cutting issues.

The SUPEERA project has analysed all the 27 National Energy and Climate Plans developed by the MS. The analyses include most of the cross-cutting issues mentioned in Table 2. Regional examples have been selected to give an overview of the cross-cutting issues across Europe. Different parts of Europe represent divergent geographic areas, with variable climates, resources for energy, and historically different ways of producing energy and traditions for cooperation

between adjacent countries. Therefore an analysis of the European regions can give an interesting overview of the situation in Europe at large and show differences in different parts of it.

The analysis focuses on how the countries present the cross-cutting issues and how they differ from neighboring countries. The selected geographical areas are:

- Central Europe, with Austria as the main example;
- Southern / Eastern Europe countries with Bulgaria as the main object of the analysis;
- Nordic countries with Denmark as representative country;
- Baltic countries with Lithuania and Latvia as main examples.

The main outcomes of the analysis are described in the following paragraphs addressing the Technological cross-cutting issues and the Non-technological cross-cutting issues for the identified geographical areas.

3.2.1 Summary on Cross-cutting issues related to Clean Energy Transition in the Central Europe's NECPs

The main example country is Austria. Belgium, France, Germany and the Netherlands have been used as comparative examples in some cases.

Technological cross-cutting issues

According to the Austria's NECP, **system integration** of the growing range of available technology and solutions, in terms of global approaches, is equally as important as the targeted development and advancement of technology and components. Austria has dedicated projects for the Energy systems integration, e.g. Energy research initiative 1: Energy systems of the future (2018-23) (FP9), and Electricity distribution networks (IRE.4). Netherlands addresses the overarching system integration development in its Multi-annual Mission-oriented Innovation Programmes (MMIPs), that interpret the required multi-annual programmatic approach to knowledge and innovation in order to contribute to the missions in 2050 and specific targets for 2030, with topics e.g. Electrification of the energy system in the built-up environment (MMIP 5) and a robust and socially supported energy system (MMIP 13).

Smart and innovative materials have not been mentioned in the Austria's NECP. In the Netherlands NECP, on the other side, high tech systems and materials are one of the "top sectors", fields in which the Dutch business community and research centres excel worldwide; or France, which leads a working group in the European Battery Alliance, with emphasis on the development of advanced materials for batteries. France also presents taking part in the Mission Innovation initiative on Advanced Materials. In nuclear energy, Belgium mentions that research

into new materials is one of the R&D and innovation in key areas, where Belgium wants to remain a world-class player.

Austria is active in **Energy storage**, with several dedicated programmes such as Large-scale thermal storage (IRE.1), Hydrogen- and gas-based storage (IRE.2) and Chemical energy storage (IRE.14). By modernising the network infrastructure, one target is to integrate buildings into the system as storage facilities. In the future, it will be increasingly possible to use buildings and their energy technology systems as energy storage systems. On the commercial side, there are already active natural gas storage operators in Austria. In Belgium, storage / power-to-gas / power-to-x / green gas initiatives/projects are supported, when they are economically or ecologically sustainable – based on costs-benefits analysis. Germany mentions that research into e.g. storage will be stepped up so that domestic companies and research institutions can assume a pioneering role in this area, which furthermore holds tremendous export potential. Federal Government of Germany has confirmed its intention to invest in energy storage technologies and smart marketing concepts in order to continue safeguarding the reliability of supply in all parts of Germany and minimise system costs and costs.

Energy efficiency measures are among the best economic measures for preventing greenhouse gas emissions and are high on the agenda in Austria, as well as being a recurring theme of the energy union ('energy efficiency first' principle). Improving energy efficiency and thereby reducing energy consumption in the long term is an important lever in achieving long-term climate goals, alongside the use of renewable energy. In Austria's Climate and Energy Strategy special emphasis is therefore placed on policies and new technology which may greatly help to improve energy efficiency. This includes, for example, continuously improving the energy efficiency of the building stock (thermal renovation and high standards for new buildings) and focusing on electromobility in transport. Belgium also addresses energy efficiency important, and most of the annual public spending on energy research (35…40 M€) is devoted to energy efficiency in Walloon area. All energy efficiency sectors are covered (industry, residential, transport, other). The rest of the sum is allocated to the development of renewable energy, smart power grids and hydrogen, and energy storage.

The need for **Digitalisation** is identified on energy security in Austria; the infrastructure must allow for new developments on the energy market, decentralised production, new storage technologies and digitalisation. Austria plans to support the Clean Energy Transition with several digitalisation projects, including both Integrated Regional Energy Systems (IRE) and Breakthrough Technologies for Industry (BTI) projects such as Digital services (IRE.9), Digital sector coupling (IRE.11) and Digitalisation and regulations (BTI 13). The BTI13 contains digitalisation as a basis for efficient production, inclusion of industry in the Smart Grid and

regulation that encourages innovation. Belgium supports digitalisation of energy systems for example through smart meters, smart data, and informing citizens and companies. In Germany, there is a programme called Smart Energy Showcases – Digital Agenda for the Energy Transition' (SINTEG), which is aimed at the development and demonstration of solutions to the technical, economic and regulatory challenges posed by the energy transition. Over 300 enterprises and other stakeholders will be involved in five large model regions ('showcases') in the SINTEG programme.

