European Commission

Roadmapping for Green Transition through the Whole-of-Government Approach

Mutual Learning Exercise on the Whole-of-Government Approach

Fourth thematic report

PSF CHALLENGE

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Roadmapping for Green Transition through the Whole-of-Government Approach. Mutual Learning Exercise on the Whole-of-Government Approach

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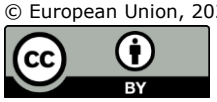
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EUROPEAN COMMISSION

Roadmapping for Green Transition through the Whole-of-Government Approach

Mutual Learning Exercise on the Whole-of-Government

Fourth Thematic Report

Edited by

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2024

Directorate-General for Research and Innovation
Horizon Europe Policy Support Facility

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1. Introduction

Within the framework of the Horizon Europe Policy Support Facility (PSF) the European Commission[1] in close collaboration with European Research Area and Innovation Committee (ERAC) delegates launched a Mutual Learning Exercise (MLE) on the application of a whole-of-government approach (WGA) in the design and implementation of national research and innovation (R&I) strategies and plans that foster the transformation of our key socio-economic systems towards sustainability. Bulgaria, Finland, Malta, Romania and Slovakia have committed to participate in this MLE. The objective is to develop a set of guidelines and recommendations for policymakers (European Commission, 2023b). A WGA ensures that R&I policies work in close synergy and are mutually beneficial with other sectoral policies. A more joined-up or systemic approach to policy making and implementation should cover the entire policy system at different levels of governance hierarchy that influence the introduction of WGA for R&I (Boekholt & Mulgan, 2023):

- Political leadership conducive to WGA;
- Policy reform to underpin WGA;
- Joined up strategy development (R&I and other policy domains);
- Coordination at the ministry/agency level and by multi-level governance mechanisms;
- Transformative policy instruments.

Earlier activities in this MLE have provided an overview of the WGA to R&I, explored new policy designs and instruments as well as new ways of actors' engagement[2].

This fourth thematic report focuses on green transition and the implementation of industrial technology roadmaps through the WGA and builds on the findings[3] from the MLE visit in Helsinki (Finland) on 25-26 September 2023. The topic is closely connected to industrial decarbonisation, which is addressed by another PSF MLE[4] (European Commission, 2023b) contributing to achieving the Green Deal objectives and following up on one of the actions of the first European Research Area (ERA) industrial technology roadmap. ERA Action 12 'Accelerate the green/digital transition of Europe's key industrial ecosystems', which aims to facilitate the development or update of specific national industrial technology roadmaps and

[1] A1 – 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 at Prosperity Directorate at DG Research and Innovation oversees the work on topic 4 of the WGA MLE.

[2] For more information about the MLE, please see: Mutual Learning Exercise on The Whole of Government Approach in Research and Innovation | Research and Innovation (europa.eu)

[3] The report benefitted from the contributions of other independent experts (Geoff Mulgan, Patries Boekholt, Susana Borrás and Wolfgang Polt, the quality reviewer (Alasdair Reid), the representatives of the participating MLE countries and the European Commission as well as other invited experts during the visit in Helsinki. Anyone interested in more information on WGA and green transition in any of the MLE WGA countries can find also further resources in Annex I.

[4] The MLE on Industrial Decarbonisation serves as a platform for 12 participating countries and runs between April 2023 and March 2024 (see for more detail, European Commission, 2023b). For more information, see the information: Mutual Learning Exercise on Industrial decarbonisation | Research and Innovation (europa.eu)

cross-sectoral strategies or programmes with key stakeholders as part of the ERA policy agenda 2022-2024.

While the green transition and decarbonisation roadmapping help focus discussion on how to apply WGA in practice, it also raises further issues to be addressed. For instance, how to enable more radical or disruptive *structural changes*, often entailing high uncertainty, needed to achieve the transition, or how to effectively *orchestrate industrial ecosystem* stakeholders amenable to turning visions into action?

This thematic report is **structured** as follows:

- Section 2 introduces the concepts and practices of roadmapping for transitions in connection with the whole-of-government approach.
- Section 3 delves into the governance of green transition and the role of decarbonisation strategies and roadmaps at the European and national levels as well as the development and implementation of sectoral roadmaps.
- Section 4 considers the practices and diverse sources for evidence-base and forward-looks in the WGA, especially in the realm of green transition.
- Section 5 broadens the scope of roadmapping to trigger the system change in the context of circular economy and discusses industrial ecosystem orchestration to align diverse interests and actions, thus moving further from the WGA towards the whole-of-society approach.
- Finally, Section 6 concludes the report.

2. Roadmapping and the whole-of-government for green transition

Technology roadmapping is applied widely to support policy planning, for instance in research and technology development. The success of roadmapping has been largely based on its flexibility, being applicable to different sectors and organisational settings (Phaal et al, 2004). Increasingly, roadmaps are also developed for major socio-technical systems changes or technological transitions (McDowall, 2012). Industry transition roadmaps are long-range strategic plans that set out actionable measures on innovation, policy, public-private partnerships and the finance required to transform industries (Johnson & Talebian, 2023).

From this variety of approaches, a set of core practices of roadmapping can be identified (adapted from McDowall, 2012):

- They are goal-oriented strategic plans with a clear timeline, showing the paths or routes to reaching specific goals (Leitner, 2023). They describe the current status of a technology and set out a view of the future of a technology, including the possibilities for its development and deployment.
- Roadmaps identify the major players in the innovation system and provide an outline of the industry or emerging innovation network. Roadmaps support the alignment of activities in industry and are particularly helpful in reducing uncertainty and providing direction to different organisations. A roadmap can help to align the activities of different actors and is also crucial for research, technology and innovation policy to base decisions on a commonly agreed plan (Leitner, 2023).

- They identify needs and priorities, including R&D needs, and sometimes market and regulatory needs, such as codes and standards.

- Those produced at the sectoral level (rather than by individual firms) aim to offer a consensus view of the way forward. As a result, they are almost always collaborative, or at least consultative, in the sense that they include the views of different teams, groups and stakeholders.

- Roadmaps are often constructed as time-based charts with multiple layers that include technology push and pull perspectives (Könnölä, 2007). They are frequently, but not always, depicted graphically.

- Many roadmaps, but by no means all, involve regular updates and monitoring of progress against milestones and targets.

The scope of the roadmap and the strategic context needs to be defined in a preliminary stage. The time horizon, the boundaries, purpose, the target groups and the governance approach (e.g. steering committee) are defined. Specific areas (e.g. industrial decarbonisation) or value chains (e.g. for circular economy) need to be defined in collaboration with the contracting authorities of a roadmap. The entire process is highly participatory and involves the engagement of various experts from different areas and countries, and from industry, academia/research, intermediaries, interest groups and policy (Leitner, 2023; Miedzinski et al., 2019). Roadmapping guidelines offer also some general steps to follow to develop a roadmap (IEA International Energy Agency, 2014; Miedzinski et al., 2019):

- They typically suggest starting with the *planning and preparation* phase, which includes scoping of the exercise, data analysis and research for already existing strategies and projects as well as the selection of methodologies to be used.

