European Commission

Framework Conditions for deployment and uptake of low-carbon technologies

Mutual Learning Exercise on Industrial Decarbonisation

Fourth thematic report

PSF CHALLENGE

HORIZON EUROPE
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Independent Expert Report

Research and Innovation

Framework Conditions for deployment and uptake of low-carbon technologies
Mutual Learning Exercise on Industrial Decarbonisation

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EUROPEAN COMMISSION

Framework Conditions for deployment and uptake of low-carbon technologies

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Fourth thematic report

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1. Introduction

This Mutual Learning Exercise (MLE) serves as a platform for the 12 participating countries to discuss their specific needs and interests, exchange experiences and knowledge about success factors and lessons learned and provide guidance to policy makers on how to develop or update their industrial technology roadmaps, and sector-specific strategies for industrial decarbonisation[1,2.]

This thematic report has been prepared as a result of the fourth meeting of this MLE, held on 28-29 November 2023 in Lisbon.

The deployment rate and scale up of the Energy Intensive Industries' (EII) decarbonisation innovations are still too slow in view of the challenging goals. It is necessary to increase the speed of the implementation of new technologies and help overcome the barriers that currently prevent the deployment of Research and Innovation (R&I) solutions for the EII to reach climate neutrality.

As the investments are high and based on an amortisation over long periods of time, medium to long-term stability of the regulatory conditions is needed. Besides, non-regulatory conditions (knowledge valorisation, standardisation and green patenting), the role of technology infrastructures, open innovation test beds, other platforms, and data and knowledge, also play a vital role in the industrial transformation to net-zero industry policy.

All these aspects were explored within the topic of framework conditions for deployment and uptake of low-carbon technologies during the two-day meeting event which took place in Lisbon on the 28th and 29th of November 2023. The aim of this meeting was two-fold, firstly to identify and address barriers and drivers, and secondly, to advise on concrete actions, through the active contribution of MLE representatives and industrial participants, in an open and constructive dialogue.

The conclusions cover a wide range of collaborative activities. As a general statement, the need to develop a compelling narrative was unanimous, emphasising the need to urgently focus on climate neutrality and the reindustrialisation of Europe. To achieve this objective, it is crucial to engage all stakeholders, including regions and municipalities, across the entire value chain.

By nature, de-risking innovation at Technological Readiness Levels (TRL) above seven requires large investments and implies a significant technical and economic risk. Therefore, co-financing and blended funding models are necessary. Subsequently, the coordination and alignment of financial schemes at the EU, national, regional, and local levels are widely sought aiming at reducing both, capital expenditures (CAPEX) and operating expenses (OPEX). In this context, Carbon Contracts for Differences (CCfDs) are recognised as a useful national financial tool, leading to the commercialisation of low-carbon technologies and large-scale deployment. In addition, regulatory sandboxes are deployed successfully in different countries to define good practices in the development and implementation of regulatory environments, facilitating their application.

[1] Factsheet: Industrial decarbonisation - Publications Office of the EU (europa.eu)

[2] European Semester and Country Intelligence' of the ERA & Innovation Directorate at DG Research and Innovation is the Policy Support Facility Team for this MLE, while E.1 — 'Industrial Research, Innovation and Investment Agendas' oversees the work, with the support of E3 — 'Industrial Transformation' of the Prosperity Directorate, DG Research and Innovation.

Resilience for the European process industries is a key driver for the EU. In particular, the access to affordable and clean energy is instrumental for decarbonising the energy-intensive industries. There is the need to assess different types of energy (and sorting systems) and how to integrate them smoothly in decarbonisation strategies. Hence, the alignment with the energy sector, which heavily impacts the framework conditions of process industries, is crucial.

From a market perspective, public awareness of the climate transition has multiplied the demand for green products. However, there is still a lack of compelling narratives and storytelling about the importance and impact in our society of green products from process industries. To this end, the support and commitment from the industry is crucial. In parallel, market pull measures, and especially green procurement and/or taxation should be further explored, which in turn require standards and measurement methods.

In times of high uncertainty, planning of supporting tools to decarbonise the industry requires flexibility and the possibility to assess different alternatives. Thus, those critical activities should incorporate updated Key Performance Indicators (KPIs) and adopt a continuous monitoring and evaluation cycle and a learning approach. However, data collection from companies poses still some challenges, which influences, for example, the effectiveness and adaptability of scenarios used in policy design. To improve this situation, the process of collecting data and identifying indicators should take place in a collaborative framework between industry and public authorities, as a mutually beneficial opportunity to align the industry' needs with the future decarbonisation programmes. In addition, obtaining permits is rapidly becoming a major obstacle for investments and require long, uncertain, and complex procedures at national level. In this sense, a fast-track procedure for obtaining permits is suggested, and in practice, a "Community of Practice on permitting" would be fruitful.

From the productivity point of view, new approaches towards sustainable business models are required. Symbiotic approaches towards multi-actor, cross-sectorial, and collaborative schemes, such as Hydrogen Valleys, Hubs for Circularity (H4C), Carbon hubs or Regional Innovation Valleys, play a pivotal role in facilitating the exchange of data, fostering co-development, encouraging co-creation, and enabling experimentation with new business models.

As part of the energy-intensive industries, large companies are key players in deploying low-carbon technologies. Nonetheless, Small and Medium-sized Enterprises (SMEs), play a key role as well. As technology providers to support the decarbonisation of processes (energy-intensive industries), they require financial mechanisms adapted to their needs. Furthermore, SMEs are also expected to decarbonise their processes, despite their low participation in co-developing public policies in this domain. Therefore, their engagement as active contributors in the road mapping exercise on decarbonisation pathways is required.

Lastly, access to talent is a major challenge facing the EII today. In a competitive environment, within the process industries but also with other vibrant sectors (e.g. energy sector), it is crucial to onboard and regularly train skilled and talented people. Furthermore, process industries need to retain talented workers and promote long-term career opportunities. In practice, a "Community of Practice on Skills and Talent" would be useful.

1.1. Background

Energy-intensive industries (EIIs), so-called process industry, are embedded in many strategic value chains, these companies produce goods and materials that enable reduction of emissions in other sectors of the economy, including transport, construction and power generation. Energy-intensive industries cover a broad range of sectors, such as chemicals, steel, paper, plastics, mining, extraction and quarrying, refineries, cement, wood, rubber, non-ferrous metals, glass, and ceramics[3], which are characterised by a high energy and carbon intensity and serving as input for many other value chains. Energy Intensive Industries employ 7.8 million people in Europe and provides a value added of EUR 549 billion (4.55% of the EU total). In 2019, the EII were responsible for 22% of total EU Greenhouse Gas (GHG) emissions[4]. They provide raw, processed, and intermediate materials. In addition, the energy-intensive industries emit a large share of global GHG emissions as industrial processes require high temperatures and depend on high energy densities to enable the processes involved. To reduce emissions, these industry sectors need to displace fossil fuel-based energy inputs with renewable electricity and other energy carriers, coupled with improved resource and energy efficiency (including circular approaches). They need to take advantage of new processes being developed and move towards the deployment of new First Of A Kind (FOAK) industrial plants to make those sectors competitive, resilient, and sustainable. Also, technology manufactures, in particular SMEs, can play a significant role in maximizing and spreading the low-carbon technologies within the same sector or across sectors.

In July 2021, the European Commission adopted a package of 13 legislative proposals jointly designed to deliver on the targets of the European Green Deal, namely, to decrease GHG emissions by at least 55% (compared to 1990 levels) by 2030, and to achieve climate neutrality by 2050[5]. Particularly relevant for the energy-intensive industries ecosystem within this package is the proposal to strengthen and extend the EU Emission Trading System (ETS), which includes a substantial increase in the size of the Innovation Fund. Furthermore, the subsequently proposed Net-Zero Industry Act aims that domestic manufacturing of strategic net-zero technologies should cover at least 40% of the EU's annual deployment needs by 2030. It also covers elements to facilitate the transition towards large scale applications (e.g., more rapid permitting procedures for projects that contribute to low carbon transition). Furthermore, the Critical Raw Materials Act also sets ambitious goals by 2030.

Other major events influenced the present and the future conditions under which energy-intensive industries will operate. The COVID-19 pandemic had a profound impact on how the process industries interact with their supply chains and their innovation ecosystem. In addition, the Russian invasion of Ukraine, changed the geopolitical framework causing significant economic problems for the process industries, and it highlighted the dependency of the European Union (EU) on external supplies of important materials and carriers of energy. Within this international context, competing countries are deploying large investment plans to work towards carbon neutrality, mainly in the US and China. Hence, there is the need to continue to reduce the cost of decarbonisation and maintain the competitiveness of the European industry throughout the net-zero transition, while increasing European autonomy in matters of raw materials and energy supply.

[3] As defined in the ASMR 2021 (SWD (2021)351) accompanying the communication on "Updating the 2020 New Industrial Strategy" (COM (2021)350).
[4] https://ec.europa.eu/docsroom/documents/51115/attachments/1/translations/en/renditions/native
[5] https://commission.europa.eu/publications/delivering-european-green-deal_en

All the elements mentioned are part of the topic framework conditions for deployment and uptake of low-carbon technologies.

1.2. Objectives

The Mutual Learning Exercise (MLE) on Industrial Decarbonisation is expected to contribute to achieving the European Green Deal (EGD) objectives and to follow-up on one of the actions of the first European Research Area (ERA) Industrial Technology Roadmap, namely, to facilitate specific national, sectoral, and cross-sectoral strategies or programmes with key stakeholders as part of the ERA Policy Agenda 2022-2024.

In addition, the MLE generates best practices and models, as well as offers a discussion of relevant framework conditions, which could support the mobilisation of private and public investments in low-carbon technologies in energy Intensive Industries (EII) and their deployment with the objective of supporting the green transition and achieving net-zero emissions.

The MLE is organised into several rounds of meetings on specific topics (, proposed by the European Commission in the ERA Forum in October 2022 and refined after a consultation process with the participating countries during an online scoping workshop on 12 December 2022.

The four topics of the MLE on Industrial Decarbonisation are as follows:

- Topic 1: Introduction and overview of national strategies
- Topic 2: Policies, design and financing for R&I investments in development, uptake and deployment of low-carbon technologies
- Topic 3: Actors' engagement
- Topic 4: Framework conditions

The kick-off meeting (online, Topic 1) was held on 28 April 2023. The second meeting was held on 29-30 June 2023 in Vienna (Austria), focusing on Topic 2. The third meeting took place on 19 September 2023 (online, Topic 3), while on 28-29 November 2023, the fourth meeting on Topic 4 of the MLE took place in Lisbon (Portugal). The final meeting (online) was organised on the 29th of January 2024 to wrap up the findings of the MLE. A dissemination event is envisaged to take place on 9-10 April 2024 under the Belgium Presidency of the Council of the European Union.

2. Methodological approach

The report extensively relies on the discussions held during the fourth meeting of the MLE in Lisbon, on 28-29 November 2023. The workshop developed key themes from previous sessions, including the analysis of elements within national strategies and industrial decarbonisation programmes, as well as the examination of the investment and policy mix of Research and Innovation(R&I) instruments and stakeholder engagement. Additionally, the workshop expanded upon the application of the Whole-of-Government Approach (WGA) and drew insights from the ongoing WGA MLE. It focused extensively on regulatory as well as non-regulatory aspects.

In this fourth thematic report (Topic 4 'Framework Conditions') the focus is on analysing and exploring three subtopics under the umbrella of framework conditions, including:

- **Regulatory frameworks** and their impact on the R&I and deployment cycle at different stages - permits to First-Of-A-Kind installations (FOAKs), impact of Waste Framework Directive, Industrial Emissions Directive, Emissions Trading System Directive, etc.

- Role of **technology infrastructures**, open innovation test beds, among others.

- **Knowledge and data** (valorisation, standardisation, monitoring of R&I data and set of KPIs, green patenting, etc.).

The meeting agenda placed emphasis on the experience of the Portuguese government, with substantial participation from Portuguese experts in all panel discussions. There were also presentations from other countries, such as Austria, Belgium, Finland, Lithuania, Slovakia, Spain, and Türkiye. Moreover, a significant aspect of the event was a policy dialogue with EII industries from Portugal, facilitating the exchange of viewpoints between MLE countries' representatives, and Portuguese industrial stakeholders.

3. Structure

First, the report presents the Introduction of the topic (Section 1), including data indicators of the process industries' ecosystem in order to indicate its importance in Europe, the modifications and support schemes at both national and international level to support the low-carbon transition, and the challenges still to face. Before the meeting in Lisbon, a comprehensive discussion paper was shared, outlining six key factors crucial in decision-making for decarbonisation investments in industries (Section 4 of this report). These factors, interlinked with the framework conditions subtopics, aimed to facilitate the exchange of ideas and experiences during both the preparation phase as well as during the two-day meeting in Lisbon.

The Lisbon meeting revolved around three panel discussions on targeted subtopics, including regulatory frameworks, technology infrastructures, and knowledge and data. The panels drew upon pre-selected best practices to share amongst colleagues, ensuring a balanced distribution of speakers and examples to explore various elements within the topic of this event. Detailed descriptions of countries' presentations, along with conclusions and recommendations during the open discussions after each panel discussions, are included in this report (Section 5).

In the preparation phase of the meeting, bilateral meetings were organized with all Member States' (MS) representatives to explain the methodology and gather information upfront. It allowed to agree upon and select the most appropriate experiences and best practices to share during each panel discussion. As a tool for the participating countries to help them prepare their presentations, a list of questions to the member states was circulated (see Annex I). As a complementary collection of information, a survey was filled in by the 12 involved countries. This information has been used to complement and enrich the information gathered during the discussions during the Lisbon meeting. Its results are summarized in Section 5 of this report. The complete answers are included at the end of the report (Annex II).

In addition, the industrial perspective assumed a pivotal role during the meeting, featuring presentations and discussions from representatives of six industrial sectors, as detailed in

Section 7 of the report. In preparation of the industrial panel, additional bilateral interviews were conducted with these industrial participants prior to the meeting in Lisbon. Also in this case, as a tool for the participating industrial representatives to help them prepare their presentations, a list of questions to them was circulated (see Annex III)

Lastly, based on the Lisbon meeting and complementary collected information from the participating countries, section 8 includes the identified barriers and drivers as lessons learned which led to section 9, devoted to the proposed actions to the way forward to achieve impact.

4. Factors

The process industry in Europe play a crucial role in the economic prosperity of European citizens. The industries generate numerous job opportunities and serve as the backbone for the manufacturing sector. As part of these industries, large companies are key players to deploy low-carbon technologies. Nonetheless, Small and Medium-sized Enterprises (SMEs), play a key role, both as companies with the need to decarbonise their processes and as technology providers to support the decarbonisation of other companies' processes. However, process industries in Europe face significant challenges from global competition, primarily attributed to high energy costs and limited resources. Balancing the imperatives of meeting climate and circularity targets while remaining economically viable poses a considerable challenge for process industries.

To comprehensively evaluate all the boundary conditions influencing investments in low-carbon technologies, six key factors have been considered:

- Policy
- Productivity
- Market for green products
- Financial
- Resources
- State aid

These factors are further elaborated in the chapters below.

4.1. Policy

Several European policies have significantly shaped the process industries over the last decade. Electrification is one of the key pathways to climate-neutrality in the energy-intensive industries. The EU is putting in place a regulatory framework including the Emissions Trading System (ETS), the Carbon Border Adjustment Mechanism (CBAM), the Energy Efficiency Directive (EED), the electricity market reform and the net-zero industry act. These regulations reinforce electrification of the process industries as a key element of the reduction of the CO2-emissions in Europe in the years to come. The technology-driven Strategic Energy

Technology (SET) Plan6, recently revised, asks MS to include national objectives stemming from the SET Plan, as well as R&I activities, in their National Energy and Climate Plans (NECPs) including the search of synergies between other relevant national funds.

Furthermore, the concept of circular economy has gained more attention with the launch of the European Green Deal (EGD). The goal of circular economy is to decouple resource consumption and wealth creation. Currently, the level of circularity is overall still marginal at a global rate of 7.2 % according to the Circularity Gap Report 20237. In addition, following the scientific baseline set by the International Panel on Climate Change (IPCC), adjustments of application to the process industries have been undertaken, such as the updated Circular Economy Action Plan (CEAP) in 2020 with a greater emphasis on holistic value chain management (strategic value chains). In addition, circularity became one of the nine drivers of long-term competitiveness of the EU8.

At national level, some policy instruments that support technological change on the production side, including primary production and recycling processes, are under evaluation. In fact, various MS have started developing industry-specific policies to facilitate commercial zero-emission basic material production.

In this context, Carbon Contracts for Differences (CCfDs) can ensure a strong and stable carbon price signal that reduces the financing costs and risks of zero-emission investments, leading to their commercialisation and large-scale use, as demonstrated with the case of Germany described in the box below. CCfDs are complementary to existing supply-side policies, such as innovation funding, the EU ETS and the Industrial Emissions, Renewable Energy and Energy Efficiency Directives.

Carbon contracts for difference (CCfDs): The case of Germany[9,10]

The German government announced its decision to provide funding to Energy Intensive Industries (EII) via a 'carbon contracts for difference' (CCfD) program. All companies reducing CO_2 emissions and converting their production to climate-friendly production will be eligible to benefit from this program and be able to receive grants independently from their production sizes, therefore including small and medium-sized companies.

CCfDs give the companies a reliable basis on which to invest, coupled with incentives to attain the promised carbon reduction targets. They can create stable demand for hydrogen and would thus have a positive impact on the supply side. The advantage of a CCfD is that it takes account of a company's actual avoidance costs and its possibilities to pass them on the market. If, over time, changes arise in the price of emission allowances, for example, or in the field of EU measures to prevent carbon leakage, the difference payments can be adjusted flexibly.

According to the Carbon Contract for Difference concept, EII will be compensated by climate protection agreements for a period of 15 years to cover for their additional costs (OPEX and CAPEX) to convert their production. These climate protection agreements thus make green technologies more attractive for EII.

[6] The revision of the Strategic Energy Technology (SET) Plan. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023DC0634&qid=1698315020718
[7] The circularity gap report 2023. Circle Economy, Amsterdam 2023.
[8] COM (2023) 168 final, accessible at https://commission.europa.eu/system/files/2023-03/Communication_Long-term-competitiveness.pdf
[9] https://www.iea.org/policies/17538-carbon-contracts-for-difference-ccfd-program-for-energy-intensive-industries
[10] https://www.bmwk.de/Redaktion/DE/Wasserstoff/Foerderung-National/018-pilotprogramm.html

CCfDs are characterised as project-specific instruments to be awarded in a multi-step and multi-criteria competitive award procedure that is open to all eligible industrial sectors. The lowest EU ETS strike prices would only be one out of multiple award criteria that are still to be defined. CCfDs shall be awarded for a contract duration of 10 years and are two-sided, whereby the strike price shall be variable and adjusted yearly, based on energy market prices.

