Policy Avenues towards a Climate-Neutral Europe

Deliverable 4.1

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Abstract

This report develops four policy avenues for attaining climate neutrality in the European Union. Policy avenues are mixes of policy instruments, sequenced over time, and the institutional arrangements to deliver them. Departing from current EU climate policy, they sketch different pathways that the EU *could* follow to align its climate policy with the goal of climate neutrality by 2050. The policy avenues elaborated in this report were developed collaboratively with expert stakeholders in a series of interactive workshops (the policy lab) and elaborated by the research team. The present report describes the process of developing the policy avenues, describes the four different policy avenues in detail, identifies core instruments across the policy avenues, and discusses some general implications for transformative EU climate policy that were identified.

Content

List of Tables

List of Figures

Executive Summary

This report develops four policy avenues for attaining accelerated climate neutrality in the European Union. The policy avenues consist of a mix of policy instruments sequenced over time, and the institutional arrangements to deliver them. The four policy avenues developed here embody different design principles that follow from various traditions of (climate) policymaking. They thus sketch different pathways that the EU could follow in order to align its climate policy with the goal of climate neutrality by 2050.

The policy avenues elaborated in this report were developed collaboratively with expert stakeholders in a policy lab, i.e., a series of interactive workshops. Based on a comprehensive scoping of the academic and policy discourse, four 'policy paradigms' – approaches towards climate policymaking – were identified that framed the policy avenues. In a series of workshops – what we refer to as a policy lab – expert stakeholders developed policy avenues that embody the principles of each paradigm and applied them to EU climate policy. The resulting policy avenues were further developed and supplemented by the research team and are described in this report.

The four policy avenues are summarised below. They represent ideal-typical, alternative choices for the future of EU climate policy and are meant to map out the policy space. In reality, policymaking tends towards compromise, reflecting path dependencies as well as different and changing political majorities that have different preferences for choosing policy instruments. As a result, real-life policies will typically not be as internally coherent, and rather combine elements of different policy avenues:

- The **Green Economic Liberalism Policy Avenue** is based on redirecting market forces and private initiative to drive the transition to climate neutrality. Existing market-based elements in the EU's climate and energy policy mix – such as emissions trading – are strengthened and expanded, to achieve broader coverage and strong enough economic incentives. These market-based policies are accompanied by supporting policies where market coordination is not feasible, such as for infrastructure planning. The policy avenue builds directly on existing EU climate policy and therefore requires few institutional changes. The greatest barriers are political resistance to higher carbon prices – and refraining from interfering in the market if the carbon price should rise.

- In the **Green Industrial Policy Avenue,** the state actively builds a green economy to achieve climate neutrality. The policy avenue aims to foster breakthrough innovations in technologies that will be needed to reach climate neutrality and aims to scale existing solutions by accelerating their market diffusion. This will be achieved by substantially increasing public investments in research and development, manufacturing, and infrastructure as well as deploying effective standards that direct technological change

and stimulate investments. Some elements described in this policy avenue already exist in the EU today, but the state-guided intervention in markets in this avenue goes much further than the status quo. To achieve it, the EU needs capable, mission-oriented governance, along with sufficiently endowed institutions – as well as stronger centralisation of power, competencies, and financial resources in EU institutions. Neither of these will be popular with many member states.

- The **Directed Transition** Policy Avenue aims to foster technological change through active government intervention and the direct phase-out of fossil technologies. This includes the heavy use of EU-level targets, carbon budgets, sectoral pathways, and strict standards. By setting high-level targets and strategies but leaving member states room to experiment, this policy avenue is more decentralized than the previous. Another key element is the extensive use of review and update mechanisms to align climate neutrality strategies with the best available science. While the policy avenue can build on a strong tradition in EU policy of governing through targets and regulating via standards, the policy avenue takes this to a new level, making it the most interventionist of the four. Developing the required institutions, tools, and governance mechanisms to successfully plan and coordinate the transition will therefore be a central challenge, as market coordination is displaced by government coordination.

- The policy avenue **Sufficiency and Degrowth** aims to increase human well-being and address climate change by reducing material and energy use, including via methods that could reduce economic activity. This includes conventional instruments, like environmental pricing but also policies that reduce and redirect economic activity, like a four-day work week, the ban of emission-intensive technologies and activities like coal power or short-haul flights, and comprehensive social welfare reforms. By strengthening inclusive and participatory forms of political deliberation and localised action, this policy avenue would also involve governance innovations, and support decentralisation of power. It is a stark departure from existing EU and member states' policy because it would explicitly aim to influence social norms and lifestyles, which are currently only indirectly addressed in EU policies. The policy avenue would also go further than other avenues in challenging conventional thinking about growth and prosperity that is internalised across EU (economic) policies and institutions. Consequently, the political and institutional hurdles are the largest, and compared to other policy avenues there is less that this policy avenue could build on.

The policy lab highlighted several institutional and political challenges for transformative climate policy in the European Union more generally:

- All policy avenues rely on substantially increased public investments. This has implications for the EU's fiscal capacities and its fiscal rules, which currently restrict public investments. To extend fiscal capacities, the EU needs larger own resources and / or a

fiscal capacity akin to the Recovery and Resilience Fund that was established in response to the pandemic. For EU Member States to be able to borrow and invest more, the EU's fiscal rules would need to be reformed.

- The developed policy avenues have implications for the relative powers and competencies of the EU institutions and the application of the principle of subsidiarity. Many of the policy options proposed in the avenues would require a stronger centralisation of decision making at EU level. This relates, for instance, to matters of EU own resources, the unanimity requirement (for matters relating to taxation, energy, and infrastructure planning), and public procurement.

- Finally, the policy lab exposed path-dependencies and vested interests as barriers to policy change. Path-dependencies and institutional inertia make deep, transformative change more difficult and bias policy towards incrementalism and compromise. Another facet of this is the risk of regulatory capture that applies to all policy avenues: standards, investment programs, but also carbon pricing instruments are prone to be captured by incumbents. Likewise, phasing out support instruments or standards when they are no longer needed presents a challenge.

1. Introduction

Climate policy in the EU must switch gears from incremental improvements towards a transformative approach that fundamentally restructures the economy in line with climate neutrality (Görlach *et al.*, 2022). The European Green Deal expresses a transformative ambition to make Europe the first climate-neutral continent. However, it is unclear if the Fit for 55 package (as subsequently amended by the RePowerEU initiative) are able to deliver the transformative impulse needed to put the EU on the path to climate neutrality. No matter the answer to this question, the EU will have to double down on its efforts soon, designing policies for the period after 2030, and taking the 2040 target into view. In short, the EU will need to choose the policies that take the continent toward climate neutrality.

This report develops four policy avenues that describe distinct climate policy mixes for attaining climate neutrality in the European Union. Policy avenues are a mix of policy instruments and institutions that are sequenced over time. The four policy avenues follow different design principles that follow from selected traditions of (climate) policymaking. They thus highlight the different paths that can be taken by EU policy going forward and can inform decision-making. Moreover, the policy avenues will feed into the analytical work of this project.

The policy avenues were developed in cooperation with stakeholders in a series of workshops. Based on a scoping of the academic and policy discourse, four 'policy paradigms' – approaches towards climate policymaking – were identified that built the starting point for the policy avenues. Based on the paradigms and starting from the current EU policy mix, expert stakeholders developed policy avenues that follow the design principles of the paradigms and apply them to the challenge of making EU climate policy fit for climate neutrality. The resulting policy avenues were further developed and supplemented by the research team and are described in this report.

This report describes the four policy avenues and how they were developed. It is structured as follows. The next section describes the method and process. Section three describes the policy paradigms that build the starting point for the policy avenues. Section four then describes the four policy avenues in detail. Section five explicates the core policy instruments that emerged from the policy lab. Section six discusses the results and some of the main implications for EU politics and policy. Section seven concludes.

2. Approach

In this section, we describe the methodological approach taken. The first part describes the concept of policy avenues and the methodological approaches that underpin the policy lab: co-production and foresight. The second part describes the policy lab process in more detail.

2.1 Overall approach

This report presents four distinct policy avenues that were designed with a group of expert stakeholders in a co-creative process. Policy avenues are combinations of policy instruments and institutions. They describe plausible scenarios how current EU climate and energy policy could evolve to realise the EU climate goals.

The four policy avenues all share a common ambition that underpins this project: if the EU is to reach climate neutrality by mid-century, it must switch gears from incremental to transformative change. Transformative change can be distinguished from incremental improvements in terms of its depth, breadth, and speed (Fazey *et al.*, 2018). Görlach *et al.* (2022) characterise transformative climate policy is terms of four hallmarks: First, transformative climate policy thinks backwards from the end goal of climate neutrality and gears all policy decisions towards attaining that goal. Second, transformative climate policy must overcome existing path-dependencies and create positive path-dependencies that reinforce climate action. Third, transformative climate policy must come with governance arrangements that generate social acceptance, adapt to changing economic, political, and technological conditions, provide predictability to investors, and can withstand crises. Last, transformative climate policy must foster integration across sectors and embed technical changes in political and socio-economic processes.

The four policy avenues each follow and express a particular approach to policy design, what we refer to as a *policy paradigm* (see Section 3). Policy paradigms are frameworks for understanding the problem of climate change and how to respond to it. We selected four paradigms based on a comprehensive scoping of the academic and policy discourse. These policy paradigms provided the guiding principles and framework for developing the policy avenues. So, while the paradigms are abstract policy design principles, policy avenues are EU-specific policy mixes.

In addition to providing the framework of the paradigms, we applied the following conditions to the design of the policy avenues:

- They all must depart from the current status quo, i.e., the climate policy that is currently in force and under consideration. This includes the European Green Deal, Fit for 55, and RePowerEU.
- All policy avenues must have a plausible chance of delivering transformative change in the EU, as set out in the terms above.
- In addition, the avenues must emphasise how they address innovation, investment, infrastructure, and integration as the key challenges in the transformation to climate neutrality (Görlach *et al.*, 2022)

- Lastly, all avenues must be rooted in real-life EU politics and policies. This means that the goal of the exercise was not to start from a clean sheet but to acknowledge the political and economic constraints on decision-making in the EU.