Non-technological cross-cutting issues

For **Circular economy**, Austria has a dedicated programme Circular economy in the industry (BTI.13). The target is the development of technologies and processes that close material cycles and thereby reduce the use of primary energy and raw materials, including e.g. depolymerisation of 'hard-to-recycle' used plastics. By developing projects and networks which increase the useful life of a project (for example repair networks, repair cafes or RE-USE projects), this will help to reduce waste and promote the circular economy.

As already described above, Austria has dedicated and fundamental **R&I policies and funding** to reach the Sustainable Development Goals. Flagship Project Green finance (FP8) to support market analysis, dialogues with stakeholders, 'Austrian Green Bonds' pilot project and energy transition investment plan. In France, there is a Program on Investments for the Future (PIA) for continuing and boosting R&D and innovation funding for the energy transition. The program is intended to support projects that promote innovation and job creation in sectors with significant potential for the French economy. In the Netherlands, there are thirteen Multi-annual Mission-oriented Innovation Programmes (MMIPs) that interpret the required multi-annual programmatic approach to knowledge and innovation in order to contribute to the missions in 2050 and specific targets for 2030. From 2020 onwards, the schemes for the Top Sector Energy that are aimed at stimulating specific issues within the programme lines of the Top Consortia for Knowledge and Innovation (TKIs), and the schemes will focus on the MMIPs that fall under the electricity, industry and built-up environment sectors as well as the overarching system integration theme.

To support the **Social acceptance** of energy transition measures, Austria has a Flagship Programme Communication – education and awareness-raising for a sustainable future (FP11). As horizontal measures, Austria has the climate protection initiative 'klimaaktiv'. klimaaktiv uses its extensive networks to promote the creation of social capital for the transition towards a sustainable society. Through standards, awareness-raising, information, consultation and further education, klimaaktiv provides incentives and market stimulus to use renewable energy sources for energy efficiency measures in the field of construction, renovation and mobility. France

addresses the social acceptance in The National Low-Carbon Strategy (SNBC), in particular in a section dedicated to "Education, awareness, appropriation of issues and solutions by citizens". In 2018, the Netherlands Institute for Social Research (SCP) launched the Sustainable Societies programme. With this programme the SCP provides a socio-cultural perspective on the transitions that should result in a sustainable society. The research programme focuses on the relationship between the citizen (individual or collective) and the authorities in the context of these transitions, on processes of the inclusion and exclusion of Dutch people (both individually and in groups) during and as a result of these transitions and on the consequences of these transitions on the quality of life.

In **International cooperation**, Austria is participating in the Mission Innovation with a focus on Smart Grids (IC1), Heating and Cooling of Buildings (IC7) and Hydrogen (IC8). Austria has the Flagship Project (FP 10) Energy research initiative 2: 'Mission Innovation Austria' programme. The Netherlands participates to three innovation challenges and activities within International Energy Agency (IEA) and is part of the Clean Energy Ministerial. France is very active in the Mission Innovation, involved with all eight challenges, and is jointly responsible for work on the challenge relating to off-grid energy access.

3.2.2 Summary on Cross-cutting issues related to Clean Energy Transition in Southern/Eastern Europe's NECPs

The main example country is Bulgaria. Malta has been used as a comparative example.

Technological cross-cutting issues

Different national scientific programs in the area of energy and climate neutrality have been developed in Bulgaria. In these programs the main focus is on conversion and **storage of renewable energy**, effective methods for carbon dioxide capture and utilization, hydrogen-based technologies and eco-mobility as a transition to a low-carbon economy and applied research aimed at creating a more sustainable, favourable and beneficial living environment. Moreover, Bulgaria is committed to promoting scientific progress in the area of innovative energy technologies, including clean power generation, development and use of advanced biofuels, renewable liquid and gaseous biofuels, and promotion of research in the area of rechargeable batteries, and hydrogen and fuel cell technologies.

Regarding energy efficiency, the Bulgarian NECP indicates different schemes for the improvement of energy efficiency such as designs for new buildings or for reconstruction, major renovation, overhaul or refurbishing of existing buildings is prepared and when the energy

efficiency of existing buildings is audited. The analysis of the possibilities for using renewable energy is part of the evaluation indicators of annual energy consumption in the building.

In the **Energy system integration**, Bulgaria informs of different measures supporting the development of energy infrastructure, the integration of electricity from renewable sources in the electricity grid and the wider uptake of smart energy storage systems will be introduced in the period 2021—2030.