In summary, the German government aims to accelerate the phasing-out of fossil fuels in EII and convert their production processes in green production (for instance in production facilities and pipelines for hydrogen). This CCfDs are therefore an important instrument to help climate-friendly industrial processes to reach market maturity and to break through on to the market.

Box 1: Carbon contracts for difference (CCfDs): The case of Germany

Making investments in new, low-carbon processes financially attractive can motivate companies to invest more in innovative solutions as opposed to mature, yet more carbon-intensive technologies, as shown in the case of the Netherlands (Box 2).

Carbon pricing policy with technology support: The case of The Netherlands[11,12]

The current Dutch policy mix for industry decarbonisation combines a carbon pricing policy with technology support in a bottom-up cluster-based strategy. Combining carbon prices with technological-specific support forms the basis of an effective and cost-efficient policy package. Well-designed carbon pricing makes a technology-neutral case for low-carbon investments and consumption choices.
However, support schemes for low-carbon technology development and deployment, such as the Sustainable Energy Transition Incentive Scheme (SDE++) subsidy or the Energy Investment Allowance (EIA) tax allowance, encourage the adoption of emerging low-carbon technologies that may achieve significant cost-efficient emission reductions on the long run.
The Dutch Stimulation of the Sustainable Energy Production and Climate Transition (SDE++) scheme establishes a project specific price floor (put-option) for electricity generation, renewable heat (CHP), renewable gas, low-carbon heat, and low-carbon production processes with an annual budget of EUR 13 billion in 2022. For all but carbon capture and storage technologies, the SDE++ scheme is a put-option based on energy prices. Awarded projects obtain a strike price for renewable energy for a period of 12 or 15 years. On an annual basis, the Ministry of Economic Affairs and Climate Policy calculates the project-specific subsidy paid out to the agents based on the actual amount of energy produced and revenue obtained.
Only in the case of Carbon Capture and Storage (CCS), the SDE++ benchmarks an emission reduction strike price (EUR per ton of CO_2 reduced) instead of an energy strike price. CCS installations receive the difference between emission allowance revenues and the strike price as long as the revenues per ton captured are lower than the strike price.
In brief, this new instrument benefits the EII with a mechanism that brings new opportunities for decarbonising Dutch process industries. As an example, the Porthos project, aiming to permanently store the emissions captured in the Port of Rotterdam offshore, has been awarded SDE++ funding.

Box 2: Carbon pricing policy with technology support: The case of The Netherlands

[11] Carbon Contracts for Differences (CCfDs) in a European context. https://henrike-hahn.eu/files/upload/aktuelles/dateien/Study_CCfD_Henrike-Hahn_6.2022.pdf
[12] https://english.rvo.nl/subsidies-financiering/sde

Other national policy actions, such as so-called "sandboxes" [13,14] are applied in different countries (e.g., Germany[15], Portugal[16], Finland[17], and Flanders[18] (Belgium)) to define good practices in the development and implementation of (future) regulatory environments, to facilitate their application. Their application is tied to the national specificities and industrial sector priority setting, and lead to the connection or addition of elements from a value chain in applying suitable framework conditions.

4.2. Productivity

Productivity of the process industries relies on internal competitive advantages linked to production and operational conditions. The industry continuously searches for further improvements in the performance and integration of technologies into existing and redesigned processes, as well as more flexibility in operational parameters. Furthermore, external factors affect the competitivity of the companies such as business climate conditions, cooperation, technology development, knowledge transfer, as well as external support for investment and innovation.

In recent years, companies have tried to implement various strategies focused on sustainability that impact the way they do business. A collaborative approach is used to favour the exchange of material, infrastructure, and energy resources that create economic and environmental benefits. Industrial symbiosis brings opportunities to generate economic returns and gain a competitive advantage, for example, in the development of business models focused on the generation/store/use of energy. In particular, Hubs for Circularity (H4C)[19] will help to accelerate the deployment of cross-sectorial innovations by involving all necessary stakeholders and maximising the synergies of different funding schemes. To this end, regional engagement allows to involve all necessary stakeholders (including cross-sectorial collaboration) and maximise the synergies of different funding schemes. Several examples can be found in which the regional authorities actively participated to adapt its regional productive capacity to sectoral and technological transformations. Those cases were driven by decarbonisation, to support the understanding of the interconnectedness of the regional problems and the potential solutions to ease technology transfer and commercialisation of innovation with a major socioeconomic impact, or to combine visioning work with concrete pilot actions[20]. This will lead to the sharing of flows of energy and materials, data, services, and infrastructures and to the joint development and

[13] European Commission, Directorate-General for Energy, Gorenstein Dedecca, J., Ansarin, M., Afrodit Adsal, K. et al., Regulatory sandboxes in the energy sector – Final report, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2833/848065

[14] European Commission, Directorate-General for Energy, Gorenstein Dedecca, J., Ansarin, M., Afrodit Adsal, K. et al., Regulatory sandboxes in the energy sector – Final report, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2833/848065

[15] https://www.bmwk.de/Redaktion/EN/Publikationen/Digitale-Welt/handbook-regulatory-sandboxes.pdf%3F__blob%3DpublicationFile%26v%3D2

[16] https://www.ani.pt/pt/valorizacao-do-conhecimento/interface/zonas-livres-tecnol%C3%B3gicas/

[17] https://www.sciencedirect.com/science/article/pii/S0166497221000183

[18] https://www.energyville.be/en/news-events/thor-park-first-regulatory-sandbox-energy

[19] Hubs for Circularity (H4C) in the context of the Processes4Planet co-programmed Partnership are industrial clusters that realize lighthouse projects in industrial and industrial-urban symbiosis and circularity of materials and resources. These projects contribute significantly: to the reduction of CO_2 emissions, energy and resource efficiency to independence from fossil-based resources, and to the reduction of waste that is incinerated or landfilled. Hubs for Circularity are focal points for the implementation of the technologies that are developed by Processes4Planet, with a focus on cross-sectorial approaches, i.e. industrial symbiosis, industrial-urban symbiosis and circular economy, in a coordinated regional setting.

[20] Andreoni, A., Janssen, M., Saublens, C., Stefanov, R. and Tolias, Y., Bianchi, G., Mifsud, S., Reimeris, R., Innovation for place-based transformations. Collection of practices, Bianchi, G. editor(s), Publications Office of the European Union, Luxembourg, 2024, doi:10.2760/17335, JRC135826.

implementation of activities. Lastly, those links will lead to increased competitiveness for the involved partners, as well as to the reduction of waste that is incinerated or landfilled.

Furthermore, the time and effort needed to bring an innovation to the next TRL-level increases significantly from low to higher TRLs. That being said, the risk that an innovation turns out to be infeasible decreases along the TRL scale. Therefore, a broad range of ideas and technologies must be explored at low to medium TRLs to fill the innovation pipeline and address challenges for which no solutions are yet known.

Measures are necessary to enhance the speed of maturation of the technologies so that the deployment or commercialisation phase is reached as soon as possible. To this end, de-risking innovation via priority setting and co-financing opportunities and incentives are important.

Green products create a need for a significant capacity increase in electricity derived from renewables. Thus, availability, steady supply, competitive renewable energy costs, and robustness of the grid, are key decisive factors for the technology shift. Access to affordable renewable energy solutions, based on relevant infrastructure, is vital. This includes, in addition to green electricity, other sustainable energy carriers and the combination thereof. However, it should be noted that new energy sources will require retrofitting activities of big installations (i.e. brownfield redevelopment), which will again be subject to large investments.

To guarantee carbon neutrality and competitivity of European industries throughout the whole value chain, close cooperation with process industries' suppliers is essential. Process industries and their productivity depend on a well-functioning European market for secondary raw materials, where manufacturers can access affordable and high-quality materials.

Overall, productivity relates to reliability of supply chains and energy grids, flexibility in sourcing material and choice of providers, quality of materials and semi-finished products, and competitive pricing. These factors significantly influence the decisions taken at international level.

4.3. Market for green products

Growing demand for green products is crucial. To this end, it is required to stimulate the changing customer requirements towards high quality green products, along the value chain, where the process industries operate. Brand owners act as drivers for green materials (made with less CO_2, with less hazardous compounds and based on high recycled material content or bio (i.e. no fossil) content. Such tendencies will result in growing investor and public interest in sustainability and low-carbon technologies. To this end, governments can take action to support low carbon manufacturers by creating demand and developing the market for low-carbon industrial products.

Process industries need to recognize the benefits of investing in sustainable production methods, such as reduced carbon emissions, increased brand value, and improved operational efficiency. When introducing a green product line, companies also need to think about creating a green branding strategy. For example, a steel company headquartered in Germany, has developed the transformation of the production as part of their contribution to carbon neutrality, with the goal to achieve 100% CO_2 emissions reductions by 2045. Their green steel is a driver of the mobility transformation, but also in the energy sector (where green steel is used in transformers and in motors of wind turbines). Stell manufacturing companies are also entering into the packaging sector, as substitute for plastic packaging. Lastly, the green steel products are increasingly present in other industries (construction and

engineering). Their decarbonisation objectives lead to positive effects in the achievement of climate change mitigation targets, maintaining value creation and stable supply chains. The overall strategy is anchored in the brand owner's approach towards the marketing of carbon-neutral steel.

Early movers with FOAK projects will act as industry leaders and promote the further development of green products. The real demand of green products will allow companies to make large scale investments in production plants, particularly in large projects and foster the development of subsequent plants.

Lastly, the market for green products relies on consumption-oriented policies, such as the revised Ecodesign Directive to move towards a circular economy, as illustrated in the box below.

Green market creation: Environmental and sustainability labelling[21,22]

Environmental/sustainability labelling, standards, and product declarations supported by public authorities are used to foster behavioural change towards long-term sustainability policy objectives. They aim to:

- spread information on the making of products,
- promote environmental and ethical values of consumers as a market incentive for producers to improve their environmental and social performance,
- provide a competitive advantage for producers in the green marketplace,
- increase the potential for environmental upgrading across the value chain and increase the life cycle of products.

In particular, labelling as a policy instrument, helps push forward transparency, and participatory and shared responsibility in environmental policy making, used by big commercial and institutional entities for benchmarking.
It boosts the development of eco-innovation and the market diffusion of environmental-friendly technologies and products, towards market incentive programmes as an instrument to help industry, private investors, and consumers cut costs while choosing green alternatives. Within these market incentive programmes, ecolabels could be introduced as a reference to a specific technical standard which producers must comply with while receiving the financial grant, and also can play an important strategic role to help the widespread and better application of Green Public Procurement (GPP). For example, in Portugal, the new National Strategy for Green Public Procurement 2030[23], defines the vision, objectives, and main vectors of action for GPP, giving this instrument a strategic role in the pursuit of the major objectives of development and sustainability of the Portuguese economy.
Furthermore, ecolabelling has become part of the various concepts of consumer education, education for sustainable development, or education for sustainable consumption.
Combining economic instruments with ecolabelling may increase the effectiveness of the policy mix to stimulate the demand for green products. A labelling system can help increase the effectiveness of a tax by providing better information to the users on the relevant characteristics of different products the tax applies to, which will in turn increase the price-sensitivity of demand for the product.

Box 3: Green market creation: Environmental and sustainability labelling

[21] https://wedocs.unep.org/bitstream/handle/20.500.11822/37045/SPPWSG.pdf
[22] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008DC0400
[23] https://ecoxxi.abaae.pt/wp-content/uploads/sites/5/2023/02/Estrategia-Nacional-para-as-Compras-Publicas-Ecologicas-2030-%E2%80%93-ECO360.pdf, https://encpe.apambiente.pt/sites/default/files/documentos/RCM_13.2023_ECO360.pdf

The automotive industry can be taken as an example where manufacturers have the ambitious aim of eliminating carbon emissions completely from their entire value chains (including their suppliers) and taking on a full life cycle perspective. This clear market signal, as mentioned previously, is driving the European steel sector towards committing large investments in implementing green technologies.

Accordingly, the process industries are expected to reach the customers high quality and safety products, at a reasonable price, driven by consumer preferences, corporate social responsibility, and government regulations.

4.4. Financial

De-risking innovation at TRLs above TRL seven requires large investments. It implies a significant technical and economic risk. Therefore, co-financing and blended funding models are necessary to de-risk them. To this end, the links to European, national, and regional programmes are required to align on strategic objectives and provide support opportunities for the most impactful innovations. It is particularly important to foster FOAKs in those countries where strong national or regional support are required either directly or indirectly by logistics or infrastructure. In the context of the process industries ecosystem within the European Green Deal, it is particularly relevant to strengthen and extend the EU Emission Trading System (ETS), which includes a substantial increase in the size of the Innovation Fund.

To further encourage the adoption of low-carbon products, public and private funding should prioritize projects and products in various industries that have a low climate impact as a key condition for financing, as demonstrated through the electrolysis example in Spain described in the box below. Also, standards for low-carbon products could differentiate between incremental emissions reductions and truly low-carbon processes, ensuring that products meet specific criteria for sustainability.

Equally important is the provision of other measures, which could support initial investments to compensate for the CAPEX requirements of the technological shift. In addition, financial schemes that support companies navigate the volatile boundary conditions and decrease over time and performance are useful tools. Lastly, financing OPEX, in function of certain parameters would reduce the economic risks of large investments (e.g., by adding additional costs compared to a non-climate neutral product and in view to the increase of the carbon price).

Furthermore, existing entities like the European Investment Bank (EIB) currently provide grants and loans, which could complement other financing instruments for supporting technology diffusion (e.g., the previously mentioned CCfDs). New financial bodies are under discussion or have recently emerged at European level to reduce the risks of large private investments. In particular, the European Hydrogen Bank (EHB), as part of the Net-Zero Industry Act, has launched their first pilot auction to stimulate and support investment in sustainable hydrogen production. This new program has been broadly recognised as a very positive signal to the market.

Process industries, in many cases, do not have the ambition to develop technologies themselves to a state where they can be commercialized and/or taken up by others in the same or in other sectors. As such, the impact remains limited unless a technology provider takes over and commercialises the development. Some of the mentioned provider companies are SMEs which play a significant role in maximizing and spreading the low-carbon

technologies within the same sector or across sectors. Financial mechanisms should stimulate their active participation in large scale projects, in view of their integrative potential.

Example of financial tools in national/regional programmes that support large investments above TRL7: The case of Spain[24]

In 2021, Spain launched a new programme aimed at supporting projects showcasing large-scale electrolysis with a capacity exceeding 20 MW. This initiative aligns with the challenges related to research and development, as well as the industrialisation of electrolysers for renewable hydrogen production, solution deployment, and their seamless integration into industrial settings.
The eligible actions under this program include:
a) Development and manufacturing of a large electrolyser, specifically the creation of a groundbreaking prototype that surpasses the current global state of the art. This prototype focuses on manufacturing and/or design aspects that impact its performance and/or efficiency. The innovative features of the prototype can be justified based on various factors, including performance, technology efficiency, scaling, implemented changes, new configurations, permutations in the components or constituents of the electrolyser, or the electrolysis system itself.
b) Real and effective integration of a large electrolyser into an industrial operational context, serving as a demonstrator of the viability of mass-producing renewable hydrogen. This sector-specific integration demonstrator should have an electrolysis capacity exceeding 20 MW.
To be eligible, it was required to demonstrate that the electricity used in the electrolyser originates from renewable sources.
The budget allocated for the 2022 call was up to 100 million euros. These funds are financed by the IDAE (Institute for Diversification and Saving of Energy) through a prior transfer from the General State Budget for 2021, under the program for "The promotion of renewable energies, energy efficiency, and sustainable mobility" (Recovery and Resilience Mechanism).
In the selection process, particular attention is given to the technological scalability, replicability, and market potential of the funded projects. One of the main selection criteria is the viability of the project's scalability, considering its contribution to the development of the renewable hydrogen sector. This includes identifying potential entry barriers and proposing strategies for overcoming them. Additionally, the project's impact on the industrial value chain of renewable hydrogen and its role in structuring, adapting, and transforming the Spanish industrial sector must be outlined.
In essence, this new program is expected to catalyse the development of large investment projects in Spain within the green hydrogen sector. Projects supported thus far demonstrate a strong commitment along the green hydrogen value chain, anticipating the creation of new opportunities and capabilities for all stakeholders in this field.

Box 4: Example of financial tools in national/regional programmes that support large investments above TRL7: The case of Spain

4.5. Resources

Resilience is a key driver for the European energy-intensive industries both in terms of energy independence and raw material independence. Firstly, it is necessary to reduce the use of energy coming from fossil sources, which has been addressed by many European regulations including, among others, the Emissions Trading System (ETS), the Energy Efficiency Directive, Carbon Border Adjustment Mechanism (CBAM), and the Renewable Energy Directive RED (III). These regulations aim to reinforce electrification of the process industries as a key element of the reduction of the CO_2 emissions in Europe in the years to come. However, there will be competition between all sectors for green electric power (e.g., transportation). Therefore, in addition to preparing and integrating a larger share of renewable

[24] https://www.idae.es/en/support-and-funding/programa-h2-pioneros-ayudas-para-proyectos-pioneros-y-singulares-de-hidrogeno

energy sources, increasing energy efficiency remains crucial. Lastly, new energy carriers can open new opportunities and increase flexibility in overall energy supply. New energy carriers (and green products) such as biogas, biomethane, green hydrogen, biomethanol, and green ammonia, have the potential to play a significant role in the decarbonisation of multiple sectors. All in all, considering the national specificities, infrastructure, and resources.

In the area of raw material independence, the Critical Raw Materials Act aims at increasing the resilience and reducing the dependency of the EU on imported materials. It underpins the urgency to create EU domestic capacities along the strategic raw material supply chain and to diversify EU supply. To achieve those goals, a substantial increase of the material efficiency in the production sector is required to reduce the amount of waste that goes to incineration or landfill and to make the best possible use of the substances which are contained in streams of by-products and auxiliary substances. In any implemented approach, a thorough monitoring procedure to measure the energy and resource needs is imperative. In this respect, data collection and generation of indicators for monitoring purposes at the EU level would be needed.

Recycling capacities and technologies to treat and reintegrate valuable components into the energy-intensive industries are a must (e.g., technologies in classification, sorting and pretreatment of waste streams). In many cases, SMEs are the technology providers and then, enablers to the energy-intensive industries towards enlarging their portfolio of valuable feedstock. In particular, SMEs can play a crucial role in the pretreatment of End Of Life (EOL) products towards secondary resources. To maximise the impact of those technology providers in the decarbonisation of the energy-intensive industries, they are required to play an active role in the definition of the decarbonisation roadmaps of energy-intensive industries.