Two methodological approaches underpinned the development of the policy avenues: co-production and strategic foresight. Co-production is "the participatory development and implementation of a research programme or project with stakeholders" (Watkins *et al.*, 2018, p. 3). The aim of co-production is to produce practice-oriented research. Specifically, the research design followed an output-oriented, instrumental approach to co-production, sometimes referred to as "bounded" co-production. The goal of bounded co-production is to translate the research into useful and usable knowledge for practitioners, but also to draw on the contextual and insider perspective of experts in the production of knowledge (Watkins *et al.*, 2018).

Foresight represents the second methodological approach that underpins this work. The OECD (OECD, 2019, p. 3) defines strategic foresight as the "structured and explicit exploration of multiple futures in order to inform decision-making." By accepting the deeply uncertain nature of sustainability transitions, foresight helps to explore alternative future scenarios and develop potential policy responses. According to the European Environment Information and Observation Network (EIONET, no date), "foresight typically involves systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building processes to uncover a range of possible alternative future visions." Given the participatory nature of foresight, we understand it as a form of co-production. The participatory process of foresight allows gathering context-specific information. In addition, foresight can enable the formation of common normative views of the future among policymakers and stakeholders.

The policy avenues were co-produced with the help of expert stakeholders in a series of workshops – what we call a policy lab. This participatory process had a clear foresight component: the goal was to develop alternative future scenarios for EU climate policy with expert stakeholders. The policy lab allowed the exploration of alternative possible policy futures. Another goal of the policy lab was to translate the abstract policy paradigms into concrete policy mixes that are EU-specific. Participants at the policy lab were all experts in (EU) climate and energy policy. The policy lab consequently added value to the literature review and identification of the paradigms through context-specific knowledge and concretisation. The process of the policy lab is described in more detail in the following section.

Co-production and strategic foresight is employed by ministries and policy agencies. For example, the European Commission's Secretariat General produces an annual strategic foresight report (see European Commission, 2022a). Likewise, both the OECD and EEA have ongoing strategic foresight programmes with a dedicated focus on the transition to climate neutrality. We consulted with both institution's foresight teams in preparation of the policy lab to improve our approach and anticipate challenges.

In future work, the construction of the policy avenues will be followed by a comprehensive assessment of core policy instruments and an integrated analysis the policy avenues. In this sense, the co-production also feeds into the research design going forward. This has the benefit of producing practice-oriented research that is relevant and can potentially inform decisions and decision-makers.

When interpreting this report and the results presented here, one should note some restrictions and caveats: As a co-creative process, the development of the policy avenues relied heavily on stakeholder input. These inputs were collected in an interactive process using a framing suggested by the authors – the policy paradigms. The results were subsequently interpreted further – filling gaps and eliminating apparent inconsistencies. The policy avenues consequently are a product that reflects the views of workshop participants as well as the interpretation by the authors of this report.

2.2 Policy lab process

The policy lab took the form of three workshops. The first and the third workshop were half-day, online workshops, while the third was a full-day, in-person workshop.

In total, about thirty experts participated in most of the three workshops. Participants were all experts on (aspects of) EU climate policy and came from policymaking, academia, industry, and civil society. Participants were almost equally men and women. In Annex A we list the participating institutions. Ahead of the first workshop, all participants as well as those invited but could not attend were asked to participate in a survey. The short survey asked for their assessment of EU climate policy and what they would consider as 'optimal' climate policy and helped designing the first workshop.

The first workshop introduced the structure and the objectives of the policy lab process. Moreover, it introduced the four policy paradigms and the four cross-cutting transformation challenges that the policy avenues need to address: innovation, infrastructure, investment & finance, and integration across sectors (the 4i's; see Box 1 for an overview). In a second step, experts discussed what they identify as the key characteristics and organising principles of the current EU climate policy based on the survey results.

The second workshop constituted the core part of the policy lab – a one day in-person workshop in Brussels. In this workshop, experts developed the four policy avenues in working groups. Each working-group was assigned one of the policy paradigms. Participants could freely choose their working group. The working-groups were assigned the task to come up with a concrete policy avenue that embodied their paradigm. A moderator guided the group through the process. Ahead of the workshop, all participants received background readings: description of the paradigms; definitions of the 4i challenge and transformation; a breakdown of what is needed to reach climate neutrality by 2050; and a list of policy instruments. The description of the policy paradigms was provided both as sober descriptions and as "personas" – fictional characters that represent the

paradigm. The list of policy instruments and both forms of the paradigms are available in the annex.

In the working groups the participants could first familiarise themselves with the task and the paradigm as well as arriving at a common understanding. As a second step, the groups identified the core and supporting instruments of their policy avenue. Following this step, they sequenced the instruments and discussed any necessary institutional or governance changes to realise the policy mix. In a fourth step, the group discussed how their policy mix addresses the 4i challenge and whether any adjustments must be made to their choices. Lastly, all working groups discussed the governance implications of their policy avenues. At the end of the day, all groups reconvened in the plenary for a gallery walk to present the policy avenues to the other groups.

The results were documented on posters. Moreover, minutes were taken to document the discussion in the working-groups. Between the second and the third workshop, the project team summarised the results of the second workshop in written form as well as on digital whiteboards (see Annex B). These summaries were then circulated among the participants ahead of the third workshop.

The third and last workshop was dedicated to scrutinising, reviewing, and validating results. Experts had the opportunity to discuss and assess the policy avenues developed by other groups. Moreover, the group discussed the implications of the policy avenues for the future of the EU, its institutions, and governance arrangements. Lastly, the workshop zoomed out and experts were asked what they consider as the most important levers and policy interventions for transformative change in the EU.

Box 1: The 4i challenges

Innovation – The transformation to a climate-neutral economy requires technologies and processes that are not yet invented or available at scale. Innovation in the 4i-TRACTION projects includes technological, business model, and governance innovation. It considers how to facilitate "technology push" and "demand pull" policies and focuses on innovations at higher levels of technological readiness.

Investment and finance - A climate neutral economy requires large-scale investments. For the investment and finance challenge, the 4i-TRACTION project seeks to identify specific instruments with a high transformative potential for mainstreaming climate issues in the financial sector by considering the role of financial supervisors and financial institutions. It also aims to develop proposals how the financial sector can contribute to the exnovation / phase-out of incumbent fossil technologies.

Infrastructure – Infrastructure is both an enabler to and a barrier for the transformation to climate neutrality – locking-in fossil technologies but also enabling clean ones. 4i-TRACTION seeks to understand what new infrastructure is needed for climate neutrality, which needs to

be upgraded, which can be converted, and which becomes obsolete. It considers how to support the co-evolution of infrastructure and technologies, and how physical infrastructure and regulation interact.

Integration – The transformation to climate neutrality requires the coordination of parallel processes. In the 4i-TRACTION project, 'integration' is understood both as *sector integration* – the economic / technical linking of different sectors through technological solutions – and as *climate policy integration* – the systematic integration of climate policy objectives across different sectors.

3. Paradigms of climate policymaking

This section describes the concept of policy paradigms and the four paradigms of climate policymaking we defined.

3.1 From schools of thought to policy paradigms

> "The ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed, the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influence, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back."
>
> - John Maynard Keynes (1935, p. 383)

As vividly spelled out by John Maynard Keynes, ideas matter for policymaking. According to the political scientist Peter Hall (1993, p. 280), "policymakers customarily work within a framework of ideas and standards that specifies not only the goals of policy and the kind of instruments that can be used to attain them, but also the very nature of the problems they are meant to be addressing." Hall refers to this framework for understanding and acting upon the world as "policy paradigms". He argues that they not always are a coherent and fully elaborate set of ideas. They moreover can change over time. Still, the web of ideas that policymakers hold will be consequential for the way they understand the problem, the options they see to address it, and the corresponding decisions they make. The influence of policy paradigms may be most consequential in "technical" areas of policymaking, that are dominated by technocratic expertise, such as monetary policy.

Policy learning and change in light of new information and experience is an important feature of the dynamically evolving climate policy landscape. Different ideas about the "right" kind of climate

policy are prevalent. These ideas have implications for policy design at multiple levels: they influence what regulation looks like, which criteria guide the choice of policy instruments and their design, and which criteria should be used to evaluate whether policies are deemed successful – but also, for instance, what the relative roles of government and private businesses should be, or which trade-offs to consider in policy formulation.

Whatever is the prevailing policy paradigm, its ideas will dominate the set of policy options. In their analysis of policy documents, Meckling and Allan (2020) show that economic ideas had been very influential in the climate policy advice of major international organisations (such as IMF, World Bank, OECD, etc.). In the 1990s, the notion was prevalent that there was a strong trade-off between economic activity and environmental protection. In terms of policy prescriptions, there was an emphasis on market-based instruments. This gave way in the mid-2000s to more affirmative approaches that saw strong complementarities between economic growth and environmental protection, influenced by Schumpeterian and Keynesian ideas. The current discourse according to Meckling and Allan (2020) is more open and diverse, which they see as a sign that climate policy entered a "post-paradigmatic" age.

Ideas do not simply trickle down from academia into policy. Shifts in policy paradigms will often coincide or be driven by political shifts, especially if they are linked to changes in government.[1]In the EU, for example, different ideas work in parallel and compete. This stems from the complex multilevel governance structure, the multiple institutions and treaties, and the diverse interests of its 27 Member States that have diverging world views. There are rarely incidents where one paradigm clearly dominates and shapes the political agenda for a given period – the turn to monetarism in many Western democracies in the 1980s is an example where shifts in (economic) thinking have had far-reaching consequences on policy and politics more generally (Blyth, 2002).