- In the next step, the *visioning* phase focuses on formulating a generic vision (for instance a national or regional vision). Policy goals, for instance on climate change, the EU's 2050 targets and the Paris Agreement, serve as important orientations. The generic vision serves as a basis for iterations leading to more specific sectoral or thematic visions.

- Based on the vision, *specific themes and topics projected in a timeline* with the short-, medium-, and long-term developments can be defined in a participatory process with different stakeholder groups and technical experts.

- Following a back-casting approach, the participants can be asked to define those projects that are required to reach the vision. Besides the definition of *R&D priorities and projects, specific policy measures and framework conditions* can be considered to achieve the vision.

In the course of the industrial decarbonisation MLE, further success factors specifically on industrial decarbonisation roadmaps have been identified (Vasara, 2023):

- Synergies: heavy industries[5] with significant climate impact are sometimes interconnected – moreover often also in conjunction with many light industries[6].

- Connected value chains: The strategic autonomy needs in practice, at least for many key parts, procurement roadmaps. Companies are responsible for their own procurement, but public/private-funded technologies need a strategic and broader view.

- Industrial installations: attention to technology readiness levels and production volumes.

- Resilient roadmaps: futureproof the roadmaps against disruptions.

- Data in the roadmaps: data for roadmap development on technological options, on impacts, costs, properties, connections and uncertainties, etc. This includes the data required for roadmap implementation monitoring. It is also worthwhile considering how the analysis of existing data could be improved through the application of artificial intelligence (AI).

The review by Miedzinski et al., (2019) on selected national and international policy and sectoral roadmaps with a focus on technology areas and societal challenges relevant for sustainability transitions provides further lessons. While there are good grounds for thinking that roadmapping can be a useful tool across several governance processes, they observe that current roadmapping practices tend to face challenges, in particular:

- Weak follow-up: failure to bridge vision with action;

- Limited link to experimentation (e.g. testing pathways);

- Weak embeddedness in the policy mix;

- Weak reflection on theories of change and pathways;

- Limited reflection on risks and uncertainties;

- Insufficient reflection on the governance of roadmaps;

- Limited focus on adaptability and learning.

Hence, the design and implementation of industrial technology roadmaps, especially for green transition, would benefit from further clarification (adapted from Miedzinski et al., 2019):

- Where are we? Policy roadmaps require a comprehensive and robust baseline analysis based on available data, evidence and expertise. Roadmaps should be based on an analysis of similarities and differences in the way different stakeholders perceive and understand the scope and nature of addressed challenges.

- Where do we want to go and with whom? It is crucial that among stakeholders a common direction can be agreed upon, so that all stakeholders have a feeling of co-ownership.

[5] The manufacture with energy or resource-intensive processes, e.g. oil and gas, steel production and mining.
[6] A diverse range of industrial sub-sectors in areas like food processing, textiles and consumer goods, which have less demanding energy needs than heavy industries such as steelmaking.

The commitments at the outset will help the implementation phase. Policy roadmaps can also be initiated and coordinated by industry or other stakeholders, other than policymakers (Box 3 and Box 7). Who initiates and calls for designing the roadmaps?

- Who defines the setting and participants? The transition challenges call for a high level of ambition. Green transition roadmaps may need to prioritise directionality over a search for horizontal consistency and coherence. If roadmaps are to become instruments promoting sustainability transitions, they may need to come with a mandate to disrupt the status quo and reorient the policy mix towards a shared vision.

- How do we want to achieve the mission and objectives? In this context, the WGA serves to explore how the roadmaps could address the multiple dimensions of industrial and societal transitions. How to develop and implement them in collaboration across departmental or sectoral boundaries together with a wider set of stakeholders. Who oversees the implementation (and its monitoring and feedback to policy)? Who will be in the driving seat for the roadmapping (government, industry or another stakeholder) is also relevant in terms of what approach is undertaken. This offers opportunities for horizontal and vertical alignment across the government and other stakeholders for the effective implementation of a roadmap (See an example in Box 1).

- What kinds of relations exist between roadmapping efforts at different levels (EU level, country level, project level? How the question of coherence between these levels can be achieved?

Green transition and inter-ministerial work in the digital compass roadmapping and monitoring in Finland

Finland's digital compass is a national strategic roadmap with a time horizon to 2030 that provides an overview of Finland's digital transformation and provides the direction for national development work. The coordination group for digitalisation is a permanent inter-ministerial working group tasked with strengthening inter-ministerial cooperation, coordination and flow of information. The coordination group for digitalisation has also been responsible for preparing the digital compass under the guidance of the Ministerial working group on developing the digital transformation, the data economy and public administration. Its duties include maintaining the digital, data and information policy situation awareness, i.e. the digital transformation portfolio. The objective is that the digital transformation and data economy development measures taken by the Ministry of Transport and Communications, the Ministry of Finance and the Ministry of Economic Affairs and Employment together form a coherent whole and create a shared situational picture. This helps to prioritise projects and enhance Finland's influence at the EU level.

The measures to be taken to put Finland's digital compass into action, and the investments they require, will be defined for each government term and updated annually between now and 2030. Decisions on national funding will be made as part of budgetary processes, and opportunities for the use of EU funding will also be explored. The coordination group for digitalisation is responsible for monitoring these measures and coordinating work between stakeholders.

With the help of compass, the ministries have a common vision of the future and can lead digitisation development across administrative and sector boundaries and support a systemic digital green transition. The digital-green transition requires a comprehensive change, which involves great opportunities for Finland. From the point of view of companies, it is an inevitable trend so that, in addition to the traditional risk and cost

perspective, sustainability is seen as a business opportunity and something that increases the company's value. Investors and financiers are increasingly allocating capital to sustainable projects because the sustainability of operations, for example in relation to climate change, affects companies' risks and thereby the development of value and profit potential. The compass outlines that Finland should promote the direction of funding towards a digital-green transition, both to achieve the goals regarding climate change and biodiversity, and to renew the economic structure.

Box 1:Green transition and inter-ministerial work in the digital compass roadmapping and monitoring in Finland

Source: (The Government of Finland, 2023)

3. Green transition: decarbonisation strategies and roadmaps

3.1. Roadmaps and decarbonisation in Europe

Reducing greenhouse gas emissions, especially from harder-to-abate industries, is crucial to achieving the goals of the Paris Agreement and pursuing efforts to reach net-zero carbon emissions by 2050. One way to achieve industrial decarbonisation targets is through industrial technology roadmaps. Industrial technology roadmaps help harmonise the technology development efforts and reduce uncertainty among the relevant actors including firms, business associations, research actors, funding agencies and investors, as well as ministries (Leitner, 2023). The first ERA industrial technology roadmap (European Commission, 2023a), published in April 2022, focuses on low-carbon technologies in energy-intensive industries. The roadmap:

- Evaluates the current state of technology and support instruments in the EU. The roadmap shows a gap in R&I investments compared to the emissions targets of the EU's Green Deal. The transition to a climate-neutral economy by 2050 requires transformation in all sectors and reducing emissions in energy-intensive industries, which accounted for 17% of the EU's total emissions in 2019. This is crucial to meet the EU climate goals.