4.6. State aid

Several forms of state aid are used by governments. Grants, interest, and tax reliefs or giving an advantage to support specific companies or industry sectors, or to companies located in specific regions are used. The Temporary Crisis and Transition Framework for State Aid measures to support the economy following the aggression against Ukraine by Russia are especially noteworthy[25]. In the case of the energy-intensive industries, their needs are targeted directly by countries' Recovery and Resilience Plans (RRPs) through EII-related measures. Several RRPs include actions to reduce the energy consumption and GHG emissions of industrial companies and support SMEs and large firms in increasing energy efficiency in their industrial processes. In addition, MS have also included reforms to accompany the proposed investments, such as improving the legislative framework to facilitate investments in energy efficiency in industry and increase the resilience of the industrial sector[26]. The measures facilitate the development of an economic activity which allows Europe to position its industry to become leaders of green products. Thus, strategic projects to gain robustness, competitivity, and reliability along the value chains in which energy-intensive industries are critical, become relevant.

State aids support projects/sectors that develop front-runner technologies as trigger for decarbonisation (e.g., electrolysers ([27]) or batteries[28]). Those initiatives reduce the need for imports of both critical raw materials and/or advanced technological devices.

[25] https://eur-lex.europa.eu/eli/C/2023/1188/oj
[26] https://ec.europa.eu/docsroom/documents/51115/attachments/1/translations/en/renditions/native
[27] https://single-market-economy.ec.europa.eu/industry/strategy/hydrogen/ipceis-hydrogen_en
[28] https://competition-policy.ec.europa.eu/state-aid/ipcei/approved-ipceis/batteries-value-chain_en

5. Key insights from countries presentations

The following presents a short synthesis of the country presentations during the Lisbon workshop, which took place on November 28th-29th in each of the three panel discussions.

Panel discussion 1: Regulatory frameworks and their impact on the R&I and deployment cycle at different stages - permits to First-Of-A-Kind installations (FOAKs), impact of the Waste Framework Directive, Industrial Emissions Directive, Emissions Trading System Directive, etc.

Ministry of Economic Affairs and Employment, Finland

Finland's proactive approach to combatting climate change is evident through its low CO_2 emissions and strategic investments in renewable energy sources like wind and solar power. With a national goal of achieving climate neutrality by 2035, Finland is fostering a transition away from fossil fuels towards sustainable alternatives, as demonstrated by companies like NESTE, which aim to be carbon neutral by 2030 through transitioning to biofuels and recycling. EII, such as pulp and paper, are actively engaging in efforts towards climate neutrality, showcasing a strong commitment to environmental sustainability. Regulatory stability is crucial for industries like steel to effectively plan and implement decarbonisation measures, emphasizing the importance of consistent policies in achieving climate goals. Finland recognizes the need to link various decarbonisation measures, advocating for their integration with existing initiatives rather than pursuing isolated actions. Initiatives like Hydrogen Valleys[29] represent promising initiatives for sustainable development.

Ministry of Industry, Commerce and Tourism, Spain

Transitioning towards electrification to reduce combustion emissions is recognized as essential, particularly for industries operating at high temperatures above 400°C, although technological challenges persist in this regard. Given the current limitations in electricity-based solutions for high-temperature applications, attention is turning towards green hydrogen as a viable alternative. Due to the specificities of each sector, there is the need for diverse technological pathways. Furthermore, permitting processes for infrastructure and demonstrators remain a significant hurdle, often taking up to two years to obtain permits for new sites. To overcome this challenge, declarations of public interest will bring new opportunities to accelerate the approval timeline. Spain is currently evaluating the feasibility of hydrogen pipelines to support new energy carriers, with a decision pending on whether to invest in pipeline infrastructure or relocate EII closer to Renewable Energy Sources (RES). The choice however is based on economic and operational considerations.

Agency of Innovation and Entrepreneurship (VLAIO), Flanders (Belgium)

Flanders has a robust network of sectoral clusters, many of which are closely tied to the chemical and steel industries, with a significant focus on Carbon Capture and Utilisation (CCU) and Carbon Capture Utilisation and Storage (CCUS) infrastructure. In particular, the ports in Flanders play a pivotal role in facilitating collaboration and coordination among industries and energy providers, serving as central hubs for regional interactions. Building on their experience, there is the need to expand the terminology such as "hydrogen valleys," "carbon hubs," or "H4C", which is often used within the same geographical region. Ports, inherently structured as clusters, operate with their own strategic agendas while remaining

[29] https://www.clean-hydrogen.europa.eu/get-involved/mission-innovation-hydrogen-valleys-platform_en

integral to the broader regional development strategy, leveraging their historical expertise in managing diverse business models. Managed by port authorities, these ports possess the necessary logistical capabilities and infrastructure to support and drive the implementation of regional initiatives and further strengthen their role as key enablers of sustainable development.

Agency for Investment and Foreign Trace (AICEP Global Parques), Portugal

The Sines Industrial and Logistics Zone (ZILS) plays a key role as a focal point for transformative industrial activities centred around decarbonisation, digitalisation, and energy production, with a strategic emphasis on renewable energy systems. Key to this zone's vision is the establishment of symbiotic relationships between industry and renewable energy producers, particularly in the realm of green hydrogen production, facilitating a shift towards sustainable energy consumption. Despite existing commitments of grid power to industry, it is evident that additional energy resources are essential to meet future demands, which requires the development of local energy production capabilities. To address this short coming, a multi-project approach is implemented, to strengthen the local transportation system, as well as the creation of a renewable energy community, and industrial symbiosis initiatives.

Results of the open discussion

Industrial clusters are common in some countries in Europe. It is very important to provide solutions for them, as they account for a significant number of CO_2 emissions at national level. To this end, a joint collaborative approach in defining national roadmaps is mandatory, to integrate their needs, align them with other pillars and priorities, and to attract investments while expanding the network. Furthermore, the infrastructure is key, especially in energy generation and distribution. There is a need to make the system resilient (and flexible) for example using systems that can work with different sources of energy e.g., burners that will work with natural gas, biogas, or hydrogen. There is no one solution that fits for all, as in some cases hydrogen would be the solution while in other cases electrification is simpler and more suitable. All in all, energy flexibility is highly recommended, by means of considering storage and energy efficiency in addition to new energy carriers. Nuclear energy was also brought to the discussion as a potential element to consider in certain countries. It is a predictable source of energy and with a role to play in those countries where nuclear reactors are up and running. It makes economic sense to extend the lifespan of nuclear reactors if safety is guaranteed and some countries have already considered this. However, constructing new nuclear stations may be more controversial as by the time of their completion there might be a need for more flexible power sources. Also, one country has recently opened new nuclear production facilities (Europe's most powerful nuclear reactor has started producing regular energy in Finland in April 2023) Overall, there is a need to join forces with the energy sector. Several countries highlighted the urgent need to strengthen the cooperation with SMEs, as they are difficult to reach and engage with in the road mapping preparation phase but also in their active transformation towards decarbonising their processes. In some countries, as a result, they have specific SME-driven support programs for decarbonisation.

Panel Discussion 2: Role of technology infrastructures, open innovation test beds, other platforms

The Scientific and Technological Research Council of Türkiye (TÜBITAK), Türkiye

The presentation of the Industrial Innovation Networks Mechanism (SAYEM) incentive programme highlights Türkiye's priority towards fostering technological innovation and collaboration within its industrial landscape. Through targeted calls aimed at facilitating the transfer of critical technologies between industrial R&D centres and academic institutions, Türkiye aims to take advantage of the collective expertise of diverse stakeholders in co-creating high-value products and technologies for the market. Central to Türkiye's approach is the establishment of collaborative platforms wherein a multitude of stakeholders across the value chain converge under a coordinator, fostering innovation and facilitating commercialisation efforts. The SAYEM initiative illustrates Türkiye's commitment to supporting research infrastructure and cooperative platforms, with specific examples from the 2020 call showcasing tangible efforts to foster innovation and technology transfer within the country.

International Iberian Nanotechnology Laboratory (INL), Portugal

The presentation shed light on the Open Innovation Test Beds (OITBs) for advanced materials managed by the International Iberian Nanotechnology Laboratory (INL), a Portuguese-Spanish intergovernmental research organisation, emphasizing their operational framework and the challenges they face. Operating across a spectrum ranging from laboratory validation to industrial prototype development, these facilities provide SMEs with access to cutting-edge technologies and services, fostering innovation and risk mitigation in product development. Despite the intention for SMEs to be the primary beneficiaries, financial constraints often hamper their utilisation of these state-of-the-art facilities. Furthermore, the main challenge this type of facility faces is the integration of new technologies in complex industrial processes, as it is often difficult to integrate those into existing systems. The presentation concluded by exploring potential pathways through which test beds could benefit process industries, highlighting opportunities for collaboration and technological integration to drive efficiency and innovation.

National Laboratory of Energy and Geology (LNEG), Portugal

The introduction of activities offered by a bioenergy research infrastructure underscores its role in supporting companies in the development of green technologies, particularly in the conversion of biomass into valuable products, materials, and chemicals. With a focus on serving biorefineries and wood-based product manufacturers, this research laboratory plays a crucial role in advancing sustainable practices within the industry. The presentation raised the pivotal question of how a local research institute could successfully become a collaborative platform, effectively engaging with SMEs to drive innovation and economic growth. This research centre is currently aiming at offering 20% of their services to fundamental research, 40% to applied research and 40% to development. However, the main challenge of how to be sustainable remains a pressing concern.

Open discussion

There are several challenges faced by testbeds as there is no legal model to accommodate all the facilities and services provided by them. An important lesson and takeaway remains that testbeds should be focused on business models and provide services for companies to attract private funding, moving from basic research to service-oriented capabilities. Testbeds

are a useful tool, and it is important to set up a system for pilots or any other facility in which a company can maximise the tests without being blocked by regulations. It is also important to involve citizens in the process as they become promoters of it. The overarching question is how to make such structures sustainable. There is funding available at the EU level as well as national sources to establish such support structures, however keeping the technology infrastructures running on long term is often a challenge. It was agreed that SMEs should remain in the focus, as large enterprises can build and maintain their own R&D structures and have advantages in obtaining relevant IP rights. It was agreed that the development of business and innovation activities is key to achieve sustainable and useful technology development infrastructures. The research aspect should remain secondary, those should not be (only) research structures. Overall, RTOs are meant to play a key role in upscaling (demo scale).

Panel Discussion 3: Knowledge and data (valorisation, standardisation, monitoring of R&I data and setting of key performance indicators, green patenting)

DG RTD is putting forward a dedicated R&I deployment agenda in 2024 towards the climate neutrality of the EU EII as a framework for ongoing and planned actions. Its aim is to support the process by stimulating, guiding, and accompanying the EII on the path of climate neutrality, with a focus on having the necessary low carbon technologies ready for deployment by 2030. The individual actions will be collected and further developed based on four themes: i) mapping and monitoring, ii) EU, national and regional synergetic use of funding, iii) market pull measures, and iv) understanding and overcoming R&I deployment barriers. The deployment agenda design and implementation is engaging private and public actors in a structured dialogue and aims at tracking the implementation of key actions and tackling gaps towards the scale-up and deployment of key decarbonisation technologies.

Ministry of Economy and Innovation, Lithuania

Lithuania's presentation highlighted the introduction of a waste-performance indicator, inspired by the Netherlands' "carbon material" indicator, aimed at quantifying the amount of waste generated by industries relative to their value added. Unlike conventional waste data collection methods that focus solely on the volume of waste produced, this new indicator integrates economic performance, offering a more comprehensive measure of waste generation efficiency. By incorporating economic factors into waste measurement, the indicator is two-fold: (i) assisting public authorities in monitoring waste reduction across economic sectors and (ii) empowering companies to recognize and leverage the value of their waste streams. The adoption of this innovative indicator reflects Lithuania's commitment to fostering sustainable practices and promoting circular economy principles by incentivizing waste reduction and resource optimisation within industries.

Ministry of Economy, Slovakia

Slovakia's presentation emphasized the importance of climate and energy modelling in providing evidence-based guidance for decision-makers, aiming to address various objectives within the context of environmental sustainability. Key approaches and challenges were discussed. As a lesson learnt, the experience has concluded that the collaboration with previously less-involved stakeholders, particularly Transmission System Operators (TSOs), to enhance the efficacy of modelling efforts was very important and productive. Furthermore, policies change relatively often, so that modelling cannot be adjusted in time, which leads to the need to work on flexible models, capable of adapting to evolving regulatory landscapes in a timely manner. An additional challenge highlighted refers to discrepancies between data provided by companies and official statistical guidance.

Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation, and Technology, Austria

Austria's presentation addressed the complexities surrounding the monitoring, evaluation, and learning processes associated with impact pathways and innovation policies, highlighting the need for a more comprehensive approach. Existing reporting indicators were inadequate in the face of driving transformative change. Thus, increased evidence on the sustainability aspects of the Strategy for Research, Technology and Innovation of the Austrian Federal Government are needed. The next steps include the standardisation of indicators and processes to present results in a more structured and comprehensive way, for each of the topics and across topics. It would allow to review and readjust/ change the individual funding instruments and related measures.

Portuguese Quality Institute (IPQ), Portugal

Portugal's presentation highlighted the pivotal role of standards in facilitating industrial decarbonisation, emphasizing their function as a guiding framework for sustainable practices. Technical committees are a key mechanism for promoting and influencing the development of future standards. Beyond industrial decarbonisation, standardisation was positioned as an integral component of broader efforts to address Sustainable Development Goal (SDG) 13, Climate Action, with direct relevance to the process industry. Portugal's commitment to leveraging standards as a strategic tool for advancing climate action is evident building on a long-term strategy.

Furthermore, a key search tool to identify interesting activities in the field was presented[30], as well as several related activities as open sources[31,32]. Lastly, several ongoing technical committees related to industrial decarbonisation[33,34,35] were introduced.

Foundation for Science and Technology (FCT), Portugal

The second presentation from Portugal elaborated on the different indicators produced in Portugal within the R&I programme, and the challenges linked to the data collection process. As next steps, they foresee to update information and their databases, including the impact of the initiatives supported by this public body.

Open discussion:

It was largely accepted that the MS face the challenge of modelling in times of high uncertainty. Also, different models are used in different countries and the difficulties of collecting data (in quantity and quality) are still significant and hamper larger and more accurate predictions. In terms of R&I funding, data sources and how to exploit those data, coordination between countries and the EC is important. The use of new KPIs that reflect the requirement of the Green Deal seems relevant for the new twin transition, as learnt from the case of Lithuania. It was highlighted that there is the need to cooperate to enhance and enrich the process industry demonstration dataset with information on nationally financed projects.

[30] https://www.iso.org/advanced-search/x/title/status/P,U,W,D/docNumber/docPartNo/docType/0/langCode/ics/currentStage/true/searchAbstract/false/stage/stageDateStart/stageDateEnd/committee/sdg/06
[31] https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100271.pdf
[32] https://www.iso.org/publication/PUB100067.html
[33] https://standards.cencenelec.eu/dyn/www/f?p=205:7:0::::FSP_ORG_ID:3356655&cs=1843926F8FC09BB963D5EA641A207A887
[34] https://www.iso.org/committee/648607.html
[35] https://www.iso.org/committee/54560.html

This would contribute to best promoting synergies and boosting cooperation between the EU, its MS and regional programmes. To further encourage the adoption of low-carbon products, public and private funding should prioritise projects and products in various industries that have a low climate impact as a key condition for financing. Those projects should be linked to the roadmaps.

6. Results of the surveys to Member States

Prior to the meeting, a survey with nine questions was distributed to all participating countries. The results were used to complement the information collected during the meeting in Lisbon. Below, the results and the most important points are summarised.

Operate "regulatory sandbox"

Most of the participating countries are in the process of evaluating how to apply regulatory sandbox environments related to the decarbonisation of the process industries. Through the Research Promotion Agency (FFG) "Energy.Free.Space" programme, Austria already launched three calls for proposals (3rd call concluded in Q2 2023). Lithuania is developing several regulatory sandboxes related to the decarbonisation of process industry as well (e.g. in the field of green and renewable technology) and uses Digital Innovation Hubs (DIH) to create sandbox-like conditions. Flanders is also operating one regulatory sandbox in Genk. Most countries are, however, paving the way to implement some actions in the field in the near future. This is the case of Spain, which is currently drafting a new Industry Law ("Ley de Industria"), and Slovakia, who is aiming at the expansion and increased use of renewable energy sources. To this end, they both are defining the legal framework to welcome those initiatives. In addition, there are other initiatives like the ones in Portugal, where the Technological Free Zones (ZLT – Zonas Livres Tecnológicas) have been established, corresponding to the concept of regulatory sandboxes.

National roadmaps supporting research infrastructures

National policies and strategies for research and technological development include, in most of the countries, measures to support technology infrastructure. However, there are no specific programmes addressing the decarbonisation of industry in particular. In several cases, the strategies refer to specific action plans for the development of technology infrastructures, and specify the criteria, priorities, and funding mechanisms to support them. Austria has a specific programme to support research infrastructures (Austrian Research Infrastructure Action Plan 2030). In some cases, technology infrastructures are specifically mentioned in parallel and related roadmaps (e.g. in the case of green hydrogen in Spain, Slovakia, and Lithuania).

Financial schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for Energy Intensive Industries (EII)

None of the countries that have responded to the survey had experience in CCfD. Many of them are evaluating the legal framework to put CCfD in place rather soon in their respective countries. Spain plans to launch a CCfD as a pilot scheme, through its program PERTE[36], in 2024. In addition, the Federal Environment Agency (UBA) in Austria was commissioned to write a policy brief with the principles and the various design options for such an instrument,

[36] https://espanadigital.gob.es/en/measure/perte-strategic-projects-economic-recovery-and-transformation

and Flanders envisions to launch a ‘test call for CCfD’ in the spring of 2024 (tbc). Portugal and other countries show interest in this supporting scheme. Lithuania is evaluating a potential cooperation scheme in this area with the Baltic countries.