Apart from such critical junctures where policy paradigms are neatly replaced, policy tends to evolve more gradually. Legal, institutional, or economic path-dependencies strongly influence the development of future policy. Moreover, policies are the outcome of political compromises and reflect the relations of power just as much as ideas. As Oberthür and Hohemeyer (2022) show, the evolution of climate policymaking in the EU is not a clear succession of policy instruments, but rather a gradual layering of different policy instruments and measures in what they call policy "thickening". So, institutions and policies different paradigms may reflect different paradigms at the same time.

Here we start from the premise that applying different paradigms helps understanding in which directions the EU policy mix *could* evolve. To this end, we have identified four different approaches to climate policy from the academic literature and policy practices that we define as policy paradigms that seem to be relevant to European environmental policymaking.[2] These policy

[1] One example of this is the institutionalisation of the Cost-Benefit-Analysis for all (environmental) regulations in the US that was passed by president Ronald Reagan in his first year in office in an effort to remove regulatory burdens (Fuchs and Anderson, 1987).
[2] It is worth pointing out that these paradigms all have a strong "economic" imprint.

paradigms are all represented in policy and/or academic discourses, and in this sense offer a plausible and relevant trajectory for how EU climate policy could evolve. They served to provide the ideational foundation and design principles, based on which stakeholders then developed concrete policy avenues in the policy lab process.

We defined four policy paradigms based on a literature review and expert assessments of policy practices. In the literature, there is little consensus over how many competing paradigms exist, nor about where one paradigm starts and the other begins. Danny Cullenward (2019), for example, identifies two competing schools of thought of climate policymaking: one that prioritises carbon pricing and cost-effectiveness above all else, and one that advocates for regulatory strategies over carbon pricing. In a similar way, Rosenbloom *et al.* (2020) identify a carbon-pricing paradigm and an opposing paradigm they call "sustainability transitions policy", that includes various instruments and employs industrial policy. Mason (2021) juxtaposes a "Neoclassical" approach to climate policy based on carbon pricing to a "Keynesian" approach based on public investments. Weiss and Catano (2017) argue that "degrowth" has emerged as a new academic paradigm.

In sum, there is no ready-made classification of paradigms, which is why we defined our own policy paradigms based on a comprehensive review of the literature and expert assessment. To improve the robustness of our selection, we consulted experts from the 4i-TRACTION consortium and scrutinised different options in internal workshops. Moreover, the 4i-TRACTION External Advisory Board Commented on their selection and provided input.

Our paradigms are summarised in Table 1 and described in more detail in the following section. It is worth pointing out that the paradigms all have a strong economic imprint. The first paradigm emerges from neo-classical environmental economics. It generally emphasises cost-effectiveness in policy design and favours market-based instruments. Government action should be limited to internalising externalities, but not interfere in the markets' allocation of resources beyond that. The second paradigm encompasses several heterodox approaches to economic policymaking and mobilises industrial policy to transition to a clean economy. It stipulates that markets need a strong hand to deliver the innovation and outcomes desired. The third paradigm is a sibling to the second but more critical of markets as a coordination mechanism. It emphasises certainty and environmental effectiveness in its design of policy and focuses on phasing out fossil technologies as directly and fast as possible. In this way, it most closely identifies with a type of governance that economic textbooks would refer to (derogatorily) as "command-and-control". The last paradigm draws on ecological economics, post-growth, and de-growth thinking. It is much more sceptical towards technological innovation and its ability to solve climate change than the other approaches. Moreover, it negates the commensurability of climate action and economic growth and thus advocates for a planned contraction of economic activity.

The second and the third paradigm can both be related to transition theory, a collection of approaches to climate policymaking that is critical of a simple neo-classical view on climate change (e.g., Patt and Lilliestam, 2018; Rosenbloom *et al.*, 2020). They both highlight the societal

complexity and engage in a historical reading of technological change. Distinguishing where one paradigm starts, and the other ends is difficult. However, for the purpose of this exercise and at the risk of inviting criticism, we distinguish two subtypes of this transition approach: The first places greater emphasis on technological innovation (focusing on novel breakthroughs), and is ready to use market-based elements as a tool and private businesses as a partner to identify and scale such solutions. The other focuses on the fast deployment of *existing* solutions (and the equally fast phase-out of obsolete, fossil technologies), and is much more sceptical of markets as a coordination mechanism.

The function of these paradigms – and the policy avenues they give rise to – is neither to predict how policy *will* evolve (i.e., forecasting), nor to postulate how it *should* evolve. The function of the four paradigms is rather to structure the policy space in which EU climate and energy policy will likely (or conceivably) evolve, and to understand what implications this may have for policymaking. As pointed out above, real-life climate policy is complex, political, and will likely reflect elements of all four paradigms defined here.

In addition, we want to emphasise that the paradigms presented here are ideal-typical and serve a functional purpose. They do not aspire to be an accurate representation of a body of thought, also given that these bodies of thought are themselves heterogeneous: some of them extend back for decades and are documented in extensive scholarly dispute (e.g., economic liberalism, degrowth). Others are more recent streams and ideas, and despite their political significance may not be based on an equally elaborate body of literature and theory as others (e.g., climate emergency). Defining a paradigm and combining different schools of thought necessarily involves some simplification. In the effort to capture the gist of the paradigm (in its relevance for EU climate policy), it may therefore fail to capture all their nuances.[3]

[3] As argued above, real-life policy would typically represent a mix of different paradigms. Generally, policymaking would be more consistent if it was based on a coherent set of principles – ideas about what form policy should take and how it will achieve its goals. This would, at least in theory, yield a policy mix that is organised in a more coherent way around clear goals and assumptions, therefore less hampered by conflicting objectives and resulting distortions, and therefore more effective and/or more efficient in reaching its goals. However, the different competing paradigms are also based on assumptions about how policies (ought to) achieve their intended objectives, and are internally consistent *given these assumptions*. Therefore, the goal of this exercise is not to establish which of the paradigms yields a more or less accurate description of realities, but rather which trajectory results *if* the paradigm is followed.

Table 1 Overview of Policy Paradigms along core dimensions

	Neoclassical Environmental Economics	Industrial Policy & Mission Innovation	Planned Transition	Post-growth /degrowth
Primary intervention mechanism	Correct market failures	Direct and accelerate technological change	Provide certainty of emission reductions	Facilitate lifestyle change
Main criteria for instrument selection	(Static) efficiency Cost-effectiveness	Dynamic[4] efficiency; environmental effectiveness	Environmental Effectiveness	Environmental, intra-, and inter-generational justice Conviviality
Main instruments	Market-based instruments, carbon pricing	Investments, standards, innovation support	Direct regulation through bans, standards, quotas, targets, carbon budgets, and planning tools	Participatory and inclusive governance Bans, taxes, behavioural change
Political theory of change	Climate action at lowest cost generates political acceptance	Coalition building, create and mobilise constituencies	Political legitimacy of interventions derived from climate targets	Policies to change societal norms and values
Faith in markets	High	Medium	Low	Low

[4] There are two economic conceptions of efficiency: static and dynamic. Static efficiency tries to maximise the efficient combination of resources at a given point in time, that is, produce at the lowest cost *now*. Dynamic efficiency, in contrast, is concerned with the efficiency of production *over* time. That is, it is concerned with the improvement of technology and practices so that production becomes more efficient and cheaper in the future.

	Neoclassical Environmental Economics	Industrial Policy & Mission Innovation	Planned Transition	Post-growth /degrowth
Technological openness	High	Medium	Low	Low
Technologically optimistic	Medium to high	High	High	Low
Political disruption necessary	Low	Medium	Low	High

Notes: "Technological openness" refers to the extent to which the instruments make explicit technological choices and convey advantages to some technologies or energy carriers. For example, a tax credit for electric vehicles would be a technology-specific instrument. "Technologically optimistic" refers to the extent to which technology is seen as a solution to climate change, and that policies (or the market) will be able to deliver such technologies. That is, if is considered sufficient if clean technologies gradually replace dirty technologies or if deeper structural, behavioural, and societal changes are necessary to address climate change.

3.2 The four selected paradigms

3.2.1 Neoclassical environmental economics

The first lineage of thinking develops out of (theoretical) neoclassical environmental economics and has been a prominent in climate policymaking. It argues strongly in favour of a market-based approach to climate policymaking that aims to preserve and utilise market dynamics and private enterprise, but is generally cautious about too much government interventions (e.g., Nordhaus, 1992, 2007; Aldy and Stavins, 2012; Baranzini *et al.*, 2017; Bergh *et al.*, 2020). It conceives of climate change as a product of market failure, foremost resulting from the lacking or inadequate pricing of the external costs of GHG-emitting activities.[5] The goal of policy should therefore be to 'correct' markets by means of imposing a carbon price in order to reinstate an efficient allocation of resources.

The paradigm is based on the view that mitigation is primarily a cost that must be balanced with its benefits of reducing climate damages (see e.g., Nordhaus, 1992). Moreover, this cost is commonly modelled to be exogenous and fixed. Critics of this view argue that this does not match

[5] Framed positively, the theory would maintain that climate change would not be a problem if all social and environmental costs were internalised in market prices.

empirical evidence and mitigation costs are in-fact endogenous (Grubb, Wieners and Yang, 2021) [6] – mitigation may even lead to cost savings regardless of climate change (Way *et al.*, 2022).

How to prioritise in the selection of policy instruments in this line of thinking is well represented by Stavins (1997) who identifies two criteria for choosing policy instruments: relative efficiency and cost-effectiveness. Relative efficiency refers to the degree that instruments maximise net benefits, i.e., where the marginal benefits of reducing emissions equals the marginal costs of doing so. Cost-effectiveness, on the other hand, is achieved when all sources of pollution face the same marginal abatement cost (i.e., cost of reducing emissions) – as a result, if marginal abatement costs are equal across polluters, the mitigation effort is distributed in the most efficient way, and emission reductions achieved at least cost. According to Stavins (1997), market-based instruments that make use of market mechanisms to distribute the mitigation effort are – in principle – superior to what he refers to as 'command-and-control' policy instruments, because they are more cost-effective.[7] The two instruments most commonly associated with 'market-based' instruments both involve a mechanism to price GHG emissions: taxes and cap-and-trade (or emissions trading).[8] In the words of some proponents of this approach the main argument for carbon pricing is its "environmental effectiveness at a relatively low cost, which in turn contributes to enhance social and political acceptability of climate policy" (Baranzini *et al.*, 2017, p. 1). Whether a tax or an emissions trading system is superior is an ongoing debate within this paradigm (Weitzman, 1974; Aldy and Stavins, 2012a; Hassler, Krusell and Nycander, 2016). Likewise, are questions around the discount rate and the 'optimal' social cost of carbon still being debated.