For **Smart and innovative materials**; the Bulgarian NECP indicates the introduction of new insulating materials for glass surfaces.
Data-analytics, artificial intelligence, digitalization: Bulgaria is committed to implement and develop some important projects and programs that will promote business innovations and digitalisation. In view of the crucial importance of cybersecurity for the management and functioning of the energy sector, the necessary high-tech solutions at the level of licensed hardware and software for monitoring and active cyber protection are planned to be additionally implemented in Bulgaria's energy system, along with information systems for electricity system management and operation.

Non-Technological cross-cutting issues

Bulgaria indicates **Circular economy** as a priority area and introduces measures that promote energy and resource efficiency, waste management improvement and the transition to a circular economy. Bulgaria intends to gain access to financing under the ERDF and the Cohesion Fund.
For **social acceptance, societal awareness, and engagement**, Consumer awareness and training is one of the four priority axes for Bulgaria particularly in the transport sector, which includes e.g., organising awareness campaigns and building stakeholder capacity for the development of resilient mobility.

The relevant institutions and local authorities are active participants in the process of dissemination of appropriate information and conducting training procedures and they will carry out combined information campaign initiatives, fora, awareness raising programmes and training programmes for citizens on the benefits of and opportunities for using renewable energy. Information campaigns are addressed to citizens and provide information on practical issues relating to the development and use of renewable energy. Moreover, similar to Malta, Bulgaria is introducing smart metering devices as an incentive for the active and effective participation of consumers in the market.

Enabling policies and regulatory measures, financing: Bulgaria has drawn up a National Strategy on Adaptation to Climate Change and an Action Plan thereto, which was adopted by a Decision of the Council of Ministers in 2019. This document defines the strategic framework and priorities for climate change adaptation until 2030. The aim is to lower Bulgaria's vulnerability to climate change and enhance its capacity to adapt its environmental, social and economic systems to climate change impacts. Bulgaria's strategical action plan contains a detailed description of the financial resources, expected results and competent institutions for the implementation of policy measures implementation for each sector.

In addition, the measures primarily aim to strengthen policy response and ensure that climate change adaptation is included in the legal framework; build adaptation capacity and develop financial, social and political guidelines on risk management; and improve knowledge management, research, education and communication with stakeholders.

Regional and International cooperation: Regarding the opportunities for regional cooperation, Bulgaria will start exploring opportunities in the electricity market (e.g., natural gas market, improving natural gas storage capacity, liquified natural gas, and integration of energy from renewable sources) for bilateral cooperation, including via existing platforms such as the Central and South-eastern Europe Energy Connectivity initiative CESEC. In terms of international cooperation, the Bulgarian NECP did not highlight particular cooperations, however other countries in the southern region such as Portugal showed interest in the SET plan, Horizon Europe, and the Investment Plan for Europe (Juncker Plan). Moreover, Bulgaria also identified possibilities for R&D&I co-operation with Romania and Greece. These co-operations cover innovative technologies development, energy storage, digitalization of energy networks through the development of smart grids and smart metering, consumer protection and addressing energy poverty.

3.2.3 Summary on Cross-cutting issues related to Clean Energy Transition in Southern the Nordic countries' NECPs

The main example country is Denmark, with comparison to Finland and Sweden.

Technological cross-cutting issues

For the **Energy System Integration** the geographic situation, Denmark has extraordinary conditions for import and export of energy, whether it is fossil or renewable fuels or electricity. In Denmark, smart grids are a particularly interesting area because of the challenge of integrating large amounts of intermittent wind power into the existing system, which to an even greater extent

is calling for ways by which to regulate electricity consumption relative to current production efficiently and intelligently. In Finland, the role of flexibility is also emphasised in the National Energy and Climate Strategy. The strategy aims to find ways to promote further customers' participation in the electricity markets and resource adequacy. Following the strategy, the Finnish Funding Agency for Innovation Tekes has invested in the energy and environmental sector programmes. SGEM (Smart Grid and Energy Markets) has produced significant competence that can be utilised in the development of intelligent electricity networks and smart control. The FLEXe programme (Flexible Energy Systems) initiated an examination of the requirements for a flexible energy system.

As for **Advanced materials,** Denmark is a member of Mission Innovation Clean Energy Materials. The latter represents a substantial effort in Danish R&D in discovering new materials for clean energy, e.g. batteries, PV, electrochemistry, fuel cells etc. The ultimate goal of this Innovation Challenge is to accelerate the exploration, discovery, and use of new, high-performance, low-cost clean energy materials by at least an order of magnitude. In addition, Finland and Sweden are also part of the global initiative working to reinvigorate and accelerate global clean energy innovation with the objective to make clean energy widely affordable.