- Indicates that some EU Member States have already created decarbonisation strategies and roadmaps for energy-intensive industries in partnership with relevant stakeholders. These strategies are important tools for designing a detailed process with milestones towards commonly agreed emission reduction targets.

The European Commission is also investing in partnerships with industry to address gaps and promote circular business models. These partnerships, such as the Clean Steel and Processes4Planet (P4P), include initiatives like the P4P Impact Panel and Hubs4Circularity to drive innovation and engage regions with heavy industrial presence in the transition to carbon neutrality (Leitner, 2023). Furthermore, the revised SET Plan[7] will aim to enable the EU to become a global leader in the development of innovative renewable energy technologies and to increase the EU's manufacturing capacity for clean energy technologies in line with the ambition of the Green Deal Industrial Plan.

In response to the challenges posed by Russia's war of aggression against Ukraine and disruptions in the global energy market, the European Commission introduced the REPowerEU Plan in May 2022. Under this plan, the Recovery and Resilience Facility (RRF)

[7] Communication from the Commission on the revision of the Strategic Energy Technology (SET) Plan, COM(2023) 634 final.

supports Member States in introducing critical reforms and investments to phase out the EU's dependence on fossil fuels and foster zero-carbon sources and energy resilience. The Commission also proposed a Net-Zero Industry Act on 16 March 2023 with clean tech objectives for 2030, focused on strategic projects and simplified permitting for new clean tech production sites.

Furthermore, a new REPowerEU chapter of the national recovery and resilience plan was proposed on 27 February 2023 as an amendment to the RRF Regulation 2021/241. An additional EUR 20 billion in grants will be made available to finance investments and reforms. Member States have included measures with a cross-border dimension and representing a minimum 30% of their REPowerEU chapter. For instance, Romania increases its resilience and energy independence by increasing the share of renewable electricity production, decarbonising the residential sector and industry, developing and digitalising transport capacities and training human resources for the renewable energy sector. Bulgaria, in turn, replaces gradually the carbon-intensive coal-fired power plants. Malta invests in large-scale electrification of road transport and in waste management. Slovakia develops alternative energy sources, building energy efficiency, sustainable mobility and green skills. The reforms and investment in Finland's plan will accelerate its digital transformation, research and investment in the green transition and promote employment and skills improvement, for instance. In this way, across Europe, the assessment and adoption process of the new REPowerEU is planned to be finalised for signing the financing and/or loan agreements in 2023. Payments under the RRF regulation can be made until December 2026 (Leitner, 2023).

3.2. National decarbonisation roadmaps and strategies

Industrial technology roadmaps are considered a valuable part of the new European Research Area (ERA) strategy (Leitner, 2023):

- They are designed to accelerate the transfer of research and innovation (R&I) results into the market to drive the green and digital transformation of industries across the EU. The roadmaps outline the way forward to better utilise industrial R&I results at the European and national levels.

- The European Commission, 21 Member States[8], three associated countries[9], and seven key stakeholders[10] have committed to supporting this effort, which also involves activities related to technology infrastructure, a policy framework to support industrial R&I and social adaptation to the green and digital transitions.

The MLE on Industrial Decarbonisation (European Commission, 2023b) with 12 participating countries[11] addresses the challenges of reducing carbon emissions and links R&I on industrial decarbonisation to National Climate and Energy Plans and the new REPowerEU chapter in the Recovery and Resilience Plans of Member States. The goal is the faster deployment of new technology, business solutions, and models to facilitate the transition to

[8] Austria, Belgium, **Bulgaria**, Cyprus, Czechia, Denmark, Estonia, France, **Finland,** Germany, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, **Slovakia**, Slovenia, Spain, and Sweden.
[9] Georgia, Israel and Norway.
[10] All European Academies (ALLEA), Committee of the Regions (CoR), European Association of Research and Technology (EARTO), European University Association (EUA), Science Europe, the Guild of European Research-Intensive Universities (the GUILD), and Universities of Applied Sciences for Europe (UAS4 Europe).
[11] Austria, Belgium, **Finland**, Georgia, Latvia, Lithuania, Portugal, **Slovakia**, Slovenia, Spain, Sweden, and Türkiye.

a climate-neutral continent, while also strengthening Europe's industrial sector (Leitner, 2023).

The first thematic report (Leitner, 2023) of the MLE on Industrial Decarbonisation gives an overview of industrial decarbonisation roadmaps and strategies at the national level, along with the initial ERA industrial technology roadmap. After presenting selected findings of the ERA industrial technology roadmap, an overview of lessons learned from past roadmapping exercises is given. A survey conducted on the MLE on Industrial Decarbonisation countries in the thematic report reveals that:

- The decarbonisation technology roadmaps at the national level are aligned to varying extents and in different ways with the National Energy and Climate Plan (NECP);
- They typically address the process industries, particularly the energy-intensive industries, such as chemicals, iron & steel, paper & pulp and non-metallic mineral products;
- They define visions or strategic objectives and the time horizon varies between 2030 and 2050, some include also milestones;
- Most countries use long-term modelling exercises to define different trajectories, pathways and scenarios for industrial decarbonisation;
- They typically take into account specific regional conditions and needs, and natural and energy resources are considered in the course of the roadmapping exercise.

The advances in the WGA MLE countries are largely aligned with the above addressing national climate strategies and further operationalised to industrial decarbonisation in a format of strategies or roadmaps:

- In Bulgaria the National Development Program 2030[12] contains specific sections on 'Transition to a circular economy' and 'Transition to a low-carbon economy'. The main goal is to reduce the resource intensity of the country's economy and increase the efficiency of the materials used. In particular, actions will be taken to increase resource productivity throughout their life-cycle and the rate of circular (secondary) use of materials in the economy, to stimulate product life extension, to reduce waste and control the need to extract new resources. Bulgaria has also its National Hydrogen Development Roadmap[13] to set as a reform in the National Recovery and Sustainability Plan (NRSP).
- In Finland, the National Climate and Energy Strategy[14] outlines measures by which Finland will meet the EU's climate commitments for 2030 and achieve the targets set in the Climate Change Act for reducing greenhouse gas emissions by 60 per cent by 2030 and being carbon neutral by 2035. Sector-specific low-carbon roadmaps have been developed (see Box 3). A recent study[15] also explored needed skills for green transition at all levels of education, in all forms and programmes. In particular, there is a need to

[12] https://www.minfin.bg/en/1394
[13] https://www.mig.government.bg/reforma-c4-r7-razgrasthane-potenciala-na-vodorodnite-tehnologii-i-proizvodstvoto-i-dostavkite-na-vodorod/
[14] https://julkaisut.valtioneuvosto.fi/handle/10024/164323
[15] https://julkaisut.valtioneuvosto.fi/handle/10024/164892

emphasise the role of transformative learning, challenging current practices, skills and structures, as part of building the knowledge base for the green transition.