The paradigm argues that the market-based allocation of resources and the coordination of production and consumption via price signals is superior to other forms of coordination. This is primarily based on assumptions about the epistemic primacy of markets, i.e., the believe that markets are better at processing decentralised information and allocating resources to the uses where it is has its highest utility (Hayek, 1945; Felli, 2015). Therefore, markets should determine where emissions are reduced and what activities can continue to emit. In turn, this means that government interventions should be limited to correcting market failures. One major market failure in this context is the external cost of GHG emissions; therefore, the solution is to internalise these costs by pricing GHG emissions – directly or indirectly. A second and related problem is that of collective action – since the atmosphere in its function as a sink of GHG emissions is a common pool resource and keeping the atmosphere intact a public good. Another argument for a limited and passive role of the state in climate policy, based on public choice arguments, are the perceived

[6] Due to effects of learning and economies of scale. But do note, that this view is disputed among neoclassical economists as well (see e.g., Acemoglu *et al.*, 2012).
[7] That is, assuming the absence of other problems and market failures, like transaction costs, information asymmetries, incomplete markets, market power, uncertainty etc.
[8] Beyond pricing carbon, there are also numerous other ways how market mechanisms can be utilised to achieve environmental outcomes, e.g., systems of tradeable quotas / renewable portfolio standards, trading of energy efficiency improvements (white certificates), auctions for renewable support, etc.

risks of government failure and rent-seeking that leads to an inefficient allocation of resources (see e.g., Helm, 2010).

3.2.2 Industrial policy and mission innovation

A contrasting paradigm emerges from what is referred to as 'heterodox' schools of economic thought, more precisely post-Keynesian, Schumpeterian, and Evolutionary economics but also other social science disciplines (economic sociology, political economy). As these schools of thought operate on different assumptions and models of the economy and socio-technical change, their policy preferences differ substantially from the preceding paradigm.

These lines of thought conceive climate change not simply as a singular market failure (of unpriced externalities) but as a much wider political and social issue. The underpriced social cost of GHG emissions is one of many interacting and overlapping market failures. Path-dependencies, institutions, infrastructure, and political lock-ins all constitute non-price barriers, which require dedicated solutions; merely correcting prices will not be sufficient to overcome these barriers (Patt and Lilliestam, 2018; Rosenbloom *et al.*, 2020). In addition, this paradigm also does not share the (neoclassical) assumption that market coordination is *a priori* superior to other forms of coordination, especially when it comes to a major transformation of the economy (Mason, 2021). Instead, climate action is regarded as a source for economic growth and non-market coordination as an important complement to market-coordination. Technological change is seen as endogenous to the economic process and policy (Pollitt, 2019; Mason, 2021). The economic process itself is primarily demand driven, which has important implications for policy.[9]

It argues that governments must actively shape and direct markets to create structural change towards a climate-neutral economy. This active effort on part of governments to change the composition of their economies is usually referred to as 'industrial policy', and the intent to transform the economy into a climate-neutral one, 'green industrial policy' (Allan, Lewis and Oatley, 2021; Nahm, 2021a).[10] Green industrial policy tends to focus on innovation and investment-led change.

There are numerous arguments for why governments should pursue industrial policy. Classical arguments involve different market failures such as knowledge spill-overs from research and associated free-riding effects, coordination failures among different actors across the value chain,

[9] While the principle of *effective demand* is a central tenant of post-Keynesian approaches, it can be argued to be compatible with evolutionary or Schumpeterian approaches that focus more on the 'micro' of technological change to the extent that the latter also explain economic dynamics as an endogenous product of the economic process itself. They thus highlight the role of learning in production and demand-pull effects in innovation.

[10] For a slightly different definition of GIP, see Tagliapietra and Veugelers (2020, p. 14) where GIP is "industrial policy in which climate change becomes a binding constraint in achieving the social welfare goal."

or information externalities (Tagliapietra and Veugelers, 2020).[11] Post-Keynesians and evolutionary economists moreover stress that production and its underlying process and technologies develop over time through the economic process as such, industrial policy can thus induce dynamic scale economies and processes of learning (in production) (Chang and Andreoni, 2020a; Mason, 2021). Lastly, on the micro-level, fundamental uncertainty and the liquidity preference of financial actors are seen as major barriers to private investments into the transition, which provide a straightforward argument for large-scale public investments and other regulatory interventions to crowd in private investment and reduce uncertainty (Mason, 2021; Krahé, 2022).

A particular approach to green industrial policy and innovation policy more specifically is called 'mission innovation', advocated by the economist Marianna Mazzucato (2013, 2022). Mission innovation turns the goal of industrial policy from specific sectors to societal challenges. Based on a historical and empirical reading of innovation, Mazzucato (2013) argues that governments have a fundamentally different and much more important role in technological change than is usually assumed by mainstream approaches. The mission innovation approach suggests that governments should spearhead technological change by providing directionality and using the full suite of policy options to "crowd in bottom-up investments and innovation across the entire economy" (like RD&D funding, procurement, loan guarantees, grants, and prize schemes) (Mazzucato and McPherson, 2019). Importantly, the mission innovation approach emphasises its qualitative difference to 'market fixing' approaches in that governments take risks and engage as 'entrepreneurial states', while at the same time creating an 'ecosystem of innovation'. Policy should "actively co-create markets, tilting the playing field in a green direction" and focus on high-risk investments, supply-push, and demand-pull instruments (ibid.).

Usually, industrial policy is also politically motivated. With regards to the international context, creating competitive advantages or technological leadership is a frequent argument in favour of industrial policy (Lachapelle, MacNeil and Paterson, 2017). With a view to domestic policy, proponents argue that green industrial policy is an effective political strategy to elicit medium to long-term support for climate policy (Meckling *et al.*, 2015). This is because industrial policy aims at decreasing the costs of clean technologies, which will improve consumer choices and make climate action cheaper (Breetz, Mildenberger and Stokes, 2018). But it is also a good political strategy because it creates new economic and thus political interests that will support climate action: if firms benefit from climate policy they are likely to support it politically and become part of a pro-climate coalition (Jenkins and Karplus, 2017; Cullenward and Victor, 2020; Mildenberger, 2020). Some even invoke the logics of public choice theory and this positive aspect of rent-seeking to argue in favour of green industrial policy (Jenkins, 2014).

[11] Therefore some 'neoclassical' economists also support targeted or horizontal industrial policy. It should be noted that many heterodox authors reject the market failure framework and its underlying equilibrium thinking in the first place (e.g., Mazzucato, 2016; Schmidt, 2018; Rosenbloom *et al.*, 2020).

3.2.3 Planned transition approaches

A third paradigm is based primarily on a planned transition, enacted through direct regulation (also referred to as 'command-and-control' policy instruments).[12] This type of regulation relies primarily on standards, bans, mandates, and other forms of direct regulation that either mandate or prohibit certain types of action or the use of certain technologies or fuels. While this paradigm is oftentimes taken as an antipode to a 'market-based' approach in academic economics (e.g., Stavins, 1997), it is well represented in civil society (e.g., CAN Europe, 2022). Moreover, direct regulation has been the dominant approach to environmental policymaking up until the 1990s and remains a core part of government practice to this day (Singhal, 2018; Pacheco-Vega, 2020).

Proponents argue in favour of direct regulation based on the premise that strong regulatory guidance is required to achieve the transition towards a climate neutral economy, certainly in the limited time that remains. Alternative approaches, such as market-based instruments, are not seen as a feasible alternative – either because they are inherently incapable of generating and sustaining a price signal strong enough to drive disruptive change, because they are not able to generate the framework conditions for their own success (e.g., institutional and infrastructural), or – even if they were able to overcome these constraints - they would take too long to deliver the necessary changes.

Two arguments are frequently mobilised for the primacy of direct regulation. First, technological and economic path dependencies lock the economy into a fossil- and emission-intensive path (Unruh, 2000; Seto *et al.*, 2016). Overcoming these path dependencies requires strong regulatory guidance, as they exert strong incentives to individual economic participants to continue business as usual. Directly regulating fossil technologies and sectors hampers the power of incumbents. Moreover, (centrally) rolling-out the infrastructure required for climate neutrality is supposed to help overcome the coordination problem that bedevils market-based regulatory approaches.

Second, direct regulation is argued to be environmentally effective, leading to *certain* outcomes (Singhal, 2018). This certainty applies both to the environmental effects as well as the distributional effects of climate action. Approaches relying on carbon pricing or innovation policy assume that emission reductions will be achieved indirectly through price-induced behavioural changes or technological substitution, and that the market is indispensable as a discovery mechanism to identify the most suitable solution. By contrast, proponents of direct regulation maintain that, at this point, many technological solutions are known (at least broadly), and the challenge is much more to roll them out at the necessary scale. This makes one main strength of market-based approaches redundant and lowers the risk of regulators choosing the wrong technology.

[12] Regulation is direct in that it directly regulates behaviour and choices, in contrast to indirect approaches that try to indirectly change behaviour through price changes or other framework conditions.

If solutions are (largely) known, the challenge is rather to take clear decisions on the fate of technologies (e.g., for banning fossil-based heating) and to create the conditions so that the identified solutions can be rolled out at scale.

There is a residual risk of getting it wrong: picking winners may be unavoidable in the short time that remains, but it involves the risk that the regulator opts for the "wrong" technology (such as a more expensive alternative). This may thus reduce cost-effectiveness, yet proponents argue that it is more environmentally effective, achieving the needed change of technological trajectories with greater certainty.