In Denmark **Energy storage** envisions Power to X (PtX) as one of the building blocks to ensure sector coupling, using green electricity for hydrogen generation, enabling the use of renewable energy in transport and getting cross-sectoral synergy. Denmark has established a national center for Energy Storage and solar PV, aiming at providing alternatives to PtX technologies for using excess wind power electricity.

On the topic of **Energy efficiency** Denmark has established an online electricity price comparison tool, elpris.dk, operated by the Danish Utility Regulator that facilitates easier comparison between different suppliers and a trustworthy source of information on the quality and terms of different products offered in the market. Sweden has a strong focus on energy-efficiency and energy-saving measures, both technical and behavior-related areas.
About **Digitalization** Denmark introduced a data hub that enables all transactions related to the retail and wholesale market to be managed through one central system operated and owned by the TSO.

Non-Technological cross-cutting issues

In Denmark **Circular economy** strategy, transition towards circular production, sets ambitious policies for waste prevention and management. The circular economy strategy was followed by a

plastics action plan later that year, and a think tank on preventing food loss and waste. Finally, increased taxes are put on single-use products.

Regarding **R&I policy and funding** both Denmark, Sweden and Finland participate in the Nordic Energy Research (NER), a platform for cooperative energy research and analysis in the Nordic region under the auspices of the Nordic Council of Ministers. On **R&I funding schemes,** Sweden has launched two ten-year CET research programs in 2017. The National Energy Research and Innovation Programme, a ten-Year National Climate Research Programme to help achieve Sweden's aim to be a fossil-free welfare society, and the National Research Programme for Sustainable Society was launched to develop knowledge and new solutions in all sectors of society, to create a safe, secure, sustainable and inclusive society. Similarly, Denmark has launched a Fund to support Danish R&D in energy storage technologies (PtX, CCUS) and demonstrate production and consumption on near-market conditions. The fund will support research and innovation activities within CET at a level of 100 million Euro in 2020.

Concerning **social acceptance** Denmark has introduced smart metering to all consumers including those that self-generate electricity is supposed to add to the transparency of such activities and make the impact on the electricity system visible. Also in Denmark, the BedreBolig scheme, launched in autumn 2014, will make it easier and clearer for building owners how to renovate their homes by offering a one-stop-shop with comprehensive, expert advice throughout the energy renovation process. The initiative is accompanied by the building job scheme - a tax incentive scheme for energy efficiency in buildings. In Sweden, there is a focus on gender mainstreaming in climate policy and decision-making. As for Finland, there are no targeted policies in the area.

Regarding **International cooperation,** all three countries participate in EC projects and programs, including the SET plan, in Mission Innovation. Sweden also participates in other international forums such as the International Energy Agency (IEA). Finland participates in Clean Energy Ministerial (CEM) cooperation, in the Electric Vehicles and Smart Grids initiatives and the 21st Century Power Partnership initiative.

3.2.4 Cross-cutting issues in NECPs related to Clean Energy Transition in the Baltic countries

The main example countries are Latvia and Lithuania.

<u>Technological cross-cutting issues</u>

On the topic of **Energy system integration** the countries of the Baltic Sea Region have special attention to the interconnections with the grid infrastructures of the Member States in order to prevent isolation but also foster market integration in the area of renewable energy. In Latvia the Baltic Synchronisation Project has been launched. This project aims to integrate the Baltic Region gas transmission systems into the single gas system of the EU and to align Lithuania's and Latvia's natural gas transmission system operators.

For **Advanced materials** Latvia's environmental, green and clean technology and new product solutions are being developed in the Competence Centre of Smart Material. On top of this initiative the Latvian Department of Technology has identified technology scouts in know research organizations within among other the sector of smart materials.
As for **Energy storage** Lithuania has focused on utilizing hydrogen in energy, industry and transport and to further develop carbon capture, use and storage technologies.

On **Energy efficiency,** Lithuania aims to reduce polluting and wasteful energy consumption by 2025 by introducing tax incentives for fossil fuels. Additionally, Lithuania has approved the National Energy Independence Strategy (NEIS) in 2012 and introduced structural reforms and strategic projects of the energy sector. The result is diversified energy supply routes and sources, reduced energy resources prices for consumers, and opened new development opportunities for the country.

On **Digitalization** Latvia's digital green and clean technology and new product solutions are developed in the Competence Centre of Information and Communication Technologies. In Lithuania, digitalization is seen as one of the most important factors for Lithuania's competitiveness improvement worldwide. The establishment of the national industry digitization platform "Pramone 4.0" is to be considered among the major industry digitization initiative implementation objectives.

Non-technological cross-cutting issues

Circular economy is not addressed in the NECPs.
Regarding **R&I policy and funding** Lithuania has launched the Interinstitutional Action Plan that defines measures for the reduction of GHG emissions and adaption to climate change in all the economic sectors.