The symbiotic approach towards multi-actor, cross-sectorial, and cross-value chain collaborative schemes

Directly or indirectly, most countries incentivise activities to foster new collaborative schemes involving process industries. A few countries (Austria and Portugal), explicitly include industrial symbiosis supporting initiatives. In other cases, collaborative actions are mandated as compulsory requirements within the rules for applicants under their aid schemes. For example, Lithuania has recently initiated the feasibility study of assessing the value chain solution possibilities, including the potential symbiosis in reducing CO_2 emissions. This study will provide recommendations regarding the creation of a pilot industrial symbiosis park. Moreover, several countries showcase notable examples of successful industrial ecosystems, as demonstrated during the Lisbon meeting. For instance, the case of Sines (PT) and two ports, Seaport and POAB (Flanders, Belgium), were presented. Additionally, Spain highlights that, based on their experience, the criteria for addressing collaborative industrial schemes have introduced a significant level of complexity, deterring many industries from participating. Consequently, in the Spanish context, the ministry has relaxed the requirements in this area in subsequent schemes or calls. Finally, countries with less experience in promoting these innovative concepts, such as Slovakia (SK), plan to support them in the future.

Links between National Climate and Energy Plan and the SET Plan objectives and especially R&I investments in process industries

Most of the participating countries are in line with the SET Plan objectives. Their respective NECP are aligned with the SET Plan objectives, which are the basis for the EU’s research and innovation agenda for the energy transition. However, like in the case of Portugal, the National Energy and Climate Plan is aligned with overall SET Plan objectives, although not specifically with R&I investments in process industries. The same applies in the case of Slovakia, whose NECP does not integrate any specific measures for R&I-investment in process industries. What it does include, however, is cooperation with other MS about information exchange on how the intentions and policies of the European Strategic Plan for Energy Technologies are reflected in the national context. Work on the revision of this plan will continue in the coming months, with a view to submitting a final version to the European Commission by 30 June 2024.

KPIs to monitor the progress of the decarbonisation roadmaps

All participating countries are using KPIs relating to decarbonisation in various ways. These include, among others, the share of renewable energy sources in gross final energy consumption, the GHG emissions intensity of the economy, the circular material use rate, the recycling rate of municipal waste, the share of organic farming in total agricultural area, etc. Furthermore, in some countries, roadmaps specify quantitative targets and the monitoring system to oversee their implementation and progress in some way. Lastly, several countries express their willingness to enlarge and increase KPIs in the near future to monitor the progress of their roadmaps, like in the case of Türkiye (in particular, within the Green Growth Technology Roadmaps).

Strategic plans related to the energy supply of different energy carriers of use to the process industries

All the countries report relevant interest and data as far as the production and use of green hydrogen is concerned. Spain, Austria, Portugal, and Flanders (Belgium) have developed a national (or regional is the case for Flanders) hydrogen strategy. In addition, Slovakia launched an action plan in 2023 on hydrogen use. In Lithuania, the national hydrogen strategy implementation guidelines are currently drafted, with Lithuania aiming to become a leading green hydrogen producer and exporter in the Baltic region by 2050. Meanwhile, Türkiye has developed a hydrogen technology roadmap and Georgia has conducted a study on the hydrogen readiness of the Georgian pipeline system. Lastly, Slovenia participates in the European Clean Hydrogen Alliance, supporting the development and implementation of pilot and demonstration projects for green hydrogen production and distribution. Some countries (ES, PT, SK, and AU), take into account other energy carriers such as biomethane and promote the further development of green gases. Some countries claim they are willing to evolve from an energy technology importer into an energy technology producer and exporter (e.g. Lithuania).

Special regulatory bottlenecks or hurdles in your country, which limit the deployment of FOAK

The oversight functions are often spread across different institutions, which may create fragmentation and duplication of tasks. The stakeholder engagement process could be more transparent and inclusive by systematically informing the public in advance of planned consultations. Even in conjunction with the operation of sandboxes. It is reported that multiple EU regulation requires an increasing number of data to be ascertained in the process of obtaining the required permits. This situation leads to a significant administrative burden (e.g. as reported in Lithuania). Lastly, it is worth mentioning the complexity of setting up large scale operations in densely populated areas.

Available programs to scale up from TRL 6 above TRL 8

Not all countries offer supporting schemes for high TRL projects, or do not specifically address FOAK initiatives. As an example, Slovenia's research and innovation strategy covers several funding instruments that can support the scale-up of technologies from TRL 6 to TRL 8, such as national grants for research and innovation projects ranging from TRL 6 to 9 and the support for start-ups with breakthrough and disruptive innovations that have the potential to create new markets. Other countries bring opportunities targeting high TRL activities for a specific type of beneficiary. In the case of Georgia, while SRNSFG does not directly fund SMEs, a new grant call is scheduled for launch in 2024. The design of this call aims to stimulate collaboration with business partners, fostering connections between research institutions and enterprises. Other countries like Austria have in place programmes aiming at high TRL levels with an active role for process industries.

7. Industrial panel

The industrial panel included six presentations, covering six industrial sectors.**APQUIMICA – Chemical, Petrochemical, and Refining Association (chemical sector)**

The chemical sector, inherently transversal and integrated across various value chains, prioritizes process efficiency as a basis for their strategies. However, it faces distinct challenges, including technological maturity, scalability, and value chain integration, which

requires tailored solutions that recognize the diversity among sub-sectors. Long-term investments characterize the industry, demanding careful risk mitigation strategies to ensure an adequate allocation of resources. Industrial symbiosis and circular economy principles emerge as crucial pathways for mitigating risk and fostering sustainability. Furthermore, access to energy and skilled human resources emerge as critical factors shaping the competitiveness and sustainability of the sector, alongside market dynamics and policy frameworks such as carbon market regulations and EU strategies. Financing and having a level playing field within Europe and with other competitors is important, which includes state aid. For this sector, the three most important actions to foster decarbonisation in their sector would be (i) sandboxes and regulatory environment; (ii) how to plan projects in a subsequent manner; and (iii) how to make a system deliver its intended results.

LINDE Engineering (engineering sector)

Maximizing the efficiency of processes is crucial for optimizing the utilisation of limited renewable energy resources. This emphasises the importance of sustainable practices in maintaining industrial competitiveness. The presentation showcased the German case as an illustration of green hydrogen production and its associated challenges and highlighted the need to increase investment on green hydrogen in Europe. Despite advancements, regulatory frameworks remain a challenge and affect the deployment of front-runner projects.

ATIC – Cement Industry Technical Association (cement sector)

Collaboration among stakeholders is critical in addressing challenges within the market. This is particularly true for industries like cement where the scale of investment necessitates shared risk and collective action. The cement sector recognizes the limitations of existing technologies and stresses the importance of complementary measures, such as public procurement for green products, to facilitate the transition towards sustainability. Effective public policies play an instrumental role in incentivizing research, development, and deployment of green technologies, as well as simplifying permitting processes and fostering industrial symbiosis to accelerate progress. The harmonisation of regulations is essential for providing certainty to companies and ensuring a favouring environment for investment and innovation, highlighting the need for coordinated efforts at national and international levels.

NAVIGATOR COMPANY (pulp and paper sector)

The company is actively carrying out initiatives aimed at achieving climate neutrality while also leveraging its position within various value chains to drive decarbonisation efforts across multiple sectors. In particular, efforts are paid to the production of bioplastics, which are influenced by market dynamics and regulatory frameworks. Recognizing the importance of partnerships, the company emphasizes the significance of establishing long-lasting alliances, which require the implementation of innovative business models to ensure sustainability and value creation within the local environment. Regulatory certainty and access to raw materials emerge as critical factors shaping the company's operations, underlining the need for stable regulatory environments and reliable supply chains to support sustainable practices. Research and innovation play a pivotal role of their strategy, and it relies on collaboration with research institutions in driving technological advancement and fostering a culture of continuous improvement.

EDP Innovation (energy sector)

Electrification represents a significant opportunity for emissions reduction and enhanced energy efficiency. However, uncertainty of investments can lead to elevated costs and capital expenditure (CAPEX). The market for green products (both industrial and final consumers) needs to flourish in the near future. In a CAPEX-intensive context, private risk management will result in less investment and higher costs for end customers. Overall, a de-risking framework is necessary to support the speed and scale required to avoid high costs of capital and more costs for consumers, coupled with long and stable regulatory environments.

CITEVE - Technological Center of the Textile and Clothing Industries (textile sector)

Electrification represents a significant technological pathway for emissions reduction. However, there are challenges to overcome due to prevalent direct combustion practices among many firms, which will need to promote a transition strategy, involving both local and global value chains. Sustainability and the circular economy have gained a lot of attention in the textile sector, driven by societal and consumer demands, although there is the need to oversee and avoid some greenwashing practices. Embracing new bio-based and secondary materials is essential for advancing sustainability objectives within the sector, alongside the increasing role of digital technologies as facilitators of decarbonisation efforts, supported by evolving policy landscapes. Recognizing the significant presence of SMEs within the textile industry, specific funding schemes tailored to their needs are crucial for fostering innovation and driving progress towards sustainability goals.

Open discussion

Data sharing with industry is important. In some cases, industry is less reluctant to share data with public authorities when incentives such as subsidies are offered. Thus, in times of crisis, this need from the industries might become an opportunity for more public-private collaboration actions. However, it is generally agreed that it is not efficient to keep changing targets as it conveys uncertainty to the industry. As acknowledged by the industries, R&D investment is the first step towards decarbonisation, and it is an important part of the entire cycle. However also, the different financial schemes for scaling up projects at low TRL up to higher TRLs remain important.

It was agreed that the three points raised by the chemical sector are vital, i.e. (i) sandboxes and regulatory environment; (ii) how to plan projects in a subsequently manner; (iii) and how to make a system deliver results, and as such are key elements to focus on. It was broadly accepted that academia and research institutions need to be closer to the industry. For example, as a lesson learnt, participating in industry associations aligns applied research with the industry needs, which results in stronger impacts. Lastly, all industries addressed the urgency for a stronger green market. More attention to public procurement is encouraged. As a good lesson from the US on public procurement, the US authorities publish a list of bio-based materials that are produced in the US as part of the green public procurement official references.

8. Barriers and drivers - Lessons learnt

The purpose of the fourth meeting in the context of the MLE on Industrial Decarbonisation, held on 28-29 November 2023 in Lisbon was to analyse all the elements considered as framework conditions. The three panel discussions and the industrial panel allowed the participants to exchange information and collect insightful inputs. The survey replies of

participating countries added additional value to the overall understanding. In addition to the open discussions which took place after each panel, elaborated in previous sections, the following general remarks could be gathered:

A compelling **narrative** is required, emphasizing the need to urgently focus on climate neutrality and the reindustrialisation of Europe. The positive outcomes for citizens, such as the creation of new skilled jobs or the improvement of the environmental ecosystems (e.g. reduced pollution) must be highlighted as well. This approach is essential to foster a positive public perception. To achieve this objective, it is crucial to engage all stakeholders, including regions and municipalities. A comprehensive approach must be adopted, considering the entire value chain. In line with this need, under the Belgian presidency, the process industries have published a joint declaration to express their full support for a European Industrial Deal to complement the Green Deal and keep high quality jobs for European workers in Europe[37], and it includes 10 actions to restore competitiveness[38]. Additionally, as part of the active communication actions in describing the benefits of the process industry to the society, results arising from publicly funded research, development, and innovation (R&D&I) projects should be used to enhance visibility and effectively communicate the impact to society at large, via the use of incentives (e.g., bonus). To this end, a strong involvement and commitment of regional authorities is required.

- Mapping, monitoring, and **modelling the impact** of the different alternatives is key to speed up the process to take informed decisions. To this end, access to data becomes an important topic. The process of collecting data and identifying indicators should take place in a collaborative framework between industry and public authorities, as a mutually beneficial opportunity to align industry needs with future decarbonisation programmes.

- As part of the elaboration of decarbonisation roadmaps, the role of **technical and scientific experts** as advisors is important. For example, ministries at the national level engage top advisers in research to coordinate training programmes, establish connections with EU institutions, and integrate scientific and technological expertise into political approval processes.

- **Research and technology infrastructures** need to be more oriented towards the needs of the industry, and move from pure research to the provision of services (new business models). In practice, science-industry relationships need to adapt their values and potential for cooperation to ultimately join forces. It is of significant value to extend the lifespan of financed infrastructures, enabling their utilisation in subsequent projects once they have surpassed their initially planned timeline. OITBs, for instance, are a way to use large demonstration facilities (with high investment costs) after finalizing the project through which it was constructed. Overall, research and technology infrastructures are meant to be sustainable.

- The **coordination and alignment of financial schemes** at European, national, regional, and local levels are widely sought. In this regard, there is a call for the synergistic utilisation of both EU and national/regional Research and Innovation (R&I) funds. Additionally, there is an emphasis on integrating these efforts with existing and complementary tools. A value chain approach is key. Creation of markets for climate-neutral, circular economy products through demand side measures (e.g. procurement) as well as empowering customers and consumers is necessary.

[37] https://antwerp-declaration.eu/.
[38] https://cefic.org/media-corner/newsroom/antwerp-declaration-for-a-european-industrial-deal/

- The **access to affordable clean energy** is instrumental for decarbonising the process industry. There is the need to assess different types of energy (and sorting systems) and understand how to integrate them smoothly in decarbonisation strategies. There is an urgent demand for a strong and fast availability of renewable energy sources, some of which will be developed on-site at industrial plants (decentralised energy generation). In some cases, new low-carbon processes might imply an increase in electricity demand compared to current industrial practices. Hence, it is also important to apply the most efficient processes to make the best use of the limited renewable energy that is or might be available. Lastly, the inherent fluctuation of renewable energy sources, the required time to access the grid (permitting), and technical challenges in connecting to the energy grid, are key elements to be considered when providing the process industry with affordable clean energy.

- Companies and several countries have raised the issue that a **level playfield within Europe and with other competitors** is critical, including the use of state aid. As highlighted, the same standards should apply for everyone. For example, for imported products, the same regulations should be followed to ensure equal competitive footing. Especially relevant, is the Carbon Border Adjustment Mechanism (CBAM), which is a key element underpinning the reduction of the CO_2 emissions in Europe in the years to come, as imported goods under the CBAM will be subject to the same carbon costs as if they were produced in the EU, therefore averting carbon leakage.

9. The way forward to achieve impact

As a result of the fourth meeting of this MLE, several areas were identified as recommendations for future actions:

Market pull measures: Public awareness of climate transition, with a lot of attention given to the topic in the media, and an increased legal obligation, norms and standards (policy pressure), have multiplied the call for green products. However, there is still a lack of narrative and storytelling about the importance and impact of green products from process industries in and for our society. To this end, the support and commitment from the industry side is crucial. In parallel, market pull measures, and especially, green procurement and/or taxation (how we tax different green products, etc.) are important to be further explored. These measures also requires standards and measurement methods for stakeholders to navigate the market

- **Fast-track procedure for obtaining permits:** permitting is rapidly becoming a major obstacle for investments. Procedures at national level should be improved in order to limit this obstacle The permitting regime, but also permits to access to the electricity grids, together with regulatory stability, are essential for industrial decarbonisation. Practically, a Community of Practice on permitting would be useful.

- **Alignment with the energy sector:** the energy sector heavily impacts the framework conditions of process industries. As highlighted previously, access to green and affordable energy is key for decarbonising process industries. The link to the energy market and the role of process industries in the energy sector should be reconsidered, which implies new discussions at EU level.

Mapping, monitoring, and modelling the impact: In times of high uncertainty, the planning of supporting tools to decarbonise the industry requires a certain degree of flexibility (e.g. to evaluate different energy scenarios) to allow to assess different alternatives. As such, critical

activities should incorporate updated KPIs and adopt a continuous cycle of monitoring, evaluating, and a learning approach.

- **Application of co-development and co-creation approaches**: a symbiotic approach towards multi-actor, cross-sectorial, and cross-value chain collaborative schemes, such as Hydrogen Valleys, H4C, Carbon Hubs or Regional Innovation Valleys, play a pivotal role in facilitating the exchange of data, fostering co-development, encouraging co-creation, and enabling experimentation with new business models. It is perceived as an opportunity for exchanging scarce resources (green energy in several cases) and increasing the competitiveness of involved companies. Additionally, these industrial environments contribute significantly to the establishment of local value chains. The needs of smart cities should be integrated, as they form an integral part of the overall solution. It is crucial to showcase the impact of and expand these collaborative environments, beyond the first pool of European cases.

- **Regulatory Sandboxes**: sandboxes are seen as a relevant tool to test regulatory and standardisation engagement, provide Intellectual Property support and set up a business case. Sandboxes are meant to promote interoperability, shared resources, and facilitate collaborative efforts. The services aligned with the needs of industries should offer service integration.

- **Role and support to SMEs and startups**: SMEs usually lack capital to put their capabilities in practice, as providers of technological solutions and equipment to the offtakes (process industry). There is the need to make SMEs greener, despite SMEs being reluctant or not in a position to undertake the transition. Thus, it is necessary to engage SMEs in defining national strategies. By doing so, national strategies can establish stronger connections with other vital ecosystems, notably municipalities, as SMEs actively participate in local level actions, creating a mutually beneficial relationship.

- **Guidelines from the EC** on aid aiming to support industrial decarbonisation from the EC. State aid guidelines from the EC on industrial decarbonisation would be very welcome by the MS. In addition, an analysis of the best and most suitable selection criteria for competition schemes would be useful. These elements will also help countries align with the EC in the development of granting state aid with competitive procedures.

- **Supportive tools to reduce industrial risk management:** the financial programmes aiming at high TRL levels are an important support to de-risk large investments. To reduce both, CAPEX and OPEX, it is critical to succeed on scaling-up new and disruptive technologies since CO_2 emissions reduction goal requires high investments in low carbon technologies. When possible, it should be considered to offer adapted financial schemes to push projects in view of level of maturity and concrete needs. This would make it easier to plan subsequent projects.

Financial mechanisms adapted to technology providers: process industries, in many cases, do not have the ambition to develop technologies themselves to a level where they can be commercialised and/or taken up by others in the same or in other sectors. The impact remains limited unless a technology provider takes over and commercialises the development. Technology providers play a significant role in maximising and spreading the low-carbon technologies within the same sector or across sectors. Financial mechanisms should stimulate technology providers' active participation in large scale projects, in view of their integrative potential. Additionally, initiatives to connect technology providers and process industries are encouraged, to create new opportunities for cooperation.

- **Raise talent**: access to talent is presently a major challenge. In a competitive environment, within the process industries but also with other vibrant sectors (e.g. energy sector), it is crucial to foster skilled and talented people. Process industries also need to retain talented workers and promote long-term career opportunities. In practice, a Community of Practice on Skills and Talent would be useful.

- **Carbon Contracts for Differences (CCfDs)**: CCfDs schemes for process industry are considered a highly promising tool and are attracting significant attention. Throughout 2024, several MLE countries plan to implement trials using this supportive scheme.