At the micro level, direct regulation strategies prescribe a specific goal and/or path to which private actors must comply. This is complemented by sectoral planning at the macro-level, e.g. in the form of sectoral carbon budgets that prescribe how much each sector can emit in any given year, or by how much it must reduce emissions in line with the overall emission reduction goal.

Command-and-control approaches assume that transformative policies need strong coordination, which only governments can (legitimately) deliver. This may include coordination of efforts within the EU (i.e., between Member States), but also between stakeholders and sectors. This results in extensive planning by means of, for example, sectoral and regional strategies, scenarios, roadmaps etc. In addition, the transition will create social hardship as some sectors and regions will be negatively affected by the shift to a climate neutral economy. It is the governments' role to manage these adverse effects through structural policies and ensure the transition happens in a socially sustainable manner.

3.2.4 Post-growth, de-growth, and ecological economics

A fourth set of intellectual currents that can be said to constitute a particular policy paradigm is represented by post-growth, degrowth, and ecological economics (for brevity subsumed under 'post-growth approaches' in the following).

Post-growth schools of thought are based on the premise that economic growth (as measured in GDP) is incompatible with 'planetary boundaries'. More precisely, its authors argue that economic growth cannot be decoupled absolutely from material resource consumption and cannot be decoupled from GHG emission *fast enough* to stop runaway climate change (Hickel and Kallis, 2020). They are generally pessimistic towards technology's ability to address climate change. Following from this, proponents of post-growth argue for abandoning economic growth as a government priority and replacing it with alternative conceptions of human well-being. And while some authors are more agnostic towards the question if GDP must be deliberately reduced (van den Bergh, 2010; Raworth, 2017), others explicitly advocate for a planned contraction of economic activity (Alexander, 2012; Wiedmann *et al.*, 2020).

Post-growth approaches focus on reducing harmful economic activities and sectors. 'Degrowth' scholars try to clarify terminological ambiguities: degrowth would not relate to GDP and a

reduction in GDP per se, but to a reduction of material throughput (Hickel, 2021). However, to the extent that proponents argue that GDP growth leads to more material throughput, degrowth does imply a reduction in GDP. They moreover argue that 'green growth' is unlikely to be achieved (Hickel and Kallis, 2020). Furthermore, authors argue that degrowth should not be confused with a recession, because it is a planned, sectorally-targeted, and pro-jobs agenda, not an uncontrolled collapse in economic activity. Finally, degrowth scholars point out is that it is primarily a strategy for the rich Global North – not a policy prescription for the developing Global South (Hickel, 2021).

In a systemic review of degrowth policy proposals, Cosme, Santos, and O'Neill (2017) identified two policy goals of degrowth in addition to the overarching aim to reduce humanity's impact on the environment: First, the redistribution of wealth and income within and between countries. Second, the pursuit of convivial and participatory forms of living instead of materialistic lifestyles.

With regards to policy instruments, degrowth proposals are diverse (Cosme, Santos and O'Neill, 2017). Recurring elements in policy proposals include taxes and specifically shifting taxation from labour to the taxation of wealth and material consumption. Degrowth proposals are critical of long-distance trade and frequently include the promotion of localised production and restrictions on trade. Finally, degrowth proposals tend to draw on standards, mandates, and bans with regards to new infrastructure development, consumption, as well as technologies.

Not all post-growth approaches agree on the need for fundamental changes to social structures (e.g., with regards to capitalism). However, they all converge on the need for lifestyle changes towards the goal of sufficiency, i.e., an intentional change of consumption patterns away from resource-intensive goods and services, and an overall reduction of consumption (Alcott, 2008). Lifestyle choices are not reduced to the individual but regarded as a function of social structures and collective norms. Therefore, post-growth approaches advocate for high-quality public goods and services as important pre-requisites for lifestyle changes. Post-growth approaches highlight the importance of equity and addressing inequalities in this respect (Tomany *et al.*, 2021): sufficiency strategies, for instances, are to begin by reducing "overconsumption" of the most affluent consumers, on the grounds that such consumption does not increase welfare, in order to free up ecological space that allows more consumption in poorer countries (Goodland and Daly, 1993). Other policy instruments to facilitate lifestyle changes are personal carbon budgets, work-time reductions and work-sharing, or limits on energy and material use through standards or price-based measures (Lorek *et al.*, 2021).

Box 2 – (Other) schools of thought considered

This box lists some other different schools of thought that were identified and considered. Some of them are (partially) reflected in the chosen policy avenues. Yet, for different reasons, they were less suitable to serve as a paradigmatic framework: in some instances, they were too far removed from the realities and discourses of EU policy making; in other instances, they

represent concepts rather than full-fledged theories with a clearly identifiable theory of change.

Experimentalist Governance – Experimentalism is an approach to governance, particularly of transnational problems. It tries to transgress discussions about the 'optimal' policy instruments and instead argues that in the face of fundamental uncertainty, wicked problems must be addressed using governance arrangements that provide dynamic incentives for public and private cooperation, enable bottom-up initiative that feed into universal standards, and flexibility to changing circumstances.

Socio-Technical-Transitions – Socio-technical-transition theory builds on innovation studies, evolutionary economics, and institutional theory, and conceives climate change as a system problem. Its overriding policy priority is environmental effectiveness, and it argues in favour of the direct stimulation of innovation. Policy should be context-specific and adapted to local and sectoral contexts, actively creating alternatives and supportive coalitions, while destabilising the old (Kivimaa and Kern, 2016; Loorbach, Frantzeskaki and Avelino, 2017; Rosenbloom *et al.*, 2020). With its focus on policies related to, direct regulation, and innovation, it can be reconciled with both Green Industrial Policy and the Planned Transitions approaches.

Ecomodernism – Ecomodernists see technological progress and economic development as indispensable for tackling climate change. Economic growth is seen tantamount to environmental sustainability as technological progress enables the decoupling of growth from environmental impacts. Ecomodernists are very optimistic about technological innovations and the compatibility of capitalism with climate action. Arguably, proponents of green industrial policy and green economic liberalism have similarly optimistic assumptions about technology.

Green Keynesianism – Green Keynesians build on classical and post-Keynesian economics and argue in favour of expansionary fiscal policies to stimulate the transition to a green economy. It can be contrasted with neo-classical approaches to (macro-)economics in its conception of the economy as primarily demand-driven and the role of the financial sector. These conceptual differences give rise to different policy prescriptions that emphasise state intervention and public investments (Mason, 2021). Keynesian thought underpins the Green Industrial Policy paradigm.

Eco-Marxism and Eco-Socialism – Eco-Marxist and Eco-Socialist approaches are heterogenous but united in their rejection of prevailing approaches to climate policy that are predicated on a capitalist organisation of production. The structural tendencies of capitalism are argued to be incompatible with climate action. Proponents emphasise the class politics of climate change and policy and argue in favour of a government-planned transition that redistributes wealth and resource so that all can meet their subsistence within planetary boundaries.

Climate emergency is a new framing for climate policy that is hoped will generate stronger climate action, convey a greater sense of urgency and to communicate more clearly the dangers of inaction (McHugh, Lemos and Morrison, 2021). In contrast to many of the other schools of thought it is not a coherent theory. While more than 2,000 jurisdictions in almost 40 countries had declared a climate emergency by October 2022, the governance implications of this step remain unclear. The intention of declaring an emergency is to change the nature of governance to an "emergency" mode, as has been observed e.g., during the Covid-19 pandemic or the 2008 / 2009 financial crisis. In practice, the implications can take the relatively modest form of giving greater priority to climate objectives in trade-offs with other policy objectives. They can also include steps to accelerate planning and place less emphasis on procedures and accountability, e.g., regarding tendering procedures, or the (temporary or permanent) suspension of legally set political constraints (e.g., debt ceilings). At the most extreme, climate emergency could be invoked to justify the equivalent of a wartime mobilisation effort (Delina and Diesendorf, 2013).

3.3 The four paradigms in current EU climate policy

As noted, real-life politics is rarely a pure embodiment of paradigms, but rather a blend of different approaches and intellectual traditions that evolves over time, driven by changes in political majorities as well as changes in thought. To understand which of the four paradigms in the views of the policy lab participants, have shaped current EU climate policy, and which influences are likely to do so in the future, we conducted a small survey among the policy lab participants.

We asked participants how, in terms of the four paradigms, (a) they would categorise existing EU climate policy, and (2) they think EU climate policy *should* evolve in the future. Participants could assess the influence of the paradigms on a scale of 1 to 5, where 1 corresponds to strong disagreement that the paradigm has an influence on EU climate policy, and 5 to strong agreement. To make the survey more accessible, paradigms were expressed as the (types of) policy instruments that best represent the policy paradigm, rather than the academic label of each paradigm. The average responses are represented in Figure 1. It should be noted that the result is based on the responses of 18 policy lab participants (representing a mix of stakeholders and policy makers engaged in EU climate policy) and is therefore not a representative sample.

As can be seen in Figure 1, the experts responded that three of the four paradigms have a considerable influence EU climate policy (i.e., average scores higher than 3). According to the survey, experts see EU climate policy most strongly influenced by market-based instruments. Innovation policies and public investment, as well as classical regulation, such as standards and mandates, are also considered represented in existing EU climate policy. By contrast, sufficiency and behavioural change – associated with the degrowth paradigm – are not widely recognised in the EU's policy mix.

In terms of their normative views on the future EU climate policy mix, experts see the strongest need to intensify sufficiency policies, followed by innovation support and public investments. In contrast, the support is weakest for further strengthening market-based instruments.