On **R&I funding schemes** Lithuania is involved in the EU-funded Horizon 2020 project "STEP", which aims to alleviate energy poverty by encouraging changes in consumer behavior. In Latvia

R&I is being developed following the Smart Specialisation Strategy (RIS3) The RIS3 specialisation area "Smart energy" in Latvia has a clear applied research orientation focusing on handling pressing challenges of the industry, whilst research excellence and international visibility, recognition, cooperation and competitiveness compared with the Baltic States and EU-28 average indicators need a considerable boost.

As for **Social acceptance,** Lithuania has a focus on public awareness and involvement in the climate management policy. Lithuania attempts to increase consumer awareness and alter consumer behaviour when it comes to energy efficiency. (Energy suppliers are obliged to conclude agreements on consumer education and consulting.). Additionally, Lithuania sees a need to raise awareness of emerging threats among residents, farmers and entrepreneurs and to promote preventive protection against the damage caused by climate change.

IV TEMPLATE

The "Template for identification and categorisation of cross-cutting issues in energy" aims at offering a coordinated input to decision-makers for addressing systemic and cross-sectorial solutions in the energy sector to support the Clean Energy Transition.

The template does not aim to serve as an exhaustive list of the technological and non-technological cross-cutting topics. Instead, it is seen as a preliminary exercise that can be elaborated further to eventually provide a universal framework that can be used for developing energy and climate transition plans and which will serve as a guidance for include the key action points essential for achieving net-zero goals in an environmentally, socially and economically sustainable way.

The template addresses non-technological and technological cross-cutting topics, and is built around the following aspects:

- Cross-cutting categories and subcategories, identified by SUPEERA project. These categories offer a higher level of granularity and a deeper level of detail. Allowing for a better assessment of the efficacy, efficiency, and overall needs in the specific topics. (column 1 and 2);
- Description's requirements provided by SUPEERA (column 3) that should ensure consistency of the information provided policymakers when describing both technological and non-technological cross-cutting topics;

- Categories and Descriptions used in the IPs and in the NECPs. In the table we only refer to the cross-cutting issues that are identified in one or two of the mentioned documents and we include the explanation used across the IPs and in the NECPs (Column 4, 5, 6).

For the Non-technological cross-cutting topics SUPEERA suggests the use of the following categories and subcategories are:

Oriented at Environmentally Sustainability: switch from critical materials to less critical ones, switching to production practices with less environmental impacts, circularity-related initiatives, limiting CO2 footprint of tech development, international context of resource use (carbon spill overs, e.g.), etc.

Oriented at Socio-Economic Sustainability: citizens' empowerment, co-designing innovations, encouraging prosuming, energy-justice-related initiatives, energy affordability and poverty, ownership structures, tariffs and taxes, technological acceptance and innovation adoption, jobs, training/re-training, innovations ecosystems, circular business models, use of digital technologies across the economy and society, etc.

The range of topics included in the non-technological cross-cutting issues was aimed to cover a wide range of priorities that can provide a holistic framework to help a more systemic and sustainable approach for technological planning. Environmental and socio-economic sustainability categories were chosen in line with the universal sustainability pillars. The specific categories within each of the topics were mainly informed by the Cross-Cutting Issues Input Paper for the CETP SRIA and the EERA CET White Paper.

For the Technological cross-cutting topics SUPEERA suggests the use of the following:

Related to improvement and development of specific technology: design improvement, efficiency increase in buildings, in industry, electrification, etc.).

Related to integration with other technologies: energy system integration, electrification, grid and energy system infrastructures, etc.

Connection to the cross-cutting technological solutions: digitalization, integrated modelling and scenario-building, exploring the role of specific tech solutions for climate-neutral pathways, etc.

Standardisation: development, data collection, gap analysis, facilitation of standardisation frameworks, access to standards, engaging developing countries.
The inputs received by the Joint Programmes Coordinators have been included in the template.

Table 4: Non-technological cross cutting topics

SUPEERA Categories	SUPEERA Sub-categories	SUPEERA Description's requirements	Cross-cutting topic appearing in the IPs and in the NECPs	Targeted descriptions used across the IPs	Targeted descriptions and requirement in the NECPs
Environmental dimension	Circular economy	Include references to LCA, reuse-reduce-recycle activities, waste reduction, circular business models.	Circular economy	Broad remit, including LCA.	Circular economy is included as requirement on the biofuel development and deployment, on assessment of the feedstock availability and resource competition. In NECPs, it is used also e.g. in relation to reduce waste, conserve natural resources, ecodesign, and better mobilisation of all stakeholders.
Environmental dimension	Impact on ecosystems of technologies' deployment	Include references to impacts on specific ecosystems (i.e. climate impact, biodiversity impact, water use, spatial planning and use, deforestation),	No direct reference to this in the IPs and NECPs	No direct reference to this.	No direct reference to this. In NECPs, references only to e.g. innovation, forestry ecosystems, protection of