- In Malta, 'the National Strategy for the Environment 2050'[16], with its strategic goal of 'Enabling and Empowering the Required Green Transition', supports the implementation of multi-faceted responses for green transition. Malta is in the process of implementing the Low Carbon Development Strategy'[17], which sets Malta's commitment to move towards a low carbon and climate-resilient socio-economic growth. 'Malta's Sustainable Development Vision for 2050'[18] the government will ensure that all individuals seeking to upskill would have access to courses which are tailored to meet emerging industry needs.

- In Romania, as part of the broader decarbonisation strategy, the government has published the norms for the decarbonisation of the Energy sector[19]. Romania is also preparing its long-term strategy[20] for decreasing its GHG emissions and has several related sectoral strategies related to green transition. The National Recovery and Resilience Plan and other EU financing programs (including the Modernisation Fund) serve the objective of accelerating the uptake of new low-carbon and other green technologies. There are many funding lines aiming at energy efficiency in buildings and industry, renewable energy sources adoption and use, hydrogen generation, storage, transport and use, deployment of battery energy storage systems (BESS), etc.

- In Slovakia, the National Energy and Climate Plan has been published. Up-skilling aimed at accelerating the uptake of new low-carbon and other green technologies is integrated in the roadmaps and strategies. Specific allocations for these areas can be found in the REPowerEU chapter of the National Recovery and Resilience Plan. Similar approach is planned for the ESIF allocations for S3. Together with OECD, Slovakia developed 'Closing the loop in the Slovak Republic; A roadmap towards circularity for competitiveness, eco-innovation and sustainability'[21] identifies and analyses three areas where circular economy policy would be particularly impactful: the use of economic instruments to promote sustainable consumption and production, the construction sector and the food and bio-waste value chain. It also proposes more than 30 concrete policy recommendations supported by an implementation plan and a monitoring framework. Implementing these recommendations can also help the Slovak economy reach its climate change mitigation objectives.

3.3. Sectoral decarbonisation plans and roadmaps

To operationalise national roadmaps, they need to be further detailed in different thematic areas and industrial sectors as well as adapted to different levels of the government, especially to regional and local governments. The implementation may also require

[16] https://era.org.mt/wp-content/uploads/2022/09/National-Strategy-for-the- Environment-2050-%E2%80%93-Public-Consultation-Draft.pdf
[17] https://unfccc.int/sites/default/files/resource/MLT_LTS_Nov2021.pdf
[18] https://meae.gov.mt/en/Public_Consultations/MSDEC/Documents/Malta's%20Sustainable%20Development%20Vision%20for%202050.pdf
[19] Emergency ordinance, No 108 of 30 June 2022 on the decarbonisation of the energy sector, https://legislatie.just.ro/Public/DetaliiDocument/256928
[20] http://www.mmediu.ro/app/webroot/uploads/files/LTS%20-%20Versiunea%201.0%20-%20Eng%20-%2005.05.2023.pdf
[21] https://www.oecd-ilibrary.org/environment/closing-the-loop-in-the-slovak-republic_acadd43a-en;jsessionid=irtl-2njix2noyFHV5-zn-dllCx8DkaI-kZEgDFW.ip-10-240-5-10

restructuring the responsibilities between ministries and dismantling of governance structures that hinder implementation (Box 2).

Austrian WGA governance structures and initiatives for industrial green transformation

In Austria, the WGA to the transformation of the industry has been brought under one ministry, the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK). Not only does the BMK set the course for a sustainable and climate-friendly policy and economy, but it also regulates and manages transport on Austria's roads by land, air, water and rail, ensures energy supply, promotes research and the provision of innovative technologies "Made in Austria" and implements the mobility of the future today.

This integrated governance structure facilitated the development of a Joint Action Plan (11 largest industrial companies and BMK) for the transformation of industry as well as a new funding instrument combining R&I and investment and targeted to be flexible, avoid over funding and guarantee long-term planning of investment decisions. BMK launched a dialogue process with the industry to create the joint action plan, which helped to build a common understanding of the paths of the energy-intensive industry towards climate neutrality. Furthermore, necessary framework conditions for decarbonisation in the national and European context shall be discussed on an ongoing basis and action plans for industrial transformation shall be specified further.

Furthermore, a detailed study on industrial GHG emissions provided the basis to define the actions needed for achieving GHG emissions targets. The study shew that Austria must reduce GHG emissions 61% by 2030 to be on track to carbon neutrality in 2040. Transformation must be initiated now given the long investment cycles and plan operating cycles and the transformation of industrial processes require early planning reliability, development of technologies and the replication and upscaling of technologies including climate neutral production plants. Austrian Industry is responsible for 37% CO2 emissions. Large parts of the emissions are concentrated in the production of a few goods (Iron & steel production is by far the largest emitter). Total investment costs of the decarbonisation lie between 5.6 and 11.2 billion Euro (excl. OPEX).

Such work has been coordinated in BMK by the cross-department working group on the industry in Directorate General – Innovation and in the cross-directorate working group on the transformation of industry as well as good cooperation with the Federation of Industry and Chamber of Commerce. However, the alignment with actions in other ministries remains to be challenging.

Box 2:Austrian WGA governance structures and initiatives for industrial green transformation
Source: Presentation of Susanne Meyer[22]

In Lithuania, a strategic analysis was conducted to identify synergies and avoid overlaps between three roadmaps: i) Lithuanian Industry Digitalisation Roadmap, ii) Roadmap for the integration of the Lithuanian industry into European value chains and iii) the first vision of the Lithuanian industry based on the principle of co-creation and partnership. This served to

[22] Presentation by Susanne Meyer, 'WGA policy and funding initiative for industrial transformation in Austria, in the country visit to Finland of the MLE WGA on Green Transition: Implementation of Industrial Technology Roadmaps through the Whole-of-Government Approach, September 25, 2023. The mentioned study: AIT (2021): Climate neutrality Austria 2040: contribution of the Austrian industry. Furthermore information, https://www.bmk.gv.at/en/ministry/organisation.html

engage ecosystem actors to identify shared priorities and visions as well as recommendations for further action.[23]

The private sector can play a key role in green transition and decarbonisation, (see an example from Finland, Box 3). Also in Bulgaria, the private sector has taken a proactive role as a major driver for green transition[24]. Furthermore, in Austria, eleven large industrial companies have drafted a Joint Action Plan with the Ministry for Climate Change for industrial transformation, to contribute to the Austrian plan to be climate-neutral by 2040.[25] It is relevant to consider also the challenges faced by the companies pioneering the green transition (see Box 4).

Sector-specific low-carbon roadmaps in Finland

The objective of a carbon-neutral Finland by 2035 was announced in the government in 2019 stating that sector-specific roadmaps to low-carbon operation would be prepared in cooperation with the sector's operators. The roadmaps were to be used to achieve a better understanding of the scale, costs, and conditions of the required actions.

A total of 13 sectors26 produced their own roadmaps in coordinated cooperation. In addition, bio energy association and one labour organisation published reports to contribute to the roadmap project. The sectors had independent control over the drafting and execution of their roadmaps.