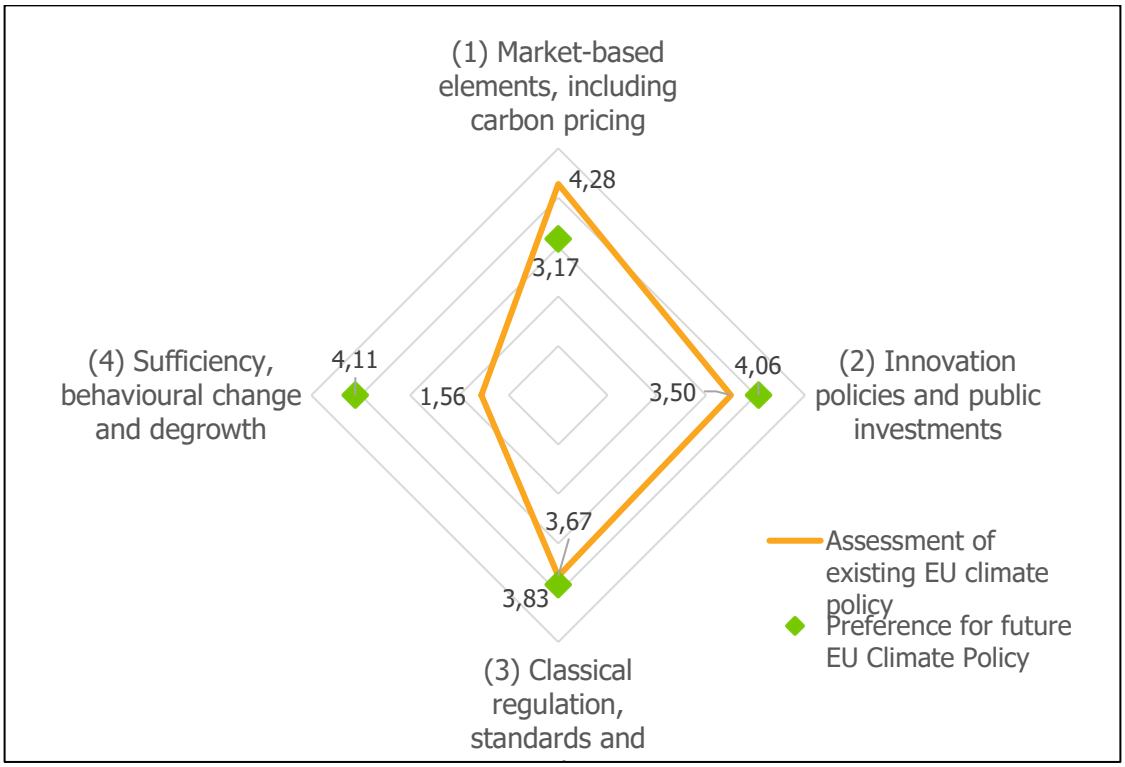

Figure 1 Experts' assessment of existing and future EU climate policy
Notes: Survey conducted in September 2022 among senior EU climate policy experts (n = 18). Responses translateed to a scale of 1 to 5, with 1 being "strongly disagree" and 5 being "strongly agree". The orange line depicts experts' assessment of existing EU climate policy with a high score indicating that experts consider this paradigm well represented in EU policy. A low score indicates that experts consider the paradigm to be less represented in EU policy.

4. Four policy avenues towards a climate-neutral EU

The following section describes the four policy avenues that were developed with stakeholders in the policy lab. To recall, the policy lab served to "translate" the policy paradigms into concrete policy avenues. The authors then developed the results of the policy labs further into the policy avenues described below. Each description includes (a) the core ideas and principles, (b) the policy instruments that would be deployed, and (c) how the avenue will specifically address the 4i challenges around which the 4i-TRACTION project is structured (innovation; investment and finance; infrastructure; and integration; see text box 1). The policy avenues are summarised in Table 2 below.

Table 2 Overview of the policy avenues

	Green Economic Liberalism	Green Industrial Policy	Directed Transition	Sufficiency and Degrowth
Core policy instruments	EU ETS (extended to shipping and waste) ETS 2 for buildings and transport Cap-and-trade system for agriculture, land use and carbon removals	Mission Coordination Board to identify and coordinate industrial policy. Public investments (RD&D, investment support, infrastructure) Performance/product standards	Targets and cross-sectoral strategies: National Energy and Climate Plans (NECPs) Standards and bans Regular updating of strategies	Continuation of EU ETS, ETS 2 Introduce personal carbon budgets Bans of high emitting / luxury technologies and practices Universal basic services/income
Innovation	Carbon Contracts for Difference; Green Lead Markets including through Climate-neutral Public Procurement. Carbon price to drive the market uptake of novel technologies	Public research, development, and demonstration funding (RD&D) funding; standards (tech push); Public procurement; subsidies, standards (demand pull); public-private / private-private research consortia.	RD&D funding for important clean technologies Standards to stimulate innovation Auctions, quotas, and price support to aid commercialisation	Accelerate Circular Economy Action Plan Investment support for low-tech system innovations Bans and phase-outs to guide innovation
Investment	Carbon price guides investment. Plus: de-risking; climate risk insurance; loan programmes for energy efficiency; prudential regulation	Public Transformation Fund to coordinate investment; standards and public procurement (to create markets); reforming EU fiscal rules	European Investment Fund to align with NECPs; public procurement; CCfDs; Green Taxonomy; prudential regulation	EU funds for local mitigation and adaptation projects; green public procurement; transition plan obligations for financial institutions; progressive property & income taxes
Infrastructure	Integrated infrastructure planning; digitalisation; auctions; nodal pricing to incentivise electricity infrastructure; insurances for decommissioning of fossil infrastructure	Missions to coordinate infrastructure planning; MS to submit integrated infrastructure plans, improving Connecting Europe Facility	Integrated infrastructure planning through sectoral roadmaps; targets for infrastructure operators (such as TSOs and DSOs)	Mandate coal phase-out by 2030; increase clean energy infrastructure funding; ban short-haul flights, and funding for new road building
Integration	(Carbon) market to facilitate integration of sectors and countries A central, non-prescriptive vision to provide guidance to market players.	Set up Mission Coordination Board to identify and coordinate missions, ensuring coherent policy outputs. Transformation Fund to facilitate coherent EU spending on climate.	Sectoral roadmaps for sector-coupling; digitalisation of end-uses for demand management; mandatory (heat and power) planning on local level	Transform CAP; integrate sufficiency in European Bauhaus; include climate-consistency assessment in impact assessments

4.1 Policy avenue 1: Green Economic Liberalism

The Green Economic Liberalism Policy Avenue was developed around the neoclassical environmental economics paradigm described in section 3.2.1.

4.1.1 Core ideas and principles of the policy avenue

Climate change is the result of market failures. Since prices have not reflected the ecological costs and externalities were not accounted for, Europe (and the rest of the world) has continuously over-invested into economic activities and infrastructure with a high carbon footprint. Since flawed price signals are one root cause of the problem, getting prices right must be the central pillar of the solution. In the context of the EU, carbon pricing by and large means emissions trading. While there are other options in theory (such as a carbon tax their potential benefits do not outweigh the low chance of their implementation within the confines of EU policy making. Taxes may play a role in addition to the EU ETS for activities or products where emissions trading is not a feasible option, or as a transitional instrument until emissions trading is implemented. Likewise, subsidies that encourage fossil fuel consumption must be removed – including temporary relief measures introduced in response to the rapid increase of fossil energy prices since Russia's attack on Ukraine.

Fixing markets can help to solve the climate problem - and markets will be needed, as they provide an unrivalled combination of effectiveness and efficiency to develop, scale up and roll out solutions, to mobilise ingenuity and private funds, to incentivise change, and to distribute efforts across sectors in an efficient way. Market-based elements should thus be used where possible to create competition, drive down costs, attract investment and coordinate efforts.

Market-based policies are broader than only carbon pricing: While the carbon price must be at the core of the policy mix, other elements will be needed. Additional policy instruments should be justified on account of whether they enable the carbon price to better perform its function, for instance by removing barriers and obstacles. For individuals – in business, private households, or public administration – to be able to respond to the carbon price signal requires having alternatives available. Public policy has a role in creating these alternatives and facilitating access to them – providing information and fostering transparency, stimulating innovation, enabling access to finance where it is lacking, providing public goods and infrastructure where the market will not deliver.

Emissions trading will continue to be the core instrument of EU climate policy. In the policy avenue, this happens in the form of three instruments, setting three emissions caps: the (existing) EU ETS covering emissions from energy, industry, aviation and eventually shipping, the (planned) ETS 2 for emissions from buildings and road transport, and a new cap for land-based emissions, i.e., from land use change, agriculture, and forestry. The three caps follow the trajectory consistent with the medium and long-term emissions targets. Existing and proposed systems need

to become more stringent and effective, for instance through the phase-out of free allocation / introduction of CBAM in the case of the EU ETS, or the absence of a ceiling price in the proposed ETS 2.

The policy avenue relies heavily on market-based mechanisms for which it is essential that they can perform its function free from political interference: political decision makers need to refrain from intervening in the carbon market and need to keep a credible commitment to the instrument also when prices rise. To ensure political acceptance, social compensation and targeted support for vulnerable groups must be part of the policy mix (including through the Climate Social Fund). These can take the form of a lump-sum payment to all households / ratepayers or as targeted assistance to vulnerable households – but not by lowering prices.

4.1.2 Description of the policy avenue

The policy avenue is built around three policy instruments that cap emissions: the existing EU ETS (incl. CBAM), the ETS 2 as an adjacent upstream system that caps emissions from buildings and road transport, and a third instrument that caps emissions from agriculture and land use. Their role and significance changes over time – but they remain the central tools for emission reductions, accompanied by other, supporting instruments.