		environmental indicators for assessing level of sustainability of different technologies.			ecosystems, resilience of ecosystems.
Socio-Economic Sustainability	International Cooperation	Include references to the specific types and scales of collaborations: transnational, European, bilateral, gov-to-gov collaboration/ exchange.	International cooperation in the IPs No direct reference to this in the NECPs	Broad remit, incl. knowledge transfer between academia and companies, capacity building, best practices exchange across countries.	No direct reference to this. In the NECPs it is mentioned e.g. as requirement to succeed in implementation and scaling-up innovations and participating to international programmes (e.g. MI)
Socio-Economic Sustainability	Education & Training	Include activities aimed at strengthening the capacity to deal with the Clean Energy Transition and related support actions.	Education & training	Incl. best practices exchange, dissemination of knowledge and experiences	Vague references to these. Specific measures to provide training on renewable energy and energy efficiency. Mentioned in the NECPs e.g. on stakeholder consultation and involvement, boosting education policy.

Socio-Economic Sustainability	Employment, job creation	Include type of jobs and qualifications related to development of a particular technological solution/strategy, activities and funding related to building training/re-training capacity, mentioning 'job spill-overs' into other sectors and regions beyond the EU, if relevant; aspects of justice and inclusiveness related to employment.	No direct reference to this in the IPs Vague references in the NECPs	No direct reference to this.	Vague reference to these; mentioned in impact assessment of planned policies and measures. In the NECPs, e.g. the energy measures must result in employment, opportunities for the employment, creation of jobs.
Socio-Economic Sustainability	Policy & regulation	For Regulation: Refer to suggestions for regulation improvements, ambiguous regulation at national and international scales, regulatory framework. For Policy: Refer to national and international policies in relevant areas, related strategies.	Policy & regulation For the NECPs references only to EC Regulations and Regulatory framework	Incl. market design, support to stable, long-term R&I policy framework, pan-European procurement models	Overview of current policy situation, policy context of the national plan, policy measures. In the NECPs, e.g. environmental regulation, regulations of offshore grids and infrastructure, harmonisation of regulation; benefits of a more advantageous regulatory framework.

Socio-Economic Sustainability	R&I funding programmes & measures	Include reference to the existing policies and measures, the planned ones and the budget allocated.	R&I funding programmes & measures	Incl. access to finance/ad hoc financial schemes (& related risk management), shared certification and shared data models, support to industry & to large-scale deployment initiatives.	National funding targets for R&I. In the NECPs: funding programmed, funding options
Socio-Economic Sustainability	Social awareness, technological acceptance	Include communication to general public about impacts of particular technologies on behaviour change. Include “training” activities regarding citizenship participation. The new generations are aware of digital capabilities, but they have to understand their use and what is underneath.	Social awareness, acceptance, engagement	KPIs to measure consumer cost and benefits, development of novel economic schemes and social acceptance models; analysis of socio-economic motivations for investing in technologies/solutions	No direct reference. Social context of the plan, social impacts. In the NECPs, e.g. ‘Participation and acceptance are vital for the spatial integration and exploitation of energy projects’, social acceptance of technologies.

Socio-Economic Sustainability	Measures to promote energy citizenship	Include reference to prosumers' support solutions, stakeholder engagement in technological solutions designs	Energy citizenship No direct references in the NECPs	Incl. Living Labs, energy technologies & solutions for decarbonized European districts and cities; social, environmental and legal aspects re to infrastructure development	No direct reference.

Table 5: Technological cross-cutting topics

SUPEERA Categories	SUPEERA Sub-categories	SUPEERA Description's requirements	Cross-cutting topic appearing in the IPs and in the NECPs	Targeted descriptions used across the IPs	Targeted descriptions and requirement in the NECPs
Related to improvement of specific technologies	Increase of energy efficiency in buildings	Include references to the different opportunities and measures for reducing energy use in buildings without sacrificing comfort levels; mechanisms for financing energy efficiency measures in buildings; summary of legislative and policy tools that have been successful in promoting energy efficiency in buildings.	In the IPs Energy efficiency In the NECPs only mentioned to Energy efficiency (no specific references to buildings and industry)	In buildings: cost reduction and increase in efficiency of micro-combined heat and power/combined cooling heat and power plants	Requirement as Dimension energy efficiency; as contributions to the Union's energy efficiency targets. No specific requirements in the NECP template for EE in buildings.
Related to improvement of specific technology	Increase of energy efficiency in industry Electrification	Include separate parts that relate to (i) the energy efficiency and energy intensity-related activities and to (ii) the industrial processes	In the IPs Energy efficiency In the NECPs only mentioned to Energy	In industry: energy efficiency of cross-sector industrial components	Requirement as Dimension energy efficiency; as contributions to the Union's energy efficiency targets.