In addition to project managers and steering groups assembled by the sectors, consultants and trade association committees were particularly important actors. Some sectors also organised workshops, discussions, avenues for comment, and member surveys to enable them to extensively listen to their membership and stakeholders. Each of the core sectoral roadmaps contain their own scenarios and models. The same consultant and core team was engaged across the roadmaps, leading to some comparability between roadmaps.

The Ministry of Economic Affairs and Employment (MEAE) supported the sectors by coordinating the whole project, offering guidance, and arranging regular discussions and seminars. Additionally, the sectoral ministries participated in monitoring the roadmap efforts and/or the utilisation of the results in their sectors.

The roadmaps show that the Government’s goal of a carbon neutral Finland in 2035 is achievable for industry and other sectors with existing or upcoming technologies. However, the realisation of roadmaps requires that the investment environment is favourable.

[23] The presentation of Erika Tauraite-Kawai, ‘Synergies in interministerial work in roadmapping in Lithuania’, in the country visit to Finland of the MLE WGA on Green Transition: Implementation of Industrial Technology Roadmaps through the Whole-of-Government Approach, September 25, 2023.
[24] Presentation of Julian Popov, Minister of Environment and Water of Bulgaria, in the country visit to Finland of the MLE WGA on Green Transition: Implementation of Industrial Technology Roadmaps through the Whole-of-Government Approach, September 25, 2023.
[25] Presentation by Susanne Meyer, ‘WGA policy and funding initiative for industrial transformation in Austria, in the country visit to Finland of the MLE WGA on Green Transition: Implementation of Industrial Technology Roadmaps through the Whole-of-Government Approach, September 25, 2023.
[26] The roadmap project identified the energy, chemical, forest and technology sectors as the key industries in terms of greenhouse gas emissions. Other sectors included agriculture, bioenergy industry, commerce, construction industry, food industry food industry, hospitality industry, logistics and transport, property owners and developers, sawmill industry and textile industry.

The results of the roadmap work have been utilised in the preparation of the Government's climate and energy policy, the targeting of R&I investments and the preparation of a sustainable recovery.

Several roadmaps were aimed at the companies in their sector, but also at policymakers, and hence the follow-up plans not only concern the development of the sectors' readiness, but also that of the external operating environment. Typical plans concerned promoting deployment, reaching SMEs, continuing cooperation between the industries, and utilising existing tools (e.g. energy performance contracting) to follow up the roadmap. It was difficult to ensure that there is no double counting of emissions reductions, which was addressed by keeping resource allocation books. Furthermore, the ledger was made on resource use across the sectors by consultants for the viability of the roadmaps.

All in all, the sectors coordinated the development of their roadmaps internally by engaging with and listening to different operators at different stages of the process. Across the sectors, it was easy to engage companies, but defining the scope of the roadmaps turned difficult, for instance with regard to how to address diverse value chains in the same sector, how to deal with related issues to decarbonisation, such as just transition and biodiversity, and how that would affect on the need to engage with different stakeholders. The sectors are themselves responsible of the monitoring of the implementation of the roadmaps. Some industries also stated that they would actively update their roadmaps and prepare supplementary publications. The roadmaps will be updated in 2023-2024, which offers an opportunity to extend the scope and take further into account aspects such circular economy, biodiversity and just transition.

Box 3: Sector-specific low-carbon roadmaps in Finland
Sources: (Paloneva & Takamäki, 2021) and the panel discussion[27]

A company perspective on the green transition

Exergi is the main utility company producing district heating in Stockholm, Sweden. After successfully transitioning from coal to bio-energy sources, since 2020 Exergi has embarked on a new and far more ambitious venture: Bioenergy Carbon Capture and Storage (BECCS). This technology captures CO2 emissions from biomass combustion and stores them, potentially resulting in negative emissions. BECCS plays a central role in IPCC mitigation pathways and Exergi has recognised an opportunity, but venturing into this uncharted territory presents numerous challenges.

One of the major challenges is the current regulatory environment. Firms in the BECCS operation value chain (like Exergi) need various, partly overlapping permits, i.e. permits for capturing CO2, transporting CO2, intermediate storage of CO2, and permanent storage of CO2. Operators need to obtain all these permits in Sweden and elsewhere, and they have highlighted that in this early stage, these permits take a long time to obtain. The operators hope that the public authorities will make the processes more predictable and standardised soon.

Exergi is considering options to store CO2 in Norway, which requires transportation from their capture plant to Norway. However, regulatory issues for a cross-border transport of CO2, as well as for permanent storage. This is a relevant matter for the BECCS value chain and for its pricing, and therefore financial investment. Exergi is hopeful that there will

[27] Panel discussion on Finnish industrial low-carbon roadmaps and implementation: public-private cooperation, in the country visit to Finland of the MLE WGA on Green Transition: Implementation of Industrial Technology Roadmaps through the Whole-of-Government Approach, 25 September 2023.

be cross-border policy coordination between the Nordic countries to secure a timely development of the components of the carbon capture and storage (CCS) value chain.

So far, there is no Nordic-level market-based cooperation to speed up the realisation of the Nordics' BECCS potential. However, the introduction of financial incentives for BECCS, has started to be introduced on a Swedish national level. In 2022, the Swedish government announced public financial support for BECCS technology in order of EUR 3 billion.

BECCS is a new and untested technology at an industrial scale, requiring substantial investments, and a market for selling carbon removal certificates (CRC) that does not exist yet. Though promising for reaching net zero targets in time, the viability of BECCS for Exergi depends on a supportive regulatory framework, cross-border cooperation, and the creation of a CRC market. To navigate these challenges, Exergi relies on creating an innovative organisational culture as well as mobilising external stakeholders. Hence, they seek to hire individuals with entrepreneurial mindsets and mobilise external expertise as well as creating strong networks and communication approaches. Yet, due to the rapid internal dynamics, some internal tensions have also come to the fore. Overall, Exergi's transition from coal to BECCS reflects the commitment to sustainable practices by an incumbent, and its willingness to seize new opportunities. The company's success in driving this transformation forward hinges on many events coming together, both external and internal to the firm.

Box 4: A company perspective to green transition
Source: (Kugelberg & Borrás, 2023)

4. Evidence-base and forward looks at the green transition

Green transition plans and roadmaps rely on available information and the current and future developments. Therefore, it is relevant to consider how such knowledge is collected and used. Langer et al. (2016) suggest a broad definition of *evidence gathering: "a systematic investigative process employed to increase or revise current knowledge*". The use of evidence contributes to good governance as it enables actors to evaluate, design and update public interventions. The evidence used to inform policy-making processes may be derived, for instance, from:

- Scientific evidence;
- Policy evaluation;
- Anecdotal observations;
- Opinions polls, each with varying strength of evidence (Acquah, 2020).