- The **EU ETS** continues to serve as the centrepiece of EU climate policy. As proposed, the coverage of the instrument is extended from the current scope (energy, industry, and aviation) to include shipping and possibly waste. Its role will be strengthened by phasing out free allocation by 2030 in parallel to the introduction of the carbon border adjustment mechanism (CBAM). Sustained by continued high prices, the function of the EU ETS will evolve: as power production increasingly moves away from fossil fuels, the EU ETS will no longer serve to replace more carbon-intensive fossil fuels with less carbon-intensive ones (i.e., switching from coal to gas), but rather to gradually eliminate the last fossil generation capacities in all but the few days of the year when they are needed. Instead, the EU ETS will increasingly serve to drive transformative change and deep emission cuts in industry, aviation, and shipping.
- The **ETS 2 for emissions from buildings and road transport**, proposed as part of the EU's fit-for-55 package is introduced with as few distortions as possible, i.e., with broad sectoral coverage, neither exemptions nor ceiling prices. Instead, a (rising) floor price is a desirable feature to provide greater certainty without jeopardising the integrity of the ETS 2 cap to ensure that emissions are continuously reduced.
- A new cap is introduced for methane and CO_2 emissions from **agriculture, forestry, and land-use**: this will not be a full-fledged cap-and-trade system, but rather a budget to manage emissions from this sector, and a testing ground for a future mechanism to trade carbon dioxide removals (which will eventually be needed from the 2040s onwards).

In theory, the most efficient approach would be to merge these three systems into a common market with a single carbon price, mobilising the cheapest abatement potentials across sectors. This is a plausible option in the medium to long term (late 2030s or 2040s), but not an important priority for the near future, since the three systems are at very different levels of maturity – meaning that the (still untested) proposed new systems should not jeopardise the integrity of the existing EU ETS. Also, the relative weight of the three caps will change over time: with energy largely decarbonised towards 2040, and only residual emissions in industry, the EU ETS cap will shrink faster than the other two. Emissions in buildings and transport – on account of them falling more slowly – will play a relatively larger role, but eventually will come to be dominated by land use and negative emissions.

While emissions trading will remain the dominant form of carbon pricing in the EU, taxes may be used as an additional / transitional instrument in instances where emissions trading is not (yet) feasible (e.g., methane emissions from livestock, tax on meat consumption, or a landfill tax that may be phased out again when an ETS is implemented for emissions from agriculture, land use and forestry). In addition, any remaining fossil fuel subsidies need to be phased out, for example, by integrating external costs in the tax rates defined in the Energy Taxation Directive. As a particularly sensitive point, this includes rebates to fossil fuel taxes which several Member States have enacted in 2022 in response to high prices of fossil energies: while their political justification is obvious, they also constitute a fundamental deviation from the idea that prices need to be able to perform their function.

The Effort Sharing Regulation, which sets binding emission targets for Member States for those emissions not covered under the EU ETS remains in place – but rather because keeping it is politically less costly than revoking it. However, as a mechanism, it becomes increasingly marginalised: the emissions covered by the Effort Sharing Regulation (ESR) are also covered under the ETS for buildings and road transport, and the new cap for land use emissions. These systems are the primary mechanisms to drive emission reductions and guarantee compliance; the ESR merely remains as a rudiment and a failsafe.

Standards are not the instrument of choice in a market-based policy mix. Still, they can continue to be a part of the policy mix particularly where there is a risk of fossil-lock in creating stranded assets, since carbon pricing instruments may not (yet) give a sufficient long-run signal. For instance, this case can be made for standards for the sale of oil and gas heating boilers: there is a risk that the expected carbon price signal from the ETS 2 would come too late / be too low to prevent their installation in the near future, therefore a ban on new installations can offer an interim solution. Ultimately though, the larger challenge is how to manage the phaseout of fossil-based technologies from the existing stock (buildings, installations, and vehicle fleets). For this coordination challenge, a sufficiently high carbon price is the most suitable option.

4.1.3 Tackling the 4i's

4.1.3.1 How will the policy avenue address innovation?

A market-based approach to fostering innovation for climate neutrality seeks to lead climate-neutral technologies to market maturity in all relevant sectors. As a side effect, it establishes European-based producers as global leaders in climate-neutral technologies, redefining the established notion of competitiveness from lowest-cost to lowest-carbon production.

A high enough carbon price will drastically accelerate market maturity of innovative climate-neutral solutions, helping to bridge the cost gap to incumbent technologies. Yet while the carbon price is very effective to push sufficiently mature technologies into the market, it is less suited to incentivise breakthrough innovations that involve fundamentally different ways of producing goods and delivering value to customers. For these technologies, other (market-compatible) tools are needed to lower their costs and lead them toward market maturity.

As these breakthrough innovations involve significantly higher risks, they are unlikely to attract sufficient private support and initiative in the absence of specific (public) innovation support. But such support needs to be targeted and temporary, so as not to create subsidy dependence (see also following section on investment). Furthermore, it must be organised in a non-distortionary, market-compatible, and competitive process, to preserve private initiative, to ensure quick cost declines and to avoid public innovation support crowding out private innovation funding. This suggests tools such as Carbon Contracts for Difference (CCfD), especially if organised as an EU-wide competitive process, which mimic / enhance the function of high carbon prices. Likewise, green lead markets (in which consumers pay a higher price for low-carbon products), quotas for low-carbon products or green public procurement can create the necessary demand and (temporarily) higher returns for innovative products, technologies, and business models. But support policies must remain temporary and conditional. Therefore, there need to be clear criteria not only for when new technologies, products and business models require support but also of the market situation, and clear timelines for phasing out support.

Carbon contracts for difference (CCfDs) are an important, market-compatible way to drive the adoption of breakthrough technologies in energy-intensive industries. CCfDs should function as a complement to the carbon price set by the EU ETS: their function is to guarantee a carbon price for investments into technologies with substantially lower CO_2 emissions. As a project-specific payment, they represent an investment subsidy. To avoid subsidy dependence, the following design features can help:

- The award of CCfDs to transformative investments needs to be organised as an EU-wide mechanism to enable competition between different projects, awarding the CCfD to the projects that require the lowest level of support.

- The award of CCfDs starts with selected sectors / processes where low-carbon alternatives are technologically viable (steel, cement), and broadened in scope.
- CCfDs are intended to close the gap between current carbon prices and the carbon price level at which decarbonisation investments become viable. As carbon prices rise, the difference that CCfDs need to bridge becomes smaller and the CCfD eventually becomes obsolete.

This corresponds to the general criterion that innovation support must be targeted and temporary – and eventually supported technologies should become the market standard. Other market-compatible options to foster the growth of low-carbon technologies are **green public procurement** and **quotas for low-carbon products**. Both serve to support the establishment of **lead markets for climate neutrality**. Through these lead markets, during a transitory period low-carbon products can command a higher price than alternatives from conventional production, either because consumers are willing to pay a higher price for the green characteristics of a low-carbon product, or since a quota for low-carbon products is mandated. In this way, the price premium compensates some of the innovation risk. As costs of low-carbon technologies decline and as low-carbon technologies move from niche to mainstream, the lead market would expand and eventually become the default. To avoid double support, care needs to be taken that production that has benefited from a CCfD (or some other direct support) is not eligible to be traded on the lead market at a premium price.

The **EU Innovation Fund** has an important role to play and should be extended in volume. To allocate funds in a transparent, competitive, and efficient way, it should use CCfDs and other market-based approaches (competitive tendering). Yet in doing so, it would be politically expedient to also include elements of intra-European solidarity – ensuring that the supported instruments benefit regions across Europe and is not exclusively focused on current industrial centres.

Beyond these instruments, there are issues where framework conditions need to be adjusted to avoid foreseeable bottlenecks. One of these concerns trade arrangements for essential raw materials. Materials will be crucial in a decarbonised economy, but the EU is dependent on non-EU suppliers. Fostering trade and cooperation agreements with supplier countries will be crucial to avoid bottlenecks in the supply of such materials. Second, biobased alternatives can play an important role in replacing fossil-based materials and value chains, as well as imported (raw) materials. However, to exploit the potential of the bioeconomy for the transformation to climate neutrality, existing regulatory barriers will need to be lowered / removed, also in contentious areas such as the use of genetically modified organisms.

4.1.3.2 How will the policy avenue address investment and finance?

Investments into transformative technologies should eventually be incentivised by the carbon price. Yet such investments carry a significantly higher risk than conventional alternatives; public

support may therefore be necessary to de-risk investments at least initially: over time, as the experience with transformative technologies grows and costs fall, as the necessary infrastructure becomes more widely available and as the carbon price rises, less support will be needed. In supporting transformative investment, measures must always be targeted, temporal and justified. Also, scrutiny is needed to avoid concentrating risks excessively in public budgets, whereas private investors would reap potential returns. One effective antidote here is utmost transparency about which investors receive investment support on what grounds, with which target: not only to reduce the risk of fraud or malfeasance, but also to communicate more clearly the climate benefits of publicly supported investments.

In terms of concrete instruments, there is inevitably some overlap with innovation support tools, as the deployment of innovative solutions also requires investment into installations and infrastructure. Thus, EU funds for transformative investments should be expanded (innovation fund developed into a transformation fund), but in disbursing funds should prioritise loans over grants to keep incentives intact / reduce distortion. More widespread use of climate risk insurance can serve to hedge not only against climate change impacts, but also against transition risks (e.g., stranded assets, eroding business case of fossil infrastructure). Public policy can support the adoption of risk insurance, for instance, by providing information and raising awareness, as well as providing greater transparency about the different insurance products available.

Targeted credit programmes are needed where access to finance / credit is a barrier that prohibits investment that would otherwise be profitable. This is especially relevant for energy efficiency investments, but also for electrification e.g., of heating. In the context of rising interest rates, access to credit may be even more important.

To support the realignment of private investment decisions towards climate neutrality, the financial literacy of private (but also institutional) investors must be improved. This includes, for instance, mandatory carbon footprints for financial products that are based on a transparent and coherent methodology. A regularly updated and revised taxonomy should provide clearer and more lasting guidance to investors in a rapidly emerging field. The current taxonomy with its binary and static distinction is not well suited for this and should be developed into a more dynamic guide that captures which investments are compatible with the transformation to climate neutrality (under different scenarios and pathways) and will remain so for the economic lifespan of the investment. In particular, the taxonomy must offer a clear indication which investments are *not* compatible with the transformation to climate neutrality (e.g., any new investment into fossil infrastructure and fossil-based value chains) under any scenario. The taxonomy would thus evolve into something akin to a rating system for climate neutral investment opportunities. At consumer level, there is more scope for information on the lifetime carbon and energy cost of appliances and buildings to be presented at the point of sale.