		electrification activities.	efficiency (no specific references to buildings and industry)		
Related to integration with other technologies	Energy System Integration Bioenergy	Include references to 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	In the IPs Energy System Integration No direct reference in the NECPs	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	No direct reference. References to Energy market integration mentioned in the requirements. Example from an NECP: possible coop on 'joint approach to hydrogen within the energy systems of Penta countries.
Related to integration with other technologies	Energy System Integration Buildings and Electrification	Include references to production, consumption and storage of renewable energies in buildings in integration with	In the IPs Energy System Integration	Synergies with building and transport/e-mobility: development of photovoltaic technologies in combination with	No direct reference. References to Energy market integration mentioned in the requirements.

		electromobility infrastructures; synergies with building and transport/e-mobility.	No direct reference in the NECPs	efficient building materials (Building-Integrated PV); production, consumption and storage of renewable energies in buildings in integration with electromobility infrastructures	In the NECPs mentioned e.g. as national programme “The new energy system in the built-up environment in balance”. Electrification mentioned in the Policies and measures to achieve low emission mobility (including electrification of transport)
Related to integration with other technologies	Energy System Integration Grid and energy infrastructures	Introduce a more structured way of addressing the grid infrastructure projects. Suggested structure can be in line with the EERA JP Smart Grids Joint Program (i) Technologies and tools for the	In the IPs Energy System Integration No direct reference in the NECPs	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	No direct reference. On Market integration Renewables, (smart) grids are mentioned to increase flexibility of the energy system.

		management of future power systems; (ii) Storage integration; (iii) Distribution network flexible operation; (iv) Flexible transmission network; (Consumer and Prosumer engagement through Digitalization and ICT)		integrate different sources of energy (grid dispatchability)	
Related to improvement of a specific technology	Design Improvement	High temperature and advanced materials as enablers to improved and develop further/new energy technologies.	In the IPs High temperature & advanced materials No direct reference in the NECPs	Development of affordable high-temperature, corrosion-resistant materials or new alloys resistant to extreme conditions for renewable fuels/sustainable transport	No direct reference. In few of the NECPs, advanced materials are mentioned, e.g. building thematic networks on advanced materials to develop skills and knowledge for R&D&I.
Related to improvement of a specific technology	Design improvement	The description from the IPs can be used as a requirement.	High temperature & advanced materials	Development of materials processing techniques and components for fast industrialization	No direct reference. In the NECP: an identified priority area on advanced

			No direct reference in the NECPs	compatible with current mass production lines in batteries	materials for batteries; develop expertise along the battery value-creation chain from material manufacture and manufacturing processes.
Related to improvement of a specific technology	Design improvement	The description from the IPs can be used as a requirement.	High temperature & advanced materials No direct reference in the NECPs	Development of effective materials to reducing issues connected with scaling and corrosion, both for low- and high-temperature geothermal applications	No direct reference.
Related to improvement of a specific technology	Design improvement	The description from the IPs can be used as a requirement.	High temperature & advanced materials No direct reference in the NECPs	Research on innovative materials and their degradation/failure mechanisms leading to the development of new and improved materials for offshore wind	No direct reference.

Related to improvement of a specific technology	Design improvement	The description from the IPs can be used as a requirement.	High temperature & advanced materials No direct reference in the NECPs	For buildings: cost-efficient, intelligent, flexible heat pumps (also thermally-driven) and heat pumps for high temperatures	No direct reference.
Related to improvement of a specific technology	Development of new technologies/ Energy System Integration – Thermal storage[14]	Include references to energy system flexibility, storage materials and components, and specifying if it is short-, mid-, or long-term storage.	Energy storage	Development of compact thermal energy storage materials, components and systems	No direct reference in the NECP requirements
				Storage and heat exchange of solar energy	Example from a country NECP: 'Large seasonal heat storage projects are being considered an option for the future of solar thermal energy.'
Related to improvement of		Include references to large-scale	No reference	No reference in the IPs	No reference in the NECPs

[14] In line with the categorization from CETP SRIA Input Paper for Energy Storage, https://www.eera-set.eu/component/attachments/?task=download&id=520:CETP_Input_Paper_Storage_and_Fuels_final

a specific technology	Development of new technologies/ Energy System Integration – Electrochemical and thermochemical storage, including fuels[14]	production, compatibility with existing fuel infrastructure, market entry strategy, and connections to CCUS activities. Specify if it is short-, mid-, or long-term storage.		Renewable energy storage	Example in the NECP: Renewable energy storage based on biofuels for aviation and shipping.
Related to improvement of a specific technology	Development of new technologies/ Energy System Integration – Cross-sectoral storage solutions, incl. hybrid or integrated energy storage, PtX[14]	Include references to energy system flexibility, storage materials and components, integration with other RES, energy storage capacity (regional or national needs). Specify if it is short-, mid-, or long-term storage.	Energy storage	New design for high temperature thermal energy storage.	Energy storage is mentioned in the Dimension energy security as means of increasing the flexibility of the national energy system. In the NECPs, e.g. Aquifer thermal energy storage (ATES) technology development.
				Hybridisation of battery systems for stationary energy storage, integration with other renewable energy systems	In the NECPs: demand for mobile and stationary electricity storage and production of the energy storage