Annex I: Questions to Member States

1. How does your initiative support the competitivity of the industrial beneficiaries?
2. How do you monitor the progress of the implemented support measure/s?
3. Does the promoted action align with another ongoing supporting financial tool? If so, how do they jointly combine at national level?
4. Is the described activity, directly or indirectly aiming at stimulating green products produced by process industries?
5. Is the presented action aimed to stimulate a market for green products down the value chain?
6. Is the described activity part of several linked activities or is it a stand-alone action? Please, explain if the former, and justify why if the latter.
7. How does this activity support a stable regulatory framework?
8. How does this activity stimulate the engagement with the whole value chain and strengthen the cooperation among the involved entities while reducing the overall carbon footprint?
9. Are symbiotic systems like hydrogen valleys, Hubs4 Circularity considered in the described measure and how?
10. Do you foresee to replicate this activity/mechanism in future planning actions within your country? How?
11. Do you use any criteria to potentially expand the activity to other sectors and/or value chains?

Annex II: Survey to member states

Austria

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?

Yes. The possibility for regulatory sandboxes is enabled through the legislative package of the Renewable Energy Expansion Act (EAG).

Through the Research Promotion Agency (FFG) “Energy.Free.Space” program three calls for proposals have taken place (3rd call concluded in Q2 2023). The projects are intended to address the system conversion of renewable energy technologies as well as storage and energy efficiency technologies, for example through the use of innovative business models. Ideas from research and their direct implementation in the energy system are intended to support a rapid energy transition and thus strengthen independence and security of supply. To this end, regulatory sandboxes and funded projects are used to develop solutions to questions regarding network usage fees, electricity supply, renewable hydrogen and renewable gases, heat, energy efficiency, sector coupling and the energy market of the future.

As part of the 2nd call for proposals, nine projects are already being carried out, including: in the areas of system integration of storage technologies, increasing system flexibility, optimal use and integration of seasonal electricity storage or options for designing network usage fees.

The goals include the expansion and increased use of renewable energy sources, for example through decentralized and regional supply concepts, the digitalisation of the energy system and the efficient use of energy.

The call for tenders for the Energy.Free.Space is based on the Guideline for Promoting the Use of Renewable Energy Sources and Storage and Energy Efficiency Technologies 2019 (EESET Guideline 2019).

In addition, the regulatory authority E-Control can grant time and location-limited exceptions to system usage fees for research and demonstration projects. The exceptions to system usage fees are anchored in the Electricity Industry and Organisation Act (ElWOG 2010) (→ RIS) and in the Gas Industry Act (GWG 2011) (→ RIS).

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?

See Austrian FTI Pact 2023 - Expand research and technology infrastructure (RTIS) and facilitate access Appropriate research and technology infrastructures are a key factor for strengthening the long-term position of Austria as a location for science and innovation. In view of the high cost of RTIs, it is particularly important to ensure that procurement is coordinated and oriented to the relevant needs and users. Providing targeted support for RTI makes a key contribution to securing Europe’s technological sovereignty, increasing productivity in key technologies in the long term and enabling a European leadership role in research and globally competitive sectors. RTIs include appropriate test environments, experimental laboratories, pilot production facilities and demonstration systems.

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?

They are essential to speed up the development, testing and successful market launch of innovations. The increasing complexity of research questions demands solutions based on data infrastructure, high performance computing, secure transmission using a quantum communication infrastructure and comprehensive data management for the calculation, analysis, storage, transfer and accessibility of data. Measures for implementation:

- Coordinated procurement, cooperative use and needs-based expansion of research, technology and data infrastructures (including international participations), such as the Lisbon Biocenter Vision, high performance computing and EuroHPC, Gaia-X, EOSC, test environments, mobility laboratories and pilot production facilities. Expansion of high-performance infrastructures (including GPU clusters) for use at the interface between science and industry;
- Implementation of the Austrian Research Infrastructure Action Plan 2030;
- On the basis of the research infrastructure database, which is to be further developed, access to research infrastructures in Austria that are open for collaboration as well as future developments will be made visible;
- Utilisation of registry data and statistical micro-data made available by the Austrian Micro Data Center (AMDC) or related funding initiatives;
- Financing of research infrastructures and corresponding research projects through NextGeneration EU or using EU programmes and funds, transnational funding schemes, ERDF funding and national instruments;
- Active and coordinated participation in the ESFRI roadmap to strengthen the internationalisation of research and to utilise infrastructures;
- Application by Austria to include MEDem in the ESFRI roadmap and to locate the headquarters in Austria.

Subsidies and specific financial schemes supporting industrial decarbonisation	Are you aware of the supporting schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for energy-intensive industries, recently approved in Germany or the Sustainable Energy Transition Incentive Scheme (SDE++) in the Netherlands? Are you evaluating the applicability of any of those schemes in your country?

Yes, aware.
The introduction of such a funding instrument in Austria is currently being prepared. As a first step, the Federal Environment Agency (UBA) was commissioned to write a policy brief with the principles and the various design options for such an instrument. In the next step, a rough instrument draft including challenges and solutions as well as a rough financing requirement will be created from the various design options. Furthermore, exemplary “Head of Terms” of such a climate protection

Subsidies and specific financial schemes supporting industrial decarbonisation	Are you aware of the supporting schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for energy-intensive industries, recently approved in Germany or the Sustainable Energy Transition Incentive Scheme (SDE++) in the Netherlands? Are you evaluating the applicability of any of those schemes in your country?

agreement should be created, also with the involvement of industry. This should serve as a basis for the design of such an instrument in Austria.

Foster new business models	Do you promote the symbiotic approach towards multi-actor, cross-sectorial and cross-value chain's collaborative schemes in the value chains where process industries operate? How? Could you please explain a specific case?

Yes. Aside from the whole of government approach and regular exchange with the Federation auf Austrian industries the policies also aim to engage (with) a wider number of actors and stakeholders to facilitate the development of holistic concepts and approaches. Equally, the Climate and Transformation Initiative, under which the Transformation of Industry funding programme is embedded encourages cooperative and collaborative projects.

The mission-oriented and transformative RTI policy will be continued. Targeted use of the entire set of applied, inter- and transdisciplinary RTI instruments will be made in conjunction with implementation and investment instruments at the national and European level, e.g. within the framework of the EU missions. This requires close networking with public agencies and stakeholders to attract new innovation actors, to expand the innovation eco-system and to ensure the impact of RTI. The mission and transformation-oriented focus of RTI represents a fundamental approach.

Due to the complexity of the issues, RTI has to be transdisciplinary, open with regard to the range of technologies, problem-, solution-, and implementation-oriented and also experimental in character. While involving the relevant stakeholders and civil society throughout the entire innovation cycle, RTI activities must be focused more strongly on solution modules that promise a broad impact contribution with both speed and scale. Continuous monitoring with appropriate impact indicators at all impact levels (technology development, system integration and transformation) can realise a high transformative potential.

Update of the National Energy and Climate Plan (NECP)	Can you provide an update on how your National Climate and Energy Plan will integrate the Set Plan objectives and especially, R&I investments in process industries?

The consultation process of the revised NECP was open for interest groups, ministries, federal states, political parties, science and civil society organisations until 30 August 2023. From Austria's perspective, a key driver for implementing the SET plan is driving Urban Transition Partnership and the Clean Energy Transition Partnership as well as the Energy research calls for proposals from the European Framework Program for Research and Innovation (Horizon Europe) and multilateral

Update of the National Energy and Climate Plan (NECP)	Can you provide an update on how your National Climate and Energy Plan will integrate the Set Plan objectives and especially, R&I investments in process industries?

research financing cooperation European states. Synergy effects with funding instruments such as LIFE EU should also be used.

In the steering group and the “bureau” of the SET plan Austria is represented by the nominees from the Innovation and Technology and Climate and Energy sections of the BMK. Through this combination or representation of both sections in the SET plan, efforts at research level and at the funding level can be better coordinated. Austria is currently actively involved in selected key actions of the SET plan with a focus on: • New technologies and services for customers • Resilience and security of energy systems • New building materials and technologies for buildings • Energy efficiency in industry • Framework conditions for the introduction of environmentally friendly and socially acceptable Energy technologies on the market (e.g. “regulatory sandboxes”) For investments – see below

Data acquisition and monitoring of R&I data	Do you use KPIs to monitor the progress of your roadmap/s? which are they? Please, include a description of how to collect and handle the data required to evaluate against the KPIs.

Current monitoring practices are based on KPIs and approach of COM – regular reviews of programmes and policies in place Monitoring, Controlling and Reporting duties are part of all financing agreements with central research and research funding institutions (e.g. FinV of the FFG and AWS) and include provisions for annual progress reports, regular exchange of information and meetings with thematic coordinators in the relevant institutions. In addition to that a set of monitoring indicators and key performance indicators are available, as well as a comprehensive set of outputs and outcomes.

At the level of the BMK a study has been commissioned for a “concept proposal for impact-oriented RTI monitoring”, awarded to Technopolis and SME Research Austria and completed in August 2023. The report contains a detailed analysis of knowledge needs and the existing monitoring structure for applied research. On this basis, a concept proposal was presented which, in addition to data infrastructure and knowledge and information requirements, also contains formats for knowledge development and exchange, in addition to a number of recommendations relating to the knowledge needs.

Next steps: Analysis of study results and formulation of standardized approach to Monitoring, Evaluation and Learning to in particular review and readjust/ change the individual funding instruments and any accompanying measures; and review and possibly adjust of the portfolio to current conditions

The Austrian Platform for Research and Technology Policy Evaluation (fteval) also aims to achieve quality, transparency and adequate coverage of evaluations for a better strategic planning of RTI policy in Austria in order to achieve a better common understanding between planners, promoters and evaluators. Members include relevant Ministries, research and funding agencies.

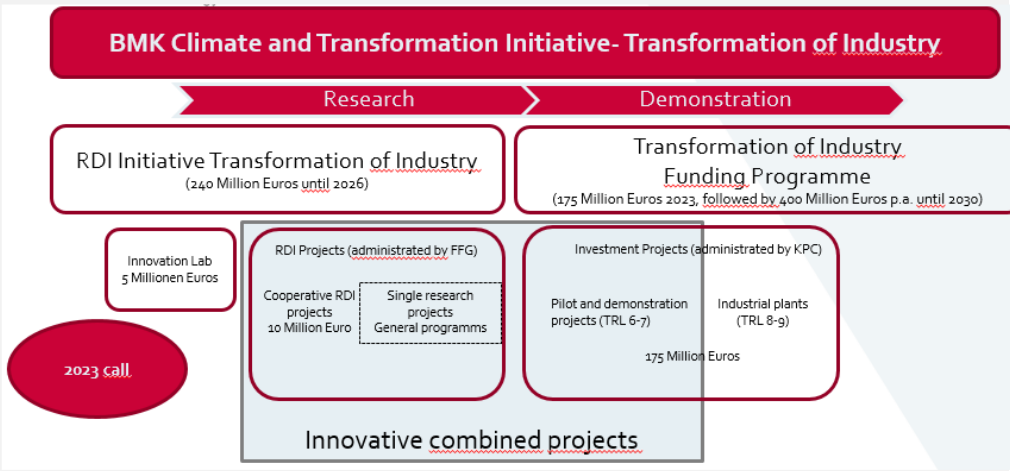
Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?

Example of hydrogen strategy for Austria:
file:///C:/Users/walker/Downloads/bmk_wasserstoff_executive-summary_EN_UA.pdf

A renewable gas law to promote further development of green gas (around 7.5 TWh by 2030) is under development

Demonstrators and first-of-a-kind (FOAK) plants	Are there any special regulatory bottleneck/s or hurdle/s in your country, which limit the deployment of FOAK (e.g. permits, landfilling restrictions/interpretations, transport of materials, etc)? Could you introduce the case and challenges as well as the mechanisms you implement to overcome it/them?

Demonstrators and first-of-a-kind (FOAK) plants	Can you update as a follow up from previous MLE meetings on the available programs to support companies to scale up from TRL 6 above TLR 8?



Under the Transformation of Industry Funding Programme Instrument funding is provided for Investment projects (TRL 6-7 pilot & demonstration projects, TRL 8-9 industrial plants) – 175 Mio. Euros in 2023 (max. 30 Mio. Euros/per project) further 400 Mio. Euros per year, in total 2.975 Billion Euros until 2030

Table 1: Austria

Flanders (Belgium)

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?

We are operating a regulatory sandbox (regelluwe zone) at THOR-park in Genk.
https://vito.be/nl/nieuws/thor-park-regelluwe-zone
New techniques or applications in the field of energy can be tested without certain current regulations standing in the way. This 'exception regime' only applies to energy legislation for the next five years. There are no plans to set up new regulatory sandboxes in the near future.

Subsidies and specific financial schemes supporting industrial decarbonisation	Are you aware of the supporting schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for energy-intensive industries, recently approved in Germany or the Sustainable Energy Transition Incentive Scheme (SDE++) in the Netherlands? Are you evaluating the applicability of any of those schemes in your country?

Yes, we are aware.
Yes, there are plans to launch a ‘test call for CCfD’ in the spring of 2024 (tbc)

Foster new business models	Do you promote the symbiotic approach towards multi-actor, cross-sectorial and cross-value chain’s collaborative schemes in the value chains where process industries operate? How? Could you please explain a specific case?

To a certain extent. Although the spearhead cluster Catalisti is focussed on the chemical industry there is an outreach to more actors.

In the field of circular economy we are running living labs aiming at systemic transformations including all relevant stakeholders https://www.vlaio.be/nl/nieuws/22-living-labs-gaan-voor-doorbraken-richting-een-circulaire-economie

Update of the National Energy and Climate Plan (NECP)	Can you provide an update on how your National Climate and Energy Plan will integrate the Set Plan objectives and especially, R&I investments in process industries?

No information yet.

Data acquisition and monitoring of R&I data	Do you use KPIs to monitor the progress of your roadmap/s? which are they? Please, include a description of how to collect and handle the data required to evaluate against the KPIs.

The energy and climate plan for Flanders (VEKP, part of the Belgian energy and climate plan) is using a broad set of indicators to monitor the results.
https://www.vlaanderen.be/veka/energie-en-klimaatbeleid/vlaams-energie-en-klimaatplan-vekp-2021-2030

The monitoring is coordinated by the energy and climate agency (VEKP). The data are provided by the departments and agencies responsible for specific tasks. A yearly report is provided.
https://assets.vlaanderen.be/image/upload/v1700832727/VR_2023_2311_MED.0420-2_VORA_VEKP23_-_bijlageBIS_u8h1ck.pdf

This report is send to the Government of Flanders.

Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?

Flanders has a vision on hydrogen since 13 November 2020 https://www.ewi-vlaanderen.be/sites/default/files/bestanden/5fad5387b328e9000c00018b.pdf

Hydrogen is one of the topics discussed in the working groups of Klimaatsprong, the process to develop a long term decarbonisation strategy for the energy intensive industry in Flanders.

The federal government of Belgium adopted its Hydrogen Strategy at 29 October 2021 and revised this strategy at 12 October 2022.
https://economie.fgov.be/nl/themas/energie/energietransitie/belgische-federale

Recently, Flanders launched a model based comprehensive study ‘Energy 2050+’ to investigate the realistic pathways to provide technology-neutral and cost-effectively climate-friendly energy in the future.

Demonstrators and first-of-a-kind (FOAK) plants	Are there any special regulatory bottleneck/s or hurdle/s in your country, which limit the deployment of FOAK (e.g. permits, landfilling restrictions/interpretations, transport of materials, etc)? Could you introduce the case and challenges as well as the mechanisms you implement to overcome it/them?
There are no specific bottlenecks for this investments other than the general complexity of setting up large scale operations in a densely populated area.	

Demonstrators and first-of-a-kind (FOAK) plants	Can you update as a follow up from previous MLE meetings on the available programs to support companies to scale up from TRL 6 above TLR 8?
There are no new programmes.	

Table 2: Flanders (Belgium)

Georgia

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?
The main legislative acts, action plans, and resolutions relevant to the direction of decarbonisation are described below: GEORGIA’S LONG-TERM LOW EMISSION DEVELOPMENT STRATEGY The LT LEDS defines a range of estimated national greenhouse gas (GHG) emissions and removals, setting a vision for 2050 based on projections of GHG emissions and removals from the GHG emitter and sink sectors, aggregated into the total national emissions. This vision is considered a GHG reduction goal by mid-century and may be subject to further review and update as suggested by changing international circumstances, commitments, and opportunities. Georgia’s LT LEDS aims to shape and formulate the vision and principles for the low-emission development of the country by 2050. The LT LEDS is fully compliant with the United Nations Framework Convention on Climate Change, including its Paris Agreement, the EU-Georgia Association Agreement, the Energy Community, and the UN 2030 Agenda (Sustainable Development Goals). National Energy and Climate Plan (NECP) The NECP is a strategic planning tool initiated by the EU, with development required in accordance with Article 3 of the Governance Regulation from Georgia. The plan should reflect the detailed vision and the ratio of planned policies and measures in five main areas: decarbonisation, energy efficiency, energy security, internal energy market, and research, innovation, and competitiveness. Georgia is finalizing its NECP as recommended as part of its commitment to the Energy Community	

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?

Treaty membership. In line with the above recommendations and the Governance Regulation set by the Ministerial Council of the Energy Community, Georgia’s NECP should cover the period from 2025 to 2030, including targets and actions for improving energy security, strengthening the energy market, improving energy efficiency, decarbonizing the economy, and promoting research and innovation in five main areas.

The Law of Georgia on Environmental Protection - This is a national legal act that includes the principles of complex governance of climate change.

Air Protection Act of Georgia - This legal act covers climate change governance issues.

Agriculture, Forestry, and Waste Sector

The main strategic document related to agriculture is the Agricultural Development Strategy of Georgia 2021-2027. The purpose of the strategy is to promote the competitiveness of agriculture, ensure sustainable management of natural resources and actions related to climate change, and achieve balanced territorial development of the rural economy and communities, including job creation and retention.

Georgia developed the 4th National Environmental Protection Action Program (NEAP) for the period 2022-2026. Some measures included in this plan are:

Improving the quality of EIA/SEA documentation.
Improvement of the mechanism of prevention and control of emissions from the industrial sector.
Increasing the effectiveness of the environmental law enforcement and supervision system.
Improving access to environmental information.
Implementation of an integrated management system of water resources.
Protection of Black Sea species and habitats.
Provision of clean and safe air for human health throughout the territory of Georgia.
Promotion of sustainable management of land resources.
Reduction of environmental pollution caused by waste.
Reducing the risk of impact on the environment and human health caused by chemical substances.
Maintaining and improving the quantitative and qualitative indicators of the forest and increasing the benefits received from the forest, taking into account the ecosystem services of the forest.
Perfection of climate change policy.
Improvement of the natural hazards and risk management system.
Improvement of the radiation protection, nuclear safety, and security system.
Measures aimed at the agricultural sector to reduce emissions caused by soil and livestock include conducting a cost-benefit analysis (CBA) before the implementation of the measures.