Sarvaranta et al. (2023) explore the future science for policy systems and highlight the need to complement the evidence base also with forward-looking perspectives of how policies might need to be readjusted in the future in the light of changing scientific findings or societal demands. Societal-challenge-oriented and mission-driven policy, especially for green transition, could integrate a science policy advice dimension within the missions. This should be backed by an effective monitoring, foresight and evaluation mechanism. Moreover, the employment of technology assessment and value-based co-creation of the missions with all stakeholders including citizens could give a direction to R&I as well as help to determine the characteristics of new technologies to some extent. This means that feedback to public policy is provided during the mission on an ongoing basis. The advice goes beyond R&I and

matters, as depending on the type of mission, other public policies such as regional policy and environmental policy need to be addressed. Hence, these other public policies will be better aligned with R&I policy. The feedback mechanism with public policy offers new ways of deliberating 'evidence' as transparent reporting by both policymakers and the actors of the missions (Sarvaranta et al., 2023).

The WGA calls for integrating knowledge from different sources and this requires building connections and relationships between actors from different scientific disciplines and across public administrations, affecting both the nature of science and the nature of politics (see Box 4). The practices between Member States vary, for instance, in Romania, the National Institute for Statistics is implementing a new set of indicators[28] to monitor the implementation of the National Sustainable Development Strategy. In Bulgaria, SZ REDA is implementing SITRANS project (LIFE+), of which activities include the preparation of an observatory related to green transition. In Slovakia, VAIA is developing an RDI project to improve foresight capabilities of the Government.

In Finland, the Prime Minister's Office of Finland coordinates and develops joint foresight work of the Government and of the Ministries. The focus is to bring future challenges and opportunities to be discussed, explored and decided together, to link futures work and strategic foresight to decision-making processes, to strengthen cross-governmental foresight work, to establish continuous strategic foresight processes in government. The main foresight processes are the Government Report on the Future and the Futures Reviews of the Ministries. The first Government Report on the Future was submitted to the Parliament in 1993. Since then, each electoral period, the Government submits a Government Report on the Future to the Parliament. To support the work on the report of the future, a complexity analysis tool[29] is used. The Ministerial Future Reviews, also done once each electoral period since 2002, provide information for forthcoming elections and government formation negotiations. Among other stakeholder engagements, citizen dialogues, e.g. in the last round with 500 citizens, were organised to explore hopes and fears about the future, and co-create preferred futures. Also, people from vulnerable communities, e.g. deaf people, immigrants, etc. were engaged.[30]

The joint report of Permanent Secretaries of the Finnish Government on green transition and economic growth

The Permanent Secretaries of the ministries drew up a joint outlook on key issues for Finland's next two government terms. The report aims to shift the focus from topical themes to a longer-term perspective. The Opportunities for Finland report published on 6 February 2023 provided a knowledge base for discussions around the elections this spring and for drawing up the next government programme. According to the outlook, the governments of the next two parliamentary terms will face five key challenges:

- The conditions for economic growth must be strengthened;
- Rapid progress must be made on the green transition;

[28] http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table
[29] https://parmenides-eidos.com/
[30] Presentation of Jaana Tapanainen-Thiess, 'The Whole of Government Approach in Government Foresight and Government Report on the Future', in the country visit to Finland of the MLE WGA on Green Transition: Implementation of Industrial Technology Roadmaps through the Whole-of-Government Approach, 25 September 2023.

- Equality and democracy must be strengthened;
- Further measures must be taken to improve Finland's security and resilience to crisis;
- General government finances must be better balanced.

The report focuses on how to address these challenges and considers what directions the solutions could take. The challenges and solutions described in the report are interconnected, both within Finland and beyond its borders. The most important thing is to work towards a balanced policy that advances different perspectives at the same time while also recognising the interdependencies between them. At the overall level, the report recognises a need to strengthen the perspectives of ecological and social sustainability alongside the economic perspective. In addition to these, the report highlights the role of security as a prerequisite for a stable and well-functioning society.

Box 5: The joint report of Permanent Secretaries of the Finnish Government on green transition and economic growth
Source: (The Finnish Government, 2023)

5. Roadmapping and system change: Ecosystem orchestration

The green (sustainability) transition calls for extending the WGA further by orchestrating the engagement of a wider set of actors beyond government entities in the joint development and implementation of transition strategies and roadmaps.

Research and policy efforts to address the transitions of highly complex societal systems (Schot & Steinmueller, 2018; Weber & Rohracher, 2012) point to the need to shift from market and system failures towards transformative innovation governance (Diercks et al., 2019). Könnölä et al. (2021) consider transformative governance to enhance the adaptiveness and resilience of the complex ecosystem as well as to orchestrate deliberate socio-technical transformation in society.

To align with the complexity of any systemic transition process it is worth extending the scope of an exercise to incorporate diverse stakeholder perspectives and searching for the interconnections, for instance, between technological, industrial, policy and social changes (Könnölä, 2007), see Table 1.

Dimensions	Examples of related concepts
Technological change	Dominant designs, emerging technologies, interoperability
Industrial change	Standards, interoperability, value chains and networks, organisational hierarchies and practices
Policy change	Regulations, economic instruments, governance, agreements, communication, coordination
Societal change	Behaviour, routines, preferences, values

Table 1: Multiple dimensions in transition roadmaps
Source: adapted from (Könnölä, 2007)

In the field of green transition and decarbonisation, (eco)system[31] innovation and system change concepts have also been applied by practitioner-based organisations such as EIT Climate-KIC (2018) and Forum for the Future (2023). For instance, Slovenia has been working with EIT Climate-KIC to reach circularity by mid-century through radical structural changes that must occur both rapidly and simultaneously on multiple fronts (see, Box 6).

Slovenia: Systems innovation for the transition to a circular, regenerative and low-carbon economy

In 2021, the Slovenian government signed an agreement with EIT Climate-KIC to participate in the Deep Demonstrations of Circular, Regenerative Economies, a programme that aims to introduce circularity by activating a coordinated portfolio of innovation actions in key economic sectors and selected value chains. Since then, the Slovenian government has articulated its vision of Slovenia as a European leader in harnessing circularity to transform and decarbonise its economy. The three-and-a-half-year project started by collectively mapping activities in the climate context, training and capacity building sessions; engaging multiple Slovenian ministries and local stakeholders from businesses, industry, research institutions, and local communities.

The participants identified food, forestry, mobility, construction, and manufacturing as five key supply chains that can be simultaneously transformed from three overarching dimensions: entrepreneurship, policy and education. The goal is to impact all five value chains in these three dimensions one by one to achieve real transformative change across the whole system by addressing the concrete and actual needs of ministries while focusing on the longer-term climate challenges that might not be visible yet but will impact the citizens in the future.

The deep demonstration focuses on systems innovation and creating a portfolio of interventions that will serve as a vehicle to drive Slovenia's national transformation to a circular economy. Using the research and stakeholder input from the first phase, in the second phase of the project, these portfolios will be created sequentially for each area (i.e. a selected value chain or sector) to focus initially on a smaller portfolio before being combined into an overall portfolio of interventions. The portfolio consists of:

Enhancing capacity building in systems innovation and circularity thinking to build a deeper systems mindset across a spectrum of stakeholders and further develop knowledge of systems innovation practice.