					reservoirs; research on battery concepts used in stationary storage systems.
				Development of local storage solutions for energy districts	Example in the NECP: Renewable energy storage capacity can be needed in some isolated areas.
Connection to the cross-cutting technological solutions	Exploring the role of specific tech solutions for climate-neutral pathways	Include references for the integrated energy system, and models and methodologies to support the Clean Energy Transition.	Energy storage	Development of a European CO2 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	CO2 storage is mentioned in few NECPs.
Connection to the cross-	Digitalisation - Cross cutting solutions	Include references to HPC, HTC, edge	Digitalisation	Internet of Things, smart cities &	No direct reference.

cutting technological solutions		computing, fog computing, Internet of Things, smart cities, connection with e-mobility, mobility and transportation systems, environmental monitoring systems (pollution, air quality), improvement of the life of the citizens and their participation by mobile apps. Digital methodologies of interest: numerical simulations, data-driven workflows, artificial intelligence, forecast and hindcast capacities, etc.	No direct reference in the NECPs.	connection with e-mobility.	In the NECPs, digitalisation is e.g. seen to play an important role for households to have an active role in the energy transition, and in modernising the network.
Related to improvement of specific technological *and* Connection to the cross-cutting	Digitalisation - cybersecurity	Include references to cybersecurity & resilience against cyber-attacks (including identification and real-time counteracting)	Digitalisation No direct reference in the NECPs.	Cybersecurity & resilience against cyber-attacks (including identification and real-time counteracting)	No direct reference. In the NECPs, cybersecurity is mentioned in e.g. digital energy systems

technological solutions					
Connection to the cross-cutting technological solutions	Use of digital technologies across the economy and society	Include references to socio-economic indicators tracking change, development and performance, separate supply- and demand-side digitalization solutions; include aspects of personal data protection and cyber-security, digital certification and market operations (blockchain), Artificial Intelligence (AI) for the support to the decision-making process	Digitalisation	Incl. creation/use of reference architecture and standards, common terminology for new energy services, in particular for data sharing/ICT in future R&I projects, e.g. energy services for smart homes and cities.	In an NECP: 'A more comprehensive Internet of Things will encourage optimum data sharing'.
Standardisation	Standardisation in digitalisation	Include references to (meta) data management / (meta) data unification issues (definition, FAIR principles, curation, data spaces interoperability,	Digitalisation	Data management/data unification issues (information platform, creation of standards and common data models at EU level)	In an NECP: e.g. data management is needed to support energy and climate policy.

		information platform, creation of standards and common data models at EU level, data sharing, data security, data protection)			
	Standardisation in energy technologies	Include references to development, data collection, gap analysis, facilitation of standardisation frameworks, access to standards, engaging developing countries. Include specific standardisation criteria that can be related to environmental of socio-economic sustainability.	Standardisation	Incl. standards and guidelines for technology evaluation and analysis; collaboration on the development of certification and safety standards	In NECPs: efforts related to the standardisation of protocols and charging infrastructure'; development of technical standards for Smart Meters

V CONCLUSION

The work on the cross-cutting issues for the Clean Energy Transition conducted by SUPEERA is part of the currently undergoing research initiatives and projects at EERA oriented at better addressing the cross-cutting aspects of the energy transition. The main idea of these initiatives is to help to avoiding silo-based approach in the EU when designing technological solutions and funding schemes to support the Clean Energy Transition towards carbon neutrality.

The results and recommendations of the SUPEERA project presented in this paper can be explored in connection to the other publications of EERA, particularly, a White Paper on the Clean Energy Transition systems-thinking approach for the Clean Energy Transition[15].

The results of the SUPEERA work on the cross-cutting issues can be broad further for developing the list of cross-cutting issues further and could be used as input for the future IPs design under the SET Plan. Further work on improving the presented template can include the inputs of the EERA White Paper on the Clean Energy Transition, where the key cross-cutting themes essential for successful energy transition are addressed. These themes include digitalization, sector coupling & system integration, circularity & efficiency, policy regulation & markets, energy citizenship & lifestyle.

[15] EERA White Paper on the Clean Energy Transition will be available online in September 2021.

ANNEX I - D1.6 “Interim report & recommendations on cross-cutting and interdisciplinary activities relevant to the SET Plan”

ANNEX II - "Common principles guiding temporary Working Groups to prepare Implementation Plans"