Forest management measures aimed at reducing the net emission of greenhouse gases include reforestation efforts and the implementation of an improved forest code. Also, as required, improving the efficiency of wood stoves (see subsection on energy efficiency).

Waste management and waste-to-energy measures are aimed at reducing the amount of waste (especially organic) disposed of in landfills and collecting/utilizing methane gas at existing landfills.

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?

Georgia has developed and adopted a strategy for the development of small and medium-sized enterprises with the purpose of improving the competitiveness of these enterprises in domestic and international markets. The strategy also aims to support the modernisation of SMEs involved in technology upgrading. Out of the five strategic directions, one focuses on promoting innovation and R&D in small and medium-sized enterprises. Although the term of the strategy expired in 2020, the new strategy is valid until 2025, making the enhancement of competitiveness for small and medium enterprises a priority issue for Georgia.
The government continues to implement measures outlined in the strategy:
Increasing awareness of innovative entrepreneurship.
Developing effective innovation and R&D funding schemes. One of the primary goals of GITA is to provide financing for innovative startups and businesses.
Promoting innovation and commercialisation of R&D. With the financial support of the EU, GITA has initiated a project to increase institutional capacity for new innovation. A component of this project is the technology transfer pilot program, designed to commercialize scientific results that respond to market needs.
Improving skills in information and communication technologies in business.
Providing infrastructure for innovation. GITA has established and continues to operate FabLabs and TechParks, offering free access to research groups and interested entrepreneurs. It actively supports innovative startups through training, grants, and free access to various infrastructures.
The priority of the Government of Georgia is the development of economic support schemes based on knowledge and directed at innovation. This vision is reflected in various state policy documents:
2021-2025 agenda of association between the European Union and Georgia.
Small and medium entrepreneurship development strategy of Georgia.
20 outcomes of the Eastern Partnership for 2020, ensuring tangible results for citizens.
Strategy of socio-economic development "Georgia 2020."
Unified strategy of education and science 2022-2030.
Goals for public/private research and innovation funding targets have not yet been set.
Targets for the use of clean energy by 2050, including low-carbon technologies.
The Ministry of Education and Science of Georgia approved the unified national strategy of education and science for 2022-2030 and the action plan for 2022-2024.
Regarding international cooperation in the RDI sector, efforts are being made to strengthen it:
Support of Georgian researchers and research organisations in major international RDI programs (NATO, SPS, COST, and others).
Increasing the involvement of Georgian scientists and researchers in the European Union's "Horizon Europe" program and their integration into the research space of the European Union.

Subsidies and specific financial schemes supporting industrial decarbonisation	Are you aware of the supporting schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for energy-intensive industries, recently approved in Germany or the Sustainable Energy Transition Incentive Scheme (SDE++) in the Netherlands? Are you evaluating the applicability of any of those schemes in your country?

Foster new business models	Do you promote the symbiotic approach towards multi-actor, cross-sectorial and cross-value chain's collaborative schemes in the value chains where process industries operate? How? Could you please explain a specific case?

Update of the National Energy and Climate Plan (NECP)	Can you provide an update on how your National Climate and Energy Plan will integrate the Set Plan objectives and especially, R&I investments in process industries?

The National Climate and Energy Plan serves as a key advisory and coordination body within the SET Plan, providing targeted and unbiased R&I recommendations. It helps guide and facilitate the research, development, and deployment of sustainable and low-carbon energy technologies in Georgia. The plan promotes collaboration, knowledge sharing, and strategic planning to advance the EU's energy and climate objectives.

Georgia has developed the TIMES model, a mechanism for predicting future greenhouse gas emissions from energy sources. In addition, other emission projections were considered to present a table showing the projected emissions in the WEM scenario, while the NECP covers other subjects. By 2030, projections that are not energy-related were developed within the framework of the Climate Strategy and Action Plan of Georgia. The 2050 forecast is based on the 2030 expansion trends in non-energy conditions. TIMES usage for energy was modeled using the 2050 usage assumption.

Integrated National Energy and Climate Plan of Georgia provides measures about R&I investments in process industries.

RIC-6: Promote certification of new products and technologies through Sustainable Business award - In order to promote penetration of modern low carbon technologies and innovative approaches to improve resource efficiency in industry and commercial sectors, a Sustainable Business Award will be established. Businesses that receive international environmental certification (e.g. ISO 50001, ISO 40001) or introduce modern low carbon technologies to significantly improve resource efficiency or reduce consumption of fossil fuels will be nominated for the Innovation Award. Timeframe of this measure is 2023 and onward.

RIC-7: Support Research2Business fellowship program for knowledge and technology transfer from science to private sector (industry) with focus on low carbon technologies. Support Research2Business fellowship programs in the field of sustainable development. Within the program PhD students and early-stage researchers can pursue/tailor their research in the specific industry (Private companies operating in the Energy and Climate fields). This will help to both increase applicability and relevance of research results as well as increase private investments in RDI. Timeframe of this measure is 2023 and onward.

Data acquisition and monitoring of R&I data	Do you use KPIs to monitor the progress of your roadmap/s? which are they? Please, include a description of how to collect and handle the data required to evaluate against the KPIs.

Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?

Georgia will continue to develop local renewable energy resources, such as hydro, wind, and solar power, to increase local generation and reduce dependence on imports. Additionally, efforts will be made to improve access to clean energy for the manufacturing and commercial sectors. In collaboration with international donor organisations, Georgia will work towards increasing the efficiency of the production sector's resources, aiming to reduce energy consumption intensity and enhance competitiveness.

To shape an effective green hydrogen policy and maximize benefits for the country and its economic stakeholders, several crucial studies are essential. These comprehensive analyses and studies must encompass various aspects, such as policy alternatives and scenarios, financial-economic and technical assessments of green hydrogen production, feasibility studies for hydrogen application in local industries and transportation, research on storage, conversion, export, and transit opportunities, as well as the development of pilot projects. These critical analyses and studies include:

1. Refine Modeling and Scenario Analysis:

- Update TIMES and PLEXOS models with hydrogen production, consumption, and export alternatives.
- Conduct rigorous scenario analysis to assess the impact on energy security, climate targets, and renewable energy goals.
- Incorporate Renewable Energy (RE) additionality compliance and climate and energy objectives in the scenarios.
- Update the National Energy and Climate Plan (NECP) with concrete provisions and measures for green hydrogen (GH2) integration.
- Examine the economic opportunities offered by planned full or (90%) renewable energy self-sufficiency of the power system that might result in a significant excess of green electricity available for GH2 production, offering opportunities for competitive green products for the EU market.

2. EU Legislation and Capacity Building:

- Conduct a comprehensive analysis of EU legislation considering Georgian conditions.
- Determine potential opportunities for Georgian stakeholders in GH2 initiatives.
- Conduct awareness-raising and capacity-building activities on regulations, emissions reduction criteria, certification governance, CBAM, and ETS systems.

3. Hydrogen Pipeline Readiness:

- Conduct a study on the hydrogen readiness of the Georgian pipeline system.

Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?

- Examine the impact of hydrogen blending on operational, infrastructure, and regulatory aspects.
- Identify necessary measures for hydrogen compliance, considering associated costs.

4. Large-Scale System Balancing:

- Conduct a study on large-scale system balancing using existing and new hydropower plants, hydrogen electrolyzer banks, and battery storage systems.
- Examine the potential for providing balancing services to neighbouring power systems and the effect on renewable energy integration.

5. Strategic Regional Initiatives and Projects:

- Initiate studies on strategic regional initiatives, including balancing load with electrolyzers in Georgia using imported renewable electricity.

6. Feasibility Studies for Hydrogen Utilisation:

- Conduct feasibility studies on using hydrogen in local industries such as fertilizer, metallurgy, mining, and cement production.
- Assess the economic and environmental viability of hydrogen applications in these sectors.

7. Explore Long-Term Partnerships:

- Explore opportunities for long-term partnerships with shipping companies like MAERSK for hydrogen usage.
- Investigate the potential for a ferry service between Georgia and the EU, focusing on connectivity for green methanol.

By undertaking these actions, the government can lay a solid foundation for the successful integration of green hydrogen and renewable energy into the national energy mix. These efforts will not only support the achievement of climate targets but also unlock new economic opportunities and enhance energy security in the count.

Demonstrators and first-of-a-kind (FOAK) plants	Are there any special regulatory bottleneck/s or hurdle/s in your country, which limit the deployment of FOAK (e.g. permits, landfilling restrictions/interpretations, transport of materials, etc)? Could you introduce the case and challenges as well as the mechanisms you implement to overcome it/them?

Demonstrators and first-of-a-kind (FOAK) plants	Can you update as a follow up from previous MLE meetings on the available programs to support companies to scale up from TRL 6 above TLR 8?

- Shota Rustaveli National Science Foundation of Georgia (SRNSFG), operating under the auspices of the Ministry of Education and Science (MoES), is empowered to promote Georgia's integration into the international science, technology, and innovation (STI) system, significantly contributing to the rapid socio-economic development and welfare of the country.

- While SRNSFG does not directly fund SME enterprises, a new grant call is scheduled for launch in 2024. The design of this call aims to stimulate collaboration with business partners, fostering connections between research institutions and enterprises. Through this collaboration, research institutions will receive funding, and enterprises will gain knowledge and technology from these institutions. It is noteworthy that the project will synergistically involve representatives from research institutions and SMEs. Discussions are ongoing on how to prioritize decarbonisation, addressing how manufacturers can leverage their influence to overcome various obstacles in the carbon conundrum and prevent climate change.

- A key mechanism for promoting research, innovation, and competitiveness is the creation of the Georgian Innovation and Technology Agency (GITA), under the supervision of the Ministry of Economy and Sustainable Development of Georgia. GITA supports capital market development across various sectors, including the energy sector. GITA is in the finalisation stages of its 2025 strategy (acceleration plan), outlining core activities as the coordinator and mediator of the national innovation policy process. The agency is actively engaged in various activities, supporting innovative projects and grants through startup support programs, including grants and innovation co-financing grant programs. GITA collaborates with the World Bank and the European Union on a pilot technology transfer program, identifying research projects with high commercialisation potential and facilitating their transfer to industry.

- The "Produce in Georgia" program is a government initiative aimed at developing entrepreneurship to promote the creation of new enterprises and the advancement of existing ones. Although not directly focused on research and innovation support, the program provides access to financing, infrastructure, and consultancy for enterprises based in and operating within Georgia. This program is well-suited for any innovative Georgian business, offering support for finance, infrastructure, and consultancy.

- As mentioned earlier, although the state program "Make in Georgia" does not directly focus on research and development, it supports local small and medium-sized businesses operating in the energy sector, producing modern energy-efficient technologies. This directly contributes to the development of technology in the country.

Table 3: Georgia

Lithuania

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?

Lithuania is developing several regulatory sandboxes related to decarbonisation of process industry in Lithuania.
One such example is implemented by the Energijos Skirstymo Operatorius (ESO, engl. Lithuanian Energy Distribution Operator). ESO is running a program that allows companies to test out their hardware and software solutions in designated locations across the country, where the companies are least likely to cause any serious damage in case of bugs or technical failure. This company provides starting or small businesses a way to understand the feasibility of their products under real-life conditions using ESO’s electricity grid and creates useful connections with experts working in the field presently.
Another example is The National Energy Regulatory Council’s legislation amendments aimed to encourage energy companies to invest in innovative projects, as well as to implement investments to reduce climate change. The idea is for start-ups to work for a certain pre-determined period without obtaining the normally required certificates in the energy sector (supply of electricity, installation of hardware, network stabilisation etc.). The project has been put on hold as the Parliament has not yet agreed on required legislation to start with the sandbox.
The Innovation Agency Lithuania together with the Ministry of Economy and Innovation have also begun planning implementation of a sandbox in the field of green and renewable technology. The plans do not focus on specific regulatory changes or physical testing ground, but rather on creating testbed innovative financial instrument that promotes cooperation between and provides access to existing infrastructure (i.e. R&D centres, ESO network, other related infrastructure) resources and support for new ventures into decarbonisation, biogas, renewable energy/hybrid energy production sites or secondary raw material use.
Lithuania also uses Digital Innovation Hubs to create sand-box conditions. In addition to customised interventions to digitalise and improve companies’ processes, products, or services, EDIHs offer personalised training programmes, workshops, mentorship, as well as access to technical expertise and cutting-edge digital technologies that can be experimented with (test-before-invest) before full-scale implementation. This option creates sand-box-like opportunities. Lithuania has 7 digital innovation hubs (DIHs) and 3 European Digital Innovation Hubs (EDIHs). The DIHs provide companies with services related to digital transformation and are the innovation mediators, offering access to test and experiment infrastructure. Lithuanian EDIHS also implement activities aimed at improving of energy efficiency and decarbonisation of industry.

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?

Research infrastructure relevant for low carbon technologies is developed by multiple public entities in Lithuania. Ministry of Energy, Ministry of Transport and Communications, Ministry of Economy and Innovation, Ministry of Environment, Ministry of Agriculture, Ministry of Education, Science and Sport via different initiatives all support research infrastructure, R&D and/or scale up of promising low carbon technologies or their application. This is done via funding instruments. Such support and measures depend on the specific national priorities for industry and that industry sector related policies. Current energy related policies include the aim to evolve from an energy technology importer into an energy technology producer and exporter. Also, by 2050 Lithuanian aims to decarbonise its energy production 100% with green hydrogen and become not only technology, but also green energy exporter to the Baltic Sea Region. There are currently two strategic documents setting out

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?

guidelines for national policies to promote research and innovation in the context of the Energy Union, namely the National Energy Independence Strategy and the Smart Specialisation Strategy (S3) (from National energy and climate change plan of Lithuania - NECP).

Currently, while implementing S3 strategy, Lithuanian (in coordination among two ministries- the Ministry of Economy and Innovation and the Ministry of Education and Science) has launched 3 innovation missions that foresee building new RDI infrastructure based on science-business partnerships (consortiums). One of the missions is “Smart and climate-neutral Lithuania" consortium is aiming to strengthen Lithuania's energy sector and increase the use of renewable energy sources and cut greenhouse gas emissions by 2030 while simultaneously increasing the added value created by the engineering industry sector. Project foresees to develop and launch 7 energy efficiency related technological innovations and prior to that developing necessary R&D infrastructure. These results are instrumental to the implementation of the National Progress Plan 2021-2030 and are approved by the national Science, Technology and Innovation Council.

National Hydrogen strategy implementation guidelines are currently also developed by the Ministry of Energy. Guidelines establish three priority sectors for hydrogen consumption – industry, transport and energy, it also foresees establishment and development of two hydrogen valleys – North-western and Central – in Lithuania, aiming to become leading green hydrogen producer and exporter in Baltic region by 2050.

Lithuania has earmarked €50 million Euros from the EU Investment Programme 2021-2027 and the EU Modernisation Fund, of which around €50 million Euros would be private investment, to increase the share of renewables in industry. This combined public and private investment of €100 million Euros in renewable energy generation capacity will allow industrial companies to generate 1 TWh for their own use by 2030, i.e. the projects will result in 52 GWh/year of renewable energy generation capacity and 767 460 tCO_2/year of CO_2/year savings in industrial companies.

First pilot hydrogen project is launched by the largest Lithuanian fertilisers production company which will lead to low-carbon ammonia production and already has started to develop the electrolyser pilot project. First stage of the project would aim at integration of electrolysers into ammonia production unit (replacement of 30 % H2) by 2027. As demand grows, 15% of the ammonia needed for fertiliser production could be produced from green hydrogen in 2030.

According to the project forecast, following the implementation of the first stage of the project the emissions of the ammonia unit will be lower than the planned emission allowances rate and will amount to 1.490 t CO_2/ t NH3. Thus, in one of the ammonia units, CO_2 emissions will be reduced by 27 %. A climate-neutral fertiliser industry would be achieved by 2050. The fertilisers installation is the largest single source of emissions in Lithuania, accounting for around 2.5 Mt CO_2e annually, or roughly 41 % of all national industrial ETS emissions. The company implementing the project has two ammonia production facilities which are the main sources of its carbon emissions as hydrogen used for ammonia synthesis is produced from natural gas.

Subsidies and specific financial schemes supporting industrial decarbonisation	Are you aware of the supporting schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for energy-intensive industries, recently approved in Germany or the Sustainable Energy Transition Incentive Scheme (SDE++) in the Netherlands? Are you evaluating the applicability of any of those schemes in your country?

Lithuanian Ministry of Energy and Lithuanian Ministry of Economy and Innovation did not know of these opportunities. However, now we intend to assess the schemes.
However, currently Lithuania is discussing on ministerial level between Estonia, Latvia, Lithuania and Germany concerning possible regional co-operations on Hydrogen supply and infrastructure development topics.

Foster new business models	Do you promote the symbiotic approach towards multi-actor, cross-sectorial and cross-value chain's collaborative schemes in the value chains where process industries operate? How? Could you please explain a specific case?

This year the feasibility study "Assessment of the possibilities of using CO_2 collection and storage, hydrogen and other innovative technologies in Lithuanian industrial companies operating in the most negatively affected areas" initiated by Ministry of Economics and Innovation. It aims to assess the value-chain solution possibilities. It will look into capabilities of Lithuanian industrial biggest emitters together with their regional industrial ecosystems and examine their potential symbiosis in reducing CO_2 emissions. We hope the study will provide recommendation regarding pilot industrial symbiosis park establishment.
Also, Lithuania has adopted guidelines for the transition from linear to circular economy within which symbiosis approach for industrial transformations is prioritised. Guidelines propose various regulatory mechanisms, determine the need for in depth analysis of existing systems and practices and suggest areas in highest need of investment. Among these suggestions is the creation of an industrial symbiosis platform that would foster symbiotic relationships between businesses in different value chains and a cross-sectoral platform to tackle waste management issues and provide new solutions for less flexible businesses.
In addition to that, various financing schemes have been implemented to foster a green economy amongst which the most successful is the Green Experiment. During the Green Experiment, €8 million have been allocated for various projects concerning recycling.
Also, a project dedicated to the facilitation of smart specialisation R&D results by digitalising production processes in industrial companies (Smart InoTech for industry) is implemented. The project aims to encourage Lithuanian companies to deploy RDI results in smart specialisation areas, digitalising production processes, in order to increase high added value to increase the scale of production of high-value products. Another project the InterInoLT project assists Lithuanian engineering companies to integrate into international experimental development and innovation value chains. The project aims to create a network of Lithuanian experimental development and innovation representatives ("ambassadors") to promote Lithuania's potential in the field of experimental development and innovation abroad: by increasing the amount of funds attracted by LT entities from international RDI programs; by attracting investments in innovation projects for the global market; and by increasing the export of high-value-added products and services (innovations) (to help companies to move out of the RDI sandbox in Lithuania to foreign countries).