Developing a policy lab to enable policy experimentation and pilot innovation actions in the public sector. The lab will aim to create a 'sandbox' environment where policymakers and stakeholders can collaboratively design, prototype and test innovative policies.

Supporting research and academic institutions in the transition to a circular economy, as they are vehicles for knowledge transfer in society. The deep demonstration team is working with the Ministry of Higher Education and Science jointly with all Slovenian universities to create action plans for new strategies to incorporate the systems innovation and portfolio approach.

[31] The terms of systems and ecosystems are increasingly used interchangeably in the area of socio-economic research.

Developing a funding strategy and investment plan to unlock the potential of portfolio activation. With a balanced financial architecture, multiple funding mechanisms could be integrated into the portfolio to accelerate the outcomes.

Combining these interventions into a portfolio helps identify and understand interdependencies, causes and effects, unexpected consequences, obstacles and barriers to transformation, potential multipliers, change dynamics and ways to scale. Learning and decision making then take place at each level of the portfolio and across levels.

Box 6: Slovenia: Systems innovation for the transition to a circular, regenerative and low-carbon economy
Source: (EIT, 2022)

Green transition roadmaps may need to integrate and seek synergies and combine in the roadmapping work exploratory scenario work (vision and pathways); a strategic planning and vision-building. Importantly, the connections between vision, pathways and planning should not be conceived as only linear; the design of a roadmap should allow for iterations between these elements (e.g. quantitative targets may be adapted based on assessing feasibility of innovation pathways) (Miedzinski et al., 2019).

Thus, transition roadmaps, at best, provide a strategic framework of action promoting a shared vision and directionality by promoting inter-ministerial policy learning environment, alignment of key stakeholders and seeking synergies between policy instruments to achieve the transition (Box 7).

The Finnish roadmap to a circular economy 2016-2025

In 2016, Finland prepared a national roadmap to a circular economy under the leadership of the Finnish Innovation Fund Sitra32. The roadmap created a platform from which to launch and advance circular economy initiatives throughout the country, while ensuring that Finland's population possesses a shared understanding and the tools to co-ordinate the transition.

The result was a unique combination of strategy, purpose and an action plan. In the roadmap, there is a strong emphasis on public-private collaboration and, as Finland is a small country, it is not only intended for policymakers but also for municipalities, companies and citizens. The roadmap to a circular economy is designed to be updateable.

In 2019, Sitra launched an update titled 'Critical Move – Finland's Roadmap to a Circular Economy 2.0'. Its goal was to chart Finland's development, raise the level of our ambition, accelerate the change and connect the circular economy to climate change mitigation as a possible solution.

Winning solutions are not simply created using the old way of doing things, but rather by demanding diverse co-operation between the public, private and social sectors and by persevering with effort and commitment. The roadmap acts as a 'wake-up call' and guide for the future-focused thinking of the circular economy's central interest groups. The roadmap also acts as encouragement for the actions outlined in the government's circular economy programme and has already influenced law-making.

[32] Sitra is an accountable and independent future-oriented fund that is influential nationally and internationally and acts as a think tank, promoter of experiments and operating models and a catalyst for co-operation. In being accountable to Parliament, its future-oriented work is funded with returns on investments based on endowment capital received originally at the behest of Parliament, see www.sitra.fi.

Related guide: How to create a national circular economy roadmap (Järvinen & Sinervo, 2020)

Box 7:The Finnish roadmap to a circular economy 2016-2025
Source: (Sitra, 2023)

The circular economy roadmaps of Sitra provided the basis for the development of the Strategic Programme for a Circular Economy. In the preparation process, the following innovative tools were used: i) a broadly-based steering group with a well-recognised chair, ii) a citizen panel with 50 members and a web brain-storming, iii) special hearing of the science panels, iv) an ex-ante evaluation of the programme, and v) during the implementation a ”cooperation group for a circular economy” with some 30 members have been following up the process and discussing key topics. Still, the process suffered from the lack of common definitions, and gaps in scientific knowledge and institutional structures to support the upscaling. Moreover, the three Ministries involved (i.e., Environment, Economy, Forestry and Agriculture) entered the process with different points of view and it was not easy to reach consensus and to achieve a clear political mandate.[33]

According to the evaluation of the programme: “the measures of the programme are diverse, and there are significant opportunities related to the key projects. However, in the measures the focus is on incentives related to the development of new solutions, while hardly any measures are targeted to dismantling the structures that slow down the progress of the circular economy. Overall, the mandate for the strategic programme and its implementation is insufficient.”[34] This example suggests that, in general, it is difficult to agree on and implement cross-sectoral strategic programmes, because public sector organisations think about their own areas, and have their budgets. Therefore, the implementation often happens in a very decentralised, horizontal way.

Alternative approaches to coordination challenges of strategies and roadmaps vary across Member States. In Romania, the Inter-ministerial Committee for Climate Change, coordinated by the Prime Minister), has a key role in planning and monitoring of the implementation of the different policy roadmaps and the flow of information and awareness.

In Malta, the governance framework of the smart specialisation strategy (S3) involved the setting up of Committees representing each of the six thematic areas outlined in the strategy. The committees are comprised of members representing each of the quadruple helix sectors with the idea of maintaining an ongoing entrepreneurial discovery process. Furthermore, due to the thematic overlaps and stakeholder representation, the committees have a broad overview of the local economic ecosystem and can provide recommendations to incentivise innovation activities that enable the green transition. The S3 strategy is also important for governing Malta’s R&I investments and engaging the industry and other stakeholders in Malta.

In Bulgaria, the governing body of the climate programme is the Ministry of Finance. Furthermore, depending on the measures, different ministries are involved in the implementation. At the regional level, for example, Stara Zagora Regional Economic Development Agency implements a cluster of decarbonisation projects in the largest coal region in Bulgaria. In Slovakia, the efforts are more fragmented with ministries having their

[33] The presentation of Annukka Berg, ‘Green transition in Finland: the preparation and implementation of the national circular economy strategy, in the country visit to Finland of the MLE WGA on Green Transition: Implementation of Industrial Technology Roadmaps through the Whole-of-Government Approach, September 26, 2023.
[34] Evaluation of the Strategic Programme for a Circular Economy, 2023, https://ym.fi/en/strategic-programme-to-promote-a-circular-economy

analytical teams and institutes working on specific issues without a cross-cutting approach, whereas VAIA is exploring its role as a research and innovation authority and how to engage in joint planning and roadmapping with various stakeholders, including new innovative actors often lacking formal representation.

6. Conclusions

Governments tend to develop new strategies and roadmaps more than they manage to implement them, be it because of the change of governments or difficulties in agreeing on the implementation process. Furthermore, societal transition be it green, digital or both, requires a large number of actors across sectors and policy domains, which can be overwhelming and difficult to manage.