Update of the National Energy and Climate Plan (NECP)	Can you provide an update on how your National Climate and Energy Plan will integrate the Set Plan objectives and especially, R&I investments in process industries?

Lithuanian NECP refers to two strategic documents that provide guidance for national policies to promote research and innovation in the context of the Energy Union – the National Energy Independence Strategy and the Smart Specialisation Strategy (S3).
The Lithuanian R&I Smart Specialisation Strategy for 2021-2027 aims to promote innovation-driven and sustainable economic growth through science-business cooperation and concentration of resources on areas with the greatest potential for research and experimental development and innovation (RDI). (specific objectives with KPI's are provided in the next section)
In total, around EUR 600 million has been allocated for the implementation of the objectives and activities of the Lithuanian S3 for 2021-2027. Lithuania adopted an updated S3 on 17 August 2022 to focus resources on areas with the highest economic potential.

Data acquisition and monitoring of R&I data	Do you use KPIs to monitor the progress of your roadmap/s? which are they? Please, include a description of how to collect and handle the data required to evaluate against the KPIs.

S3 strategy R&I priorities relevant to the National Energy and Climate Plan include:
pew production processes,
renewable energy technologies,
energy efficiency,
new (advanced) materials and technologies.

S3 aims to ensure efficient and sustainable business development and the deployment of digital solutions and new technologies, as well as industrial cooperation between business and science, thereby increasing productivity, added value and energy efficiency. Priorities include the development of technologies for energy storage and use, the development of energy markets, changes in the functioning of the electricity system, new methods of electricity system management, power mechanisms and the active involvement of consumers in the functioning of the electricity system and markets. It will contribute to improving energy efficiency in the sectors with the highest potential – industry and buildings and transport.

The implementation of all measures under the S3 in all priority areas are expected to contribute to the achievement of these specific goals/KPIs in 2030:
R&I investment in Lithuania will increase to 2.2 % of GDP (from 1 % of GDP) GDP in 2019);
The Global Innovation Index will rise to 30th place in Lithuania (39th in 2021);
the number of enterprises active in innovation will increase to 57 %. (46.9 % 2018);
the share of Lithuanian high-tech goods exports in the overall goods export structure will increase to 44 %. (40.3 % in 2020);
the number of innovative small and medium-sized enterprises will increase significantly, up to 51.4 %. (38 % in 2020)
NECP foresees that additional promising area for the development of energy innovation and energy competences, the exploitation of R&D results in other areas of the economy, the growth of exports and the development of new business in the country is the use of hydrogen in energy, industry and transport. It is also necessary to further develop CCU, CCS technologies and to analyse their applicability in Lithuania. It is also necessary to set up an open-access CO_2transport infrastructure that creates the preconditions for the transfer of carbon captured from emission sources to geological

Data acquisition and monitoring of R&I data	Do you use KPIs to monitor the progress of your roadmap/s? which are they? Please, include a description of how to collect and handle the data required to evaluate against the KPIs.

storage sites (in December of 2022, joint consortium of Polish, Lithuanian and Latvian enterprises submitted two applications for PCI status for CO_2 transport infrastructure projects).
Ministry of Economy and Innovation and Lithuanian Innovation Agency are responsible for monitoring of S3 research and experimental development indicators and impact assessment. The data is collected via multiple agencies – Energy agency (LEA) collects energy consumption, technology and efficiency data, Environment protection agency (LEPA) collects footprint data. Innovation agency, when monitoring S3 implementation, will combine different sources of data and will connect it to the economic indicators in order to assess the progress.

Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?

National strategies include:
Lithuanian National Progress Plan,
National Energy Independence Strategy,
National Smart Specialisation Strategy (RDI),
National Climate Change Management Agenda,
National Energy and Climate Change Action Plan,
National Waste Prevention and Management Plan.
It is recognised in current policies that aiming for Lithuania to evolve from an energy technology importer into an energy technology producer and exporter, it is necessary to promote the experimental and industrial development of the most promising energy technologies as well as innovation incubators, research, and pilot implementation of research results in practice. Research and development in the field of energy in Lithuania and the products developed must be integrated into industrial production and become part of Lithuanian exports, thus contributing to the economic growth of the country. Lithuania needs to identify energy research and innovation priorities at national level and focus on them to create a competitive advantage. There are currently two strategic documents setting out guidelines for national policies to promote research and innovation in the context of the Energy Union, namely the National Energy Independence Strategy and the Smart Specialisation Strategy (as established in National energy and climate change plan of Lithuania - NECP).
As mentioned before, National hydrogen strategy implementation guidelines are currently drafted by the Ministry of Energy in co-operation with other ministries. Guidelines establish priority sectors for hydrogen consumption – industry, transport, and energy. Guidelines also foresee establishment and development of two hydrogen valleys – North-western and Central – in Lithuania, aiming to become leading green hydrogen producer and exporter in Baltic region by 2050.
Also, in the next few years, Lithuania will work together with scientists from the United States of America (USA) to prepare a model for the transformation of the energy sector, which will foresee the fastest and most economically efficient ways for Lithuania to reach 100 % renewable energy production.
The modelling study is being prepared as part of the Ministry of Energy and the US Department of Energy's signed Memorandum on cooperation in the field of energy in 2022. One of the largest and most significant energy projects will be implemented by the scientists of the US National Renewable Energy Laboratory together with the Lithuanian Energy Agency (LEA). Until 2025 the comprehensive

Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?

assessment of the Lithuanian energy sector will be completed, and a transformation model of the Lithuanian energy sector will be prepared. The aim of the model - Lithuania becoming a fully self-sufficient country in electricity supply as soon as possible and achieve that 100% of consumed electricity would be produced from green renewable energy sources.
The results of the modelling study will be a set of various energy models that will form a general model of the transformation of the Lithuanian energy system. The model will be prepared after evaluating the development of electricity generation sources and their integration, the electrification of transport, industry and other sectors, the influence of the electricity exchange model, the use of hydrogen and green gas and other aspects. Using the created model, the main transformation scenarios will be simulated. The modelling study will become the basis for updating and clarifying strategic planning documents in the field of energy.

During the preparation of the study, the data of the entire Lithuanian energy system will be collected, prepared, and modelled. For this purpose, a working group composed of representatives of the US National Renewable Energy Laboratory, the Department of Energy, LEA, and other energy companies. After completing the necessary preparatory work, representatives of socioeconomic partners will be included in the development of the model and, accordingly, in the preparation of the study. The implementation of this project will be based on the exemplary and currently implemented energy sector transformation model developed by the US National Renewable Energy Laboratory in Los Angeles, USA. Lithuania will be the first country in the world where such a model will be created for energy transformation. The preparation of the modelling study and, accordingly, the creation of the model is be financed with the funds of the Economic Revitalisation and Resilience Enhancement Plan (RRF).

Demonstrators and first-of-a-kind (FOAK) plants	Are there any special regulatory bottleneck/s or hurdle/s in your country, which limit the deployment of FOAK (e.g. permits, landfilling restrictions/interpretations, transport of materials, etc)? Could you introduce the case and challenges as well as the mechanisms you implement to overcome it/them?

There are currently no indications from industry of any particular bottleneck. However, multiple EU regulation requiring ascertaining an increasing number of data assessed per business is becoming a significant administrative burden and is reported by businesses. Sometimes, f.e., when opening novel processing plant certain environmental requirements need to be met, certification acquired, construction safety rules to be followed and standards adhered to, hence procedure can be lengthy and seen negatively by businesses. Most of such regulatory challenges in practice are dealt case by case – companies do reach out for public (relevant) agency consultations and assistance. In cases if hurdle procedure deemed superfluous for the case, then ways of reducing administrative burden are sought after. For instance, if the length of procedure is questioned (and when possible) necessary registration documentation assessment stages are arranged simultaneously to fast stream the process.
One example of potentially FOAK could be Vilnius central heating (VCH) company project. VCH have started a new project to build a 3 MW electrolyser in one of the thermal plants, providing centralised heat, to produce green hydrogen from renewable electricity. Hydrogen will be used in

public transport, however the key innovation is combining electrolyser with a heat pump and using excess heat for centralised heating. When producing hydrogen, approximately 30% of the consumed electrical energy is released in the form of heat. By implementing this project, it will enhance system efficiency, maximizing the system's potential and reducing the cost of green hydrogen.

Demonstrators and first-of-a-kind (FOAK) plants	Can you update as a follow up from previous MLE meetings on the available programs to support companies to scale up from TRL 6 above TLR 8?
Under the supervision of Ministry of Economy and Innovation there are three main technology development and innovation support longitudinal financial schemes in Lithuania, namely - InoStartas, InoPažanga and InoBranda. These schemes focus on innovators and innovations within National Smart Specialisation priority areas. All three aim to create a coherent framework for the promotion of innovation activities. They stimulate the innovation development by investing in activities for the development of new high added-value technologies, products and enable researchers to participate in the research and experimental development activities of enterprises; by fostering intellectual property, stimulating the early pilot production of new products developed, and preparing them for the market. Projects of higher TRL are prioritised. Total allocated value of the associated financial instruments: InoStartas - €2.5 million, funding up to €200 thousand per company for youg/ new innovators. InoPažanga - €26.9 million, funding up to €1.2 million per company for projects at the later innovation stages. InoBranda - €20 million, funding up to €2 million per company, well established innovators. In addition, to the above longitudinal schemes there is a whole array of ad-hoc measure. One of such is the Green Experiment financial measure which funds the development of innovative technologies for environmentally friendly, sustainable products. It invests in research and experimental development (R&D) and patenting activities that aim to help businesses find science-based environmental solutions. Other ministries (energy, transport, agriculture, environment etc.) also have their environmental R&I support measures that in one or the other way promote decarbonisation of economy and specific industries.	

Table 4: Lithuania

Portugal

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?
In Portugal we have established the **Technological Free Zones** (**ZLT** – Zonas Livres Tecnológicas), which are demonstration and testing areas or spaces for new technologies that need specific and adapted regulatory regimes. They are a "safe space" in which companies can test innovative products, services, business models, and delivery mechanisms without immediately incurring all the normal regulatory consequences related to the activity in question. They are intended to allow testing	

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?

and experimentation in a real or near real way, with direct and permanent control by the competent regulatory authorities, particularly in terms of testing, provision of information, guidelines, and recommendations, **corresponding to the concept of regulatory sandboxes**.

Until now, we have established 2 ZLT’s:

- ZLT Infante D. Henrique, in Troia, aiming at testing unmanned security and defense systems and other technologies in subsurface, surface (land and wet) and air environments.
- ZLT Matosinhos aims at promoting experimentation and testing of innovative solutions of mobility geared towards carbon neutrality in cities.

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?

National policies and strategies for research and technological development include measures to support research infrastructure, advances in promising technologies, including those related to reducing carbon emissions, and in fact are partly funded by innovation programmes.

The **national Roadmap to Carbon Neutrality 2050 (RNC)** is a strategy that identifies emission reduction trajectories for the various sectors of the economy and the technological options with the potential to make the transition. It will be implemented by 2030 through the 2021-2030 NECP, which introduces the main reform for the industrial sector within this timeframe **by establishing "Goal 7 - Develop an innovative and competitive industry" among its objectives.**

Goal 7 includes a number of lines of action that stand out:

- 7.1 Promote the decarbonisation of industry - through electrification, the incorporation of energy from renewable sources and alternative fuels;
- 7.2 Promoting energy and resource efficiency - through efficient technologies, energy efficiency and high-efficiency renewable cogeneration;
- 7.3 Encourage eco-innovation and cleaner production processes, promote the digitalisation of industry (industry 4.0) - promoting the digitalisation of industry, the decarbonisation of industrial processes and the reduction of fluorinated gases;
- 7.4 Promote the circular economy in industry by promoting the circular and low-carbon economy, industrial symbioses and new circular and low-carbon products and services;
- 7.5 Promote R&D projects that support an innovative and competitive low-carbon industry.

The RNC2050 concludes that all sectors will contribute to reducing emissions, increasing efficiency and innovation, promoting improvements, namely in buildings, agriculture, waste management and

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?

industry, with the energy system making the biggest contribution, particularly with regard to electricity generation and transport.

It should be noted that Portugal's Recovery and Resilience Plan (PRR) is also a continuous effort to attract public and private stakeholders, and 38 per cent of its total allocation has been focused on measures that financially support and promote projects and new processes for low-carbon technologies in industrial and industrial energy efficiency, incorporating renewable energy sources.

* Portugal is underlining the implementation of its decarbonisation roadmap for the chemical and cement sectors, with the financial help of the National Recovery and Resilience Plan (PRR).

Subsidies and specific financial schemes supporting industrial decarbonisation	Are you aware of the supporting schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for energy-intensive industries, recently approved in Germany or the Sustainable Energy Transition Incentive Scheme (SDE++) in the Netherlands? Are you evaluating the applicability of any of those schemes in your country?

We are aware of such ongoing programmes in other countries – at the moment CCfDs are not being considered for Portugal. Under the revision of the National Energy and Climate Plan and of the Carbon Neutrality Roadmap both CCfDs and SDE++ similar scheme could be considered in the future.

Foster new business models	Do you promote the symbiotic approach towards multi-actor, cross-sectorial and cross-value chain's collaborative schemes in the value chains where process industries operate? How? Could you please explain a specific case?

Yes. The Carbon Neutrality Roadmap was the first of such plans in EU that explicitly considered circular economy options as action towards GHG mitigation. During the next year a large-scale industrial symbiosis study will assess the role of cross-sectorial and cross-value chain's collaborative schemes to improved environmental performance including GHG emission mitigation.

Update of the National Energy and Climate Plan (NECP)	Can you provide an update on how your National Climate and Energy Plan will integrate the Set Plan objectives and especially, R&I investments in process industries?

The National Energy and Climate Plan is aligned with overall Set Plan objectives, although not specifically with R&I investments in process industries.

Also, in accordance with Article 14 of the Regulation on the Governance of the Energy Union and Climate Action, Portugal carried out a draft update of the PNEC 2030 (see here), submitted to the European Commission on 30 June 2023, establishing, among other aspects, new national targets for the reduction of greenhouse gas emissions and new targets for the incorporation of energy from renewable sources, as well as new lines of action and policies and measures to be adopted to achieve them.

The preparation of this document resulted from a participatory process open to the general public, with a prior public consultation carried out on the Participa Portal, the organisation of a technical workshop with the different interested sectors and several regional Participatory Assemblies.

Work on the revision of this Plan will continue in the coming months, with a view to submitting a final version to the European Commission by 30 June 2024.

Data acquisition and monitoring of R&I data	Do you use KPIs to monitor the progress of your roadmap/s? which are they? Please, include a description of how to collect and handle the data required to evaluate against the KPIs.

KPI are used but not specifically for R&I data.

Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?

Portugal has a national green hydrogen strategy (EN-H2) that specifically considers hydrogen for industry. The national Biomethane Action plan mainly addresses use of biomethane in other sectors as transport and buildings.

The Hydrogen Roadmap and Action Plan for Portugal aim to gradually introduce hydrogen as the main driving force behind the transition to a decarbonised energy system, boosting the decommissioning of fossil-fuelled power stations and stimulating the development of renewable production. It also develops an analysis of the opportunities and competitiveness of renewable hydrogen and a predictive analysis of the impacts of hydrogen in different dimensions[39].

[39] https://www.ap2h2.pt/download.php?id=178

Demonstrators and first-of-a-kind (FOAK) plants	Are there any special regulatory bottleneck/s or hurdle/s in your country, which limit the deployment of FOAK (e.g. permits, landfilling restrictions/interpretations, transport of materials, etc)? Could you introduce the case and challenges as well as the mechanisms you implement to overcome it/them?
The most relevant bottlenecks are long permitting processes and limited market availability of innovative technologies with long response time from technology suppliers. Efforts are ongoing to accelerate permitting processes. Currently, in Portugal we have the industrial licensing system SIR - Responsible Industry System that establishes the necessary procedures for the licensing of industrial establishments and Responsible Business Zones (ZER), as well as the accreditation process of entities within the scope of this licensing.	
Demonstrators and first-of-a-kind (FOAK) plants	Can you update as a follow up from previous MLE meetings on the available programs to support companies to scale up from TRL 6 above TLR 8?
"First of a kind" (FOAK) installations refer to projects or installations that are the initial examples of a specific technology or concept. They are often pioneering endeavours that serve as prototypes or proof-of-concept implementations. FOAK installations are crucial for testing and validating new ideas, technologies or processes before they are adopted more widely. They play a significant role in innovation and can pave the way for future developments in various fields.	

Table 5: Portugal

Slovakia

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?
The Regulatory Office for Network Industries (URSO) has been operating Regulatory Sandbox since 2021.The main objective of the Regulatory Sandbox is to promote innovation leading to or has the potential to reduce costs and the final price of regulated commodities and services authorities, streamlines the investment and operation of regulated entities and ultimately delivers new products and services to consumers in network industries. The aim is to support projects whose potential market expansion after successful testing presupposes the benefit of: – Optimising unit prices or total costs or setting more reasonable prices and conditions for services provided within network industries for customers, as well as enabling customers to better manage and optimise their energy and water costs.	

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?

- Decarbonisation, deployment of renewable energy sources and environmental protection, promoting the sustainable development of regulated network industries.
- The protection of vulnerable customers and customers in energy poverty.
- The introduction of tools to promote competition among energy suppliers, investment in resource adequacy and demand management; (e.g. this refers to the development of APAs or other instruments)
- Increasing the level of flexibility, dynamism, openness and transparency of the energy market (e.g. interoperability).

Experience from the implementation and results of the Regulatory Sandbox will be reflected by the Office when changes in legislation and regulatory policy will take place in the next period.

On top of that, through the Strategy of the economic policy of the Slovak Republic we are planning to launch similar concept in the agriculture sector, so called Climate Farms that can serve as a testing ground for new technologies, practices and research projects as well as a mechanism or a tool of trying state schemes of support for innovations in the small scale to identify the shortcomings of such schemes. We believe that through experiences from these measures as well as through best practices of other countries that we learned through MLE on Industrial decarbonisation we will start evaluating launching regulatory sandboxes in industry as well.

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?