The WGA addresses such coordination challenges. The good practices identified in this report may offer some guidance on how to move forward. The engagement of key actors in the process of implementing the roadmap can help to create commitment into action. Sometimes, even the engagement of members of the parliament may be needed to ensure a sufficient mandate for the exercise. Furthermore, defining the right granularity and complexity in the roadmap aligned with the governance system at hand can be a key to success. Another option is to establish coordination structures for inter-ministerial work and agree on the shared responsibilities for implementation and follow-up. Alternatively, ministerial responsibilities can be restructured to bring the transition area under one ministry, as in Austria, and thus have more control of the whole policy cycle.

The examples discussed on industrial decarbonisation pinpoint the need for the engagement of industry actors to benefit from their competencies and resources to define and implement the actions. However, to prepare for future challenges the government needs to balance between selecting participants from the representative structures of current industries and from the emerging fields, for instance start-ups, research and technology organisations and civil society organisations. Further to exploring how to apply WGA in decarbonisation at the national level, also further coordination is needed between the EU initiatives and the national strategies/projects as well as cross-border cooperation to capture further opportunities.

In addition to participants and their coordination, it is relevant to establish at the outset a common understanding of the current situation and future challenges and discuss alternative scenarios of industrial trajectories to identify the most desired and viable pathways. What data and information is used and if all actors can trust and rely on it can influence heavily on the possibilities to agree on the targets and their implementation.

While this report has provided insights into various practices for advancing with roadmapping and WGA, it seems appropriate to conclude by providing a set of questions (see, Annex II) that can guide further discussion. They can help the reader assess the individual circumstances and reflect on the factors of success and failure when engaging in further dialogue with colleagues and national stakeholders to define shared visions and turn them into action for the green transition.

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Annex I: Further resources

Further resources on decarbonisation and WGA based on the PSF MLE Country Response Forms for the Preparation for the MLE visit to Finland on 25-26 September 2023.

Bulgaria

The National Development Program 2030, including sections 'Transition to a circular economy? and 'Transition to a low-carbon economy': https://www.minfin.bg/en/1394

National Hydrogen Development Roadmap, in Bulgarian only: Реформа C4.R7 „Разгръщане на потенциала на водородните технологии и производството и доставките на водород" - Министерство на иновациите и растежа на Република България (government.bg)

SZ REDA SITRANS project (LIFE+)

Finland

Finnish carbon neutrality strategy: https://julkaisut.valtioneuvosto.fi/handle/10024/164323

Finnish industrial decarbonization roadmapping: https://julkaisut.valtioneuvosto.fi/handle/10024/162851

Interministerial work in the digital compass roadmapping and monitoring, Finland including sections on green transition: https://valtioneuvosto.fi/en/-//10623/government-report-on-the-digital-compass-sets-the-course-for-finland-s-digital-transformation

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Annex II: Questions for countries to guide their thinking about WGA in implementing industrial technology roadmaps

Questions on the green transition industrial technology roadmapping and the whole of government

- Who initiates and calls for designing the roadmaps? Who defines the setting and participants?
- How to develop a comprehensive and robust baseline analysis for roadmaps based on available data, evidence and expertise, taking into account similarities and differences in the way different stakeholders perceive and understand the scope and nature of addressed challenges?
- How to agree among stakeholders on a common vision and direction so that stakeholders have a feeling of ownership?
- How to ensure the high ambition level and directionality of a transition roadmap without losing the buy-in of stakeholders?
- How to develop and implement roadmaps in collaboration across departmental or sectoral boundaries together with a wider set of stakeholders? How to structure the governance of horizontal roadmapping work (e.g. coordination groups with a rotating presidency)?
- What kinds of relations exist between roadmapping efforts at different levels (EU level, country level, project level? How the question of coherence between these levels can be achieved?

Questions on the current status and challenges of strategy and roadmapping work on green transition and decarbonisation.

- What national and sectoral roadmaps/strategies on green transition and/or industrial decarbonisation exist in your country/regions?
- To what extent have they been developed on an inter-ministerial basis?
- How far do they detail the scale, costs, conditions and responsibilities of actors for the required actions?
- Can you provide examples of data collection, evidence gathering, internal and external expertise that is helping the roadmapping exercise?
- Do they consider support for up-skilling aimed at accelerating the uptake of new low-carbon and other green technologies?
- Can you provide an update on your National Climate and Energy Plan? What progress has been made on national R&I investments in energy-intensive industries?

- Can you provide an update on your country preparation of the new REPowerEU chapter of the Recovery and Resilience Plan?

Questions on industrial low-carbon roadmaps and implementation: public-private cooperation

- What is needed to create a successful process of developing a sectoral decarbonisation roadmap? How does the process influence the resulting roadmap and its implementation? How can possible resistance/rivalry between industry participants be dealt with? How to ensure that the industry is well represented without being able to co-opt the process?

- What kind of challenges does the roadmapping work face and how can they be overcome both in the roadmap development and implementation?

- What is your experience in working with different ministries and government agencies, as well as other stakeholders, in developing and implementing roadmaps? What works well and what barriers should be avoided?

- How do you monitor implementation? Is there a shared responsibility for monitoring the progress? Who oversees the implementation (and its monitoring and feedback to policy)?

- Can WGA help to develop a policy mix of 'sticks and carrots' so that the outcomes are achieved?

Questions on the use of evidence and forward-looks in green transition

- How to integrate different sources of knowledge from across the ministries as well as from other stakeholders? How to validate the source and knowledge acquired for the common strategy work?

- How to incorporate in a balanced manner data-driven evidence-based and forward-looking stakeholder contributions? What decision mechanisms are put in place to decide between different technological solutions (weighing alternative scenario pathways?

- What kinds of governance practices facilitate the joint formulation of policy messages?

- How to prepare for possible readjustments in the future in the light of changing scientific findings or societal demands?

- How does mission-driven policymaking alter knowledge production and spearhead new practices of the whole-of-government approach?

Questions on whole of government approach in transition towards circular economy

- How to design and implement roadmaps as inclusive and participative processes, so that all stakeholders have a feeling of ownership?

- How does a coordinating body and its positioning in the national system affect the roadmapping or strategy work and its outcomes? For example, compare a prime minister´s office, ministry, or an independent think tank.

- How to develop roadmaps and strategies in a way that they are ambitious and disruptive when needed, but also inducive to turning vision into action?

- How to address risks and uncertainties in a way that leads to proactive and mindful action rather than paralysis?

- How to consider the future updates and adaptation to changes in the development of roadmaps and strategies?

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This thematic report is the fourth of the Mutual Learning Exercise (MLE) on the application of a Whole-of-Government Approach (WGA) to the design and implementation of national research and innovation (R&I) strategies and plans that foster the transformation of our key socio-economic systems towards sustainability. It provides the basis for discussion about green transition and the implementation of industrial technology roadmaps through the whole-of-government approach. While the green transition and decarbonisation roadmapping help focus WGA discussion on a specific context, it also brings up multiple further issues to be addressed, like how to enable more radical or disruptive structural changes, often entailing high uncertainty, needed to achieve the transition or how to effectively orchestrate ecosystem stakeholders amenable to turning visions into action.

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