Decarbonisation has become one of the key elements in quite a few strategies and the relating roadmaps in Slovakia.
Beside the key strategy of the Smart Specialisation (SK RIS3 2021+), including strong decarbonisation element in domains of Industry and Mobility it is applied in National R&D&I Strategy 2030 (info in SK), as well as partial strategies for the specific fields, including electromobility Strategy for the development of electromobility in the Slovak Republic and its impact on the national economy of the Slovak Republic (document SK) or employing hydrogen – National Hydrogen Strategy (document EN) and the their action plans (eg hydrogen strategy action plan) aim to the detailed roadmap, focused on PoCs, demonstration implementations and later pilot larger scale decarbonisation projects, based on the application of innovative technology solutions in decarbonising various areas of economy and society. The same approach is applied in mobility Smart and Sustainable Mobility Strategy of the Slovak republic (document SK).
Strategic decarbonising framework is set by the NECP of Slovakia (draft update 2023), as well as the Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050 (document EN)

Subsidies and specific financial schemes supporting industrial decarbonisation	Are you aware of the supporting schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for energy-intensive industries, recently approved in Germany or the Sustainable Energy Transition Incentive Scheme (SDE++) in the Netherlands? Are you evaluating the applicability of any of those schemes in your country?

For technology development, state aid schemes supporting various TRL projects, focused on decarbonisation, financed by SK Recovery and Resilience Plan are implemented by the unit of the Government Office responsible for the creation and coordination of research and innovation policies (VAIA) and the Ministry of Economy
Under the SK Recovery and Resilience Plan, as well as the Modernisation Fund, industry decarbonisation state aid schemes are implemented, providing the above BAT decarbonisation projects in ETS undertakings in the Slovak industry. However, both schemes, as supporting large full scale decarbonisation project, exclude pilot implementations and focus on industrialised technology solutions, achieving DNSH requirements (e.g. excluding fossil energy as main energy source).

Foster new business models	Do you promote the symbiotic approach towards multi-actor, cross-sectorial and cross-value chain's collaborative schemes in the value chains where process industries operate? How? Could you please explain a specific case?

Currently such approach is only recommended through the strategic documents, including the above mentioned. However, it is clear, that successful implementation in various fields (incl. urban and rural mobility as well as supply chain and distribution logistics, including zero and low carbon mobility employment; effective RES implementation in the electro energy sector, including system balancing solutions and smart grid; energy community operation; and smart industry implementations) can only deliver when applying multi-actor approach, based either on quadruple-helix or manufacturing-energy-ICT industrial and similar projects. We are creating a project pipeline and hope to be able to present specific case studies in the above-mentioned areas within the one-two year period.

Update of the National Energy and Climate Plan (NECP)	Can you provide an update on how your National Climate and Energy Plan will integrate the Set Plan objectives and especially, R&I investments in process industries?

So far, the draft version of the NECP doesn't integrate any specific measures for R&I-investment in process industries. What it does include however, is cooperation with other Member States about information-exchange on how the intentions and policies of the European Strategic Plan for Energy Technologies are reflected in the national context.
Beyond that, the above-mentioned SK RRP implementation, as well as the implementation of the above-mentioned National Hydrogen Strategy continuously become parts of the NECP draft updates, as the measures progress in implementation. Also, the RES, including battery solutions and biomethane are supported by the SK RRP schemes.

Data acquisition and monitoring of R&I data	Do you use KPIs to monitor the progress of your roadmap/s? which are they? Please, include a description of how to collect and handle the data required to evaluate against the KPIs.

It is necessary to use KPIs, as according to EU financial instruments (structural funds, RRF…) implementation rules or national directive on strategy documents including action plans and roadmaps. The structure, including data collection and evaluation, is individual and is usually provided as a part of the methodology base of the specific document.

Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?

So far this year we launched an Action plan on hydrogen use that sets objectives of doing research of possible use of hydrogen in industry. The Slovak NECP so far counts with the substantial use of hydrogen, biomethane and synthetic methane in the gas blending in the future (after 2030) that would be use also by industrial companies. Companies that use these gases in the industrial processes, such as refineries or steel companies already have their own plans and are eligible for state support through the modernisation fund.
Including the above-mentioned strategies´ implementation, new areas are open also by the new chapter of the SK RRP, called REPowerEU – opening sustainable biomass trajectories, biogas-to-biomethane transformation roadmaps and geothermal energy measures.

Demonstrators and first-of-a-kind (FOAK) plants	Are there any special regulatory bottleneck/s or hurdle/s in your country, which limit the deployment of FOAK (e.g. permits, landfilling restrictions/interpretations, transport of materials, etc)? Could you introduce the case and challenges as well as the mechanisms you implement to overcome it/them?

At the moment we are in the process of evaluating and collecting the data on such bottlenecks through the Strategy of the economic policy of the Slovak Republic and we will be able to provide information later. An example of a case that we evaluated can be a regulatory bottleneck of the use of drones in agriculture, as Slovakia yet doesn't have a registration system for such technology which results in the inability of subjects to do any economic activity connected with drones, so that they cannot legally operate.
As a part of the above-mentioned REPowerEU chapter measures of the SK RRP, significant improvements for regulation are introduced, mostly for technical norms and standards, legislation, permitting regulation and other areas of the renewable energy sector, especially wind and geothermal energy, sustainable biomass, biomethane and the entire value chain of the hydrogen utilisation (R&D, production, storage, distribution, industry, transport, energy sector).

Demonstrators and first-of-a-kind (FOAK) plants	Can you update as a follow up from previous MLE meetings on the available programs to support companies to scale up from TRL 6 above TLR 8?
For technology development, state aid schemes supporting various TRL projects, focused on decarbonisation, financed by SK Recovery and Resilience Plan are implemented by the unit of the Government Office responsible for the creation and coordination of research and innovation policies (VAIA) and the Ministry of Economy Under the SK Recovery and Resilience Plan, as well as the Modernisation Fund, industry decarbonisation state aid schemes are implemented, providing the above BAT decarbonisation projects in ETS undertakings in the Slovak industry. However, both schemes, as supporting large full scale decarbonisation project, exclude pilot implementations and focus on industrialised technology solutions, achieving DNSH requirements (e.g. excluding fossil energy as main energy source).	

Table 6: Slovakia

Slovenia

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?
Slovenia is currently not operating any regulatory sandbox or planning to launch one in the future.	

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?
The Slovenian plan for decarbonisation and Scientific research and innovation strategy includes a significant support for research infrastructures as a trigger to test and scale up promising low-carbon technologies, as well as to enhance the competitiveness and sustainability of the process industry in Slovenia. The strategy includes a specific action plan for the development of research infrastructures, which defines the criteria, priorities, and funding mechanisms. The action plan also identifies the key research infrastructures that are relevant for the decarbonisation of the process industry, such as the Centre for Industrial Gasification, the Centre for Hydrogen Technologies, the Centre for Circular Economy, and the Centre for Sustainable Chemistry.	

Subsidies and specific financial schemes supporting industrial decarbonisation	Are you aware of the supporting schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for energy-intensive industries, recently approved in Germany or the Sustainable Energy Transition Incentive Scheme (SDE++) in the Netherlands? Are you evaluating the applicability of any of those schemes in your country?

I am not aware of any Slovenian supporting schemes for low-carbon technology development and deployment that are similar to the CCfDs or SDE. Slovenia does not have any specific policy instruments that provide direct financial support for low-carbon technologies in the energy-intensive industries. However, we do have some general supporting schemes that could facilitate the adoption of low-carbon technologies.

Foster new business models	Do you promote the symbiotic approach towards multi-actor, cross-sectorial and cross-value chain's collaborative schemes in the value chains where process industries operate? How? Could you please explain a specific case?

Slovenia does promote industrial symbiosis, which is a form of circular economy that involves the exchange of resources (such as materials, energy, water, by-products, waste, etc.) among different industrial actors to create mutual benefits and reduce environmental impacts.

Update of the National Energy and Climate Plan (NECP)	Can you provide an update on how your National Climate and Energy Plan will integrate the Set Plan objectives and especially, R&I investments in process industries?

The Slovenian National Climate and Energy Plan is a strategic document that sets out the objectives, policies and measures for Slovenia on the five dimensions of the Energy Union for the period up to 2030. The NECP is aligned with the Set Plan objectives, which are the EU's research and innovation agenda for the energy transition. The NECP includes several actions and initiatives that support the Set Plan objectives, such as increasing the investment in research and development (R&D) to 3% of GDP by 2030, developing and upgrading research infrastructures, especially in the areas of digitalisation, artificial intelligence and biotechnology.

Data acquisition and monitoring of R&I data	Do you use KPIs to monitor the progress of your roadmap/s? which are they? Please, include a description of how to collect and handle the data required to evaluate against the KPIs.
Slovenia does use KPIs to monitor the progress of its green transition roadmap/s. Some of the KPIs are the share of renewable energy sources in gross final energy consumption, the greenhouse gas emissions intensity of the economy, the circular material use rate, the recycling rate of municipal waste, the share of organic farming in total agricultural area.	
Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?
The Integrated National Energy and Climate Plan's (NECP) key objective is to increase the share of renewable energy sources in gross final energy consumption to 27% by 2030. The NECP identifies several priority areas for the development and deployment of renewable energy sources, such as biomass, biogas, hydro, wind, solar, and geothermal. As for the specific energy carriers of interest to the industries, such as green hydrogen and biomethane, the NECP declares developing a national hydrogen strategy, participating in the European Clean Hydrogen Alliance, supporting the development and implementation of pilot and demonstration projects for green hydrogen production and distribution, promoting the production and use of biomethane from biodegradable waste and agricultural residues, as well as the injection of biomethane into the natural gas network.	
Demonstrators and first-of-a-kind (FOAK) plants	Are there any special regulatory bottleneck/s or hurdle/s in your country, which limit the deployment of FOAK (e.g. permits, landfilling restrictions/interpretations, transport of materials, etc)? Could you introduce the case and challenges as well as the mechanisms you implement to overcome it/them?
The OECD Regulatory Policy Review of Slovenia to cover the assessment of non-financial impacts and recommends the introduction of preliminary impact assessments. The report also identifies challenges and areas for improvement in the regulatory policy and governance in Slovenia. The oversight functions are spread across different institutions, which may create fragmentation and duplication of tasks. The stakeholder engagement process could be more transparent and inclusive by systematically informing the public in advance of planned consultation.	

Table 7: Slovenia

Spain

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?

Spain is not operating any regulatory sandbox related to industrial decarbonisation.
The Spanish government is currently drafting a 3new Industry Law (“Ley de Industria”), which will substitute the current 1992 law. The draft is still to be adopted by the Council of Ministers as a legislative proposal to be sent to Congress.

Article 22 of the latest draft regulates for the first time in Spain regulatory sandboxes. These sandboxes could support pilot projects as well as the growth of collaborative environments and industrial ecosystems. Pilot projects should be sanctioned by the Council of Ministers, which could agree on derogations of relevant regulation for these projects, with a limited scope, space and timeline.

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?

The Hydrogen roadmap includes measures to support public research institutes like CDTI (Centre for Industrial Technology Development) and CNH2 (National Centre for Hydrogen), create a new excellence centre for energy storage. It also includes support for R&D in the private sector.
The Biogas roadmap also includes R&D support measures.

Subsidies and specific financial schemes supporting industrial decarbonisation	Are you aware of the supporting schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for energy-intensive industries, recently approved in Germany or the Sustainable Energy Transition Incentive Scheme (SDE++) in the Netherlands? Are you evaluating the applicability of any of those schemes in your country?

Yes, we are aware of these schemes and have started to analyse them.

PERTE Industrial Decarbonisation includes, as measure no. 3, a feasibility study of the applicability of CCfDs to support industrial decarbonisation in Spain and the possibility of launching a pilot CCfD scheme.

Foster new business models	Do you promote the symbiotic approach towards multi-actor, cross-sectorial and cross-value chain's collaborative schemes in the value chains where process industries operate? How? Could you please explain a specific case?

Collaboration between companies along a value chain was a key element of the PERTE model devised by the Spanish Ministry of Industry. In the first calls of these aid schemes, collaboration was compulsory. However, this condition added a great amount of complexity and deterred many industries from participating, so it has been relaxed in later schemes or calls.

Update of the National Energy and Climate Plan (NECP)	Can you provide an update on how your National Climate and Energy Plan will integrate the Set Plan objectives and especially, R&I investments in process industries?

The draft revision of the Spanish NECP (PNIEC) has integrated the SET-Plan objectives in its structure and its targets are aligned with it. Furthermore, measure 5.2 is "Implementation of SET-Plan".

Data acquisition and monitoring of R&I data	Do you use KPIs to monitor the progress of your roadmap/s? which are they? Please, include a description of how to collect and handle the data required to evaluate against the KPIs.

All roadmaps include quantitative targets and monitoring in some way. For instance, the Roadmap for on-site electricity consumption includes as measure no. 36 creating an "Observatory of on-site electricity consumption", but it has not yet been implemented.

Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?

Spain has published the following roadmaps related to energy supply since 2020:
Hydrogen roadmap
Biogas roadmap
On-site electricity generation roadmap
Energy storage roadmap
Off-shore wind and marine energy roadmap

Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?
The revised NECP will update many targets of these roadmaps and trigger their analysis and potential review.	

Demonstrators and first-of-a-kind (FOAK) plants	Are there any special regulatory bottleneck/s or hurdle/s in your country, which limit the deployment of FOAK (e.g. permits, landfilling restrictions/interpretations, transport of materials, etc)? Could you introduce the case and challenges as well as the mechanisms you implement to overcome it/them?
One of the most important hurdles in Spain is that permits take a considerable time to be approved. According to Spanish law, environmental permits are generally managed and awarded by the regional administrations, need stakeholder consultation and specific permits of municipalities affected.	

Demonstrators and first-of-a-kind (FOAK) plants	Can you update as a follow up from previous MLE meetings on the available programs to support companies to scale up from TRL 6 above TLR 8?
No.	

Table 8: Spain

Turkiye

Regulatory framework	Is your country operating any “regulatory sandbox”? If yes, please explain it. If not, are you evaluating to launch a “regulatory sandbox” in the future and in which domain related to decarbonisation of process industry?
No, our country does not operate “regulatory sandbox”. There is not a plan to launch in short term.	

Technology infrastructures	To what extent does the national roadmap/s include the support for research infrastructures as a trigger to test and scale up promising low carbon technologies?

Our roadmaps include recommended collaboration models for each RDI topic where the relevant research infrastructures are mentioned.

Subsidies and specific financial schemes supporting industrial decarbonisation	Are you aware of the supporting schemes for low-carbon technology development and deployment, such as Carbon Contracts for Differences (CCfDs) for energy-intensive industries, recently approved in Germany or the Sustainable Energy Transition Incentive Scheme (SDE++) in the Netherlands? Are you evaluating the applicability of any of those schemes in your country?

Yes, considering RDI supports, TÜBİTAK (the major public RDI funding organisation) introduced a novel RDI funding scheme for Decarbonisation of industry which combines grants and reimbursable finance for exploitation of green technologies in industry. Likewise, for emission taxes Minister of Environment, Urbanisation and Climate Change has introduce numerous schemes such as “Carbon Market”, National Emmision Trade System, etc.

Foster new business models	Do you promote the symbiotic approach towards multi-actor, cross-sectorial and cross-value chain’s collaborative schemes in the value chains where process industries operate? How? Could you please explain a specific case?

Yes, our platform supports (such as Industrial Innovation Networks (SAYEM)) comprise of multi-stakeholder, cross-sectoral consortia. (The support scheme was explained in Panel 2)

Update of the National Energy and Climate Plan (NECP)	Can you provide an update on how your National Climate and Energy Plan will integrate the Set Plan objectives and especially, R&I investments in process industries?

Data acquisition and monitoring of R&I data	Do you use KPIs to monitor the progress of your roadmap/s? which are they? Please, include a description of how to collect and handle the data required to evaluate against the KPIs.
We plan to prepare an implementation plan regarding our Green Growth Technology Roadmaps in which KPIs will be included.	
Complementary instruments	Can you update on the strategic plans related to energy supply of different energy carriers of use to the process industries (roadmaps in, among others, green hydrogen, biomethane, energy infrastructures, etc)?
Hydrogens technology Roadmap and Carbon Capture Utilisation and Storage Technology Roadmap have been prepared by TÜBİTAK Marmara Research Center. Relevant technological objectives have been included in recently announced Net Zero Energy Plan of Türkiye	
Demonstrators and first-of-a-kind (FOAK) plants	Are there any special regulatory bottleneck/s or hurdle/s in your country, which limit the deployment of FOAK (e.g. permits, landfilling restrictions/interpretations, transport of materials, etc)? Could you introduce the case and challenges as well as the mechanisms you implement to overcome it/them?
Demonstrators and first-of-a-kind (FOAK) plants	Can you update as a follow up from previous MLE meetings on the available programs to support companies to scale up from TRL 6 above TLR 8?
World Bank Türkiye Green Industrial Project TÜBİTAK will provide reimbursable financing for the scaling up of RDI results.	

Table 9:Turkiye

Annex III: Questions to industrial panel's participants

1. Is industrial performance (high productivity, reliable production, high quality etc.) a prerequisite for an industrial plant to be qualified for support and funding for deployment?

2. Are market studies/estimates about the new greener produced products a prerequisite? How is that linked to the needs by brand owners and their market foresights?

3. In which way does policy play an important role to support investment (tax incentives, regulation, regional support via infrastructure, …)? Are integrated, symbiotic systems like hydrogen valleys, Hubs4 Circularity of any help to feel embedded in a larger industrial ecosystem providing you more guarantee for future development and to be resistant against new unknown crises?

4. In your opinion, which funding mechanisms (financial support) would play a role and what kind of interaction between EC, national, regional fundings could maximise the impact of investing in a low carbon technology/plant?

5. In which way does the availability of resources (including energy) impact on the investment's life cycles? Do you start from a demand to create a supply, or do you want first an assured supply before you start investments? Can some underlying mechanisms be of help?

6. Do you see restrictions on deployment due to state aid rules and what could be changed to avoid these hurdles?

7. Would you high light other framework conditions that are of importance to help to make the transition from R&I to full deployment of large demo plants and, especially to full scale FOAKs?

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This Fourth Thematic Report from the Mutual Learning Exercise on Industrial Decarbonisation describes the framework conditions essential for the adoption and necessary innovation of low-carbon technologies in the energy-intensive industries. The report combines insights from twelve participating countries. It emphasises the importance of regulatory stability, innovative financing mechanisms, and the necessity of enhancing technology infrastructures and data sharing to accelerate the deployment of research and innovation solutions.

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