4.1.3.3 How will the policy avenue address infrastructure?

Rolling out the necessary infrastructure for the transformation to climate neutrality, at the pace needed, is not conceivable without planning and coordination – all the more so since different types of infrastructure are concerned (electricity, heat, hydrogen, CCS), with competing solutions and interdependencies between different types of infrastructure. To some extent, different types of infrastructure may complement each other – in other instances they will compete. Effective coordination between different types of infrastructure cannot be delivered by the market but requires centralised planning.

Yet the necessary infrastructure roll-out will not be feasible without significant private investment. If well regulated, some parts of infrastructure can be privately built, owned, and operated (e.g., vehicle charging points and networks). For others, public support may be necessary in the initial phase, but eventually infrastructure should be privately operated (e.g., hydrogen, CCUS). This means careful assessment and regular re-evaluation is needed to determine which infrastructures can be provided by the market (in a given regulatory framework), where is public support needed, at what level and for how long. Again, transparency about the need and the justification for public support should be ensured, creating an effective remedy against subsidy dependence. Furthermore, communicating transparently about why particular infrastructure is needed may also help to reduce public resistance against the construction of new infrastructure.

A central element is therefore the integrated planning for different infrastructure types that are relevant for the transition (heat, electricity, green hydrogen, carbon, mobility – all in combination with digital infrastructure). The infrastructure needs to be capable of coordinating (energy) supply as well as demand responses from users. Next to coordination across sectors and infrastructure types, this also extends to coordination across EU boundaries, and across governance levels (for instance extending to mandatory municipal heat planning). Integrated infrastructure planning should be a learning system of coordination, regularly updated in response to new development and insights.

New infrastructure must be planned and built to be smart and resilient: as sensors are becoming cheaper, they need to be included in all parts and all types of infrastructure, both to digitise the operation of the infrastructure, optimise infrastructure maintenance and enable new business models. The repurposing of infrastructure (existing and new) needs to be factored into the planning from the outset, e.g., converting fossil gas infrastructure to transport green hydrogen and derivatives, or using infrastructure for liquid fossil fuels for biobased ones or synthetic fuels. Where repurposing of (fossil) infrastructure is not feasible or necessary, provisions need to be made for its decommissioning (including financial provisions). Finally, climate change effects (with more extreme weather) need to be factored in during infrastructure planning (e.g., district heating and cooling demand).

Within the framework set by integrated infrastructure planning, market mechanisms should be used where possible to incentivise the expansion of infrastructure. This includes exploiting

connections between electricity market design and infrastructure, e.g., by using nodal pricing that uses price differences to reward interconnection in the electricity grid: if electricity prices at different nodes in the grid diverge significantly and for a sustained amount of time, this creates an incentive to extend interconnection capacity. Similarly, price discovery through auctions can help to determine the adequate level of public support for the construction of new infrastructure, with bidders competing for the right to build / operate new infrastructure.

Green Hydrogen and CO_2 networks (the latter for Carbon Capture and Utilisation / Storage, CCUS) are cases where the feasibility and the economic viability of technological options largely depends on the infrastructure available, and the cost of using it. Leaving the construction to the market thus creates an excessively high risk for investors. To scale up these technologies, they need to be developed predominantly around local and regional clusters (also including heat networks).

In those instances where it is largely open which technological option will emerge to be dominant, but where the feasibility of solutions depends on infrastructure, real-life laboratories offer a controlled environment for the large-scale testing of promising techniques and associated business models (e.g., electrification of road freight with battery swapping or overhead pantographs).

In the medium to longer term, the infrastructure challenge will shift from rolling out the needed energy infrastructure for a predominantly renewable, electrified energy system, to also dismantling the existing fossil-based infrastructure. As the new and the old infrastructure will not necessarily be owned and operated by the same operators, there is a case that operators are obliged to build up reserves / set-asides to support the clean-up of fossil infrastructure when it becomes derelict. This can also take the form of a mandatory insurance mechanism to pool risks across operators, and account for situations where owners / operators are no longer in a position to cover the costs.

4.1.3.4 How will the policy avenue address integration?

Integration requires coordination of efforts: Complete technological neutrality is unlikely to be successful, for instance because many solutions require infrastructure to work, and thus a co-evolution of innovations, investment, and infrastructure. Leaving this coordination entirely to the market would imply a high risk that investments may not materialise.

Integration, understood as coordination of efforts across sectors, needs to be based on a central vision, providing some guidance where economic and technological development should go. At the same time, any coordination should leave room for individual initiative and the discovery of new solutions (technological openness). To facilitate integration across sectors, the EU needs to agree on a comprehensive vision of the transformation, regularly updated in light of new developments. This should not be a detailed technology roadmap, but rather provide orientation (for instance which technological races are called, which are still fundamentally open), and describe the distribution of responsibilities between private and public agents.

In the medium to long term, integrating (and balancing) efforts across countries and sectors should be delivered through the (carbon) market, achieved through a merger / linking of the different trading mechanisms (EU ETS, ETS 2 and a cap on land-based emissions and removals). The single price on emissions is needed not only to align efforts across sectors and deliver cost-effective emission reductions – but also to enable sector coupling, which erodes traditional sector boundaries. Different carbon prices in different sectors can create distortions and obstacles to sector coupling. This is the case in the EU now, where electricity generation is subject to a higher carbon price than other energy carriers, although they compete in the same end-use sector (e.g., mobility, where EVs competes with combustion engines).

Beyond sectoral integration, there is also a need for integration across environmental challenges. The transformation to climate neutrality needs to be coupled with advances in resource efficiency and circular economy. To promote this, support for circular / modular construction is required, most effectively achieved through building codes. Taxes on the use of virgin resources could also support such changes, while lowering taxes on repairs.

Finally, integration is also needed across national boundaries. Decision making rules around energy supply are still largely nationally determined, but increasingly need to be aligned and possibly integrated across national boundaries. This holds, for instance, for the electrification of road transport (passenger and freight), transmission infrastructure for electricity vs Power-to-X products, integration of markets for electricity and (green) hydrogen. Compatibility here relates not only to the infrastructure, but also to business models and services: it is not only a matter of ensuring that electric vehicles use the same plugs, but also regulations on international roaming for EVs, transboundary railway tickets, etc.

4.2 Policy avenue 2: Green Industrial Policy

The Green Industrial Policy Avenue was developed around ideas from the industrial policy and mission innovation paradigm described in section 3.2.2.

4.2.1 Core ideas and principles of the policy avenue

The fundamental idea of the Green Industrial Policy Avenue is that to reach climate neutrality, the state must actively build a green economy. The avenue consequently requires optimistic assumptions about the ability to address climate change with technologies, and the ability of the state to choose and promote the right technologies.

The policy avenue is structured around two goals. First, to **foster breakthrough innovations** in technologies that will be needed to reach climate neutrality. This goal goes beyond 'inventing' new technologies and encompasses the improvement of existing technologies as well as innovations in manufacturing and business models. And second, to **scale up existing solutions** by accelerating their market diffusion. Taken together, these two elements will drive technological

change and make clean alternatives more affordable, which in turn secures political acceptance for transformative climate policy.

The policy avenue is based on three assumptions that give rise to its logic of intervention.

1. First, the policy avenue follows the logic that transformative technological change rarely comes on its own. Markets on their own tend to favour incumbents – path-dependencies are a major barrier for innovations to take hold. Moreover, while price signals are important, they are insufficient to coordinate structural change (Mason, 2021). In consequence, there is a need for governments to shape markets and to actively direct technological change in certain directions.

2. Second, the policy avenue assumes that fundamental uncertainty is a major barrier to private investment in innovative solutions. This gives a *prima facie* case for the government to step in to reduce uncertainty through different interventions (Chang and Andreoni, 2020b). The state must reduce uncertainty about future technological developments, through *inter alia* RD&D funding, setting standards, or providing research related public goods, such as open data. In addition, the government can reduce uncertainty by guaranteeing demand for clean goods and services. The tools for this include standards, public procurement, but also by giving preferential treatment to certain firms.

3. Third and last, the policy avenue presupposes that active support for industries and reducing the cost of clean solutions will translate into long-term social and political support. Supporting green industries and creating clean jobs will strengthen pro-climate coalitions. Moreover, by making clean options cheaper, climate policy is no longer perceived primarily as a cost or sacrifice. At the same time, the government must manage political conflict, that will naturally arise from structural change. Strong social and regional policies will be needed.

The logic of intervention reflects some core principles that determine the policy mix.

- First, accelerating the clean transition requires a comprehensive programme of industrial policy, in which government drives strategic investments. While this approach may not be the most efficient, it is expected to be more effective.

- Next, different industrial policies need to be aligned and integrated. Transformative investments cannot be successful if, e.g., regulatory standards are not aligned and pull in the other direction. The policy avenue therefore includes high-level coordination and planning.

- The policy avenue will strongly support certain industries, meaning that some actors will benefit greatly from the green industrial policy push. But the policy avenue must avoid a situation where profits are privatised, and risks socialised. Instead, there must be a new

model for sharing the risks and benefits between public and private players. This may come in the form of targeted corporate taxation, governments taking a stake in the companies they helped succeed, or through new approaches to sharing the intellectual property that public investments help create.

- The policy avenue's goal is to accelerate technological change. This is incompatible with being fully technologically neutral – governments must identify and support promising technologies. At the same time, being specific does not imply closing the doors for other technologies to succeed. The policy avenue must be adaptive and should not place all their bets on one horse.

- Lastly, government support for firms or industries is finite. There must be clear sunset arrangements. A successful industrial policy approach builds in mechanisms for ending the support for firms and industries as soon as they are competitive on their own. Policy must consequently build in the right conditionalities, facilitate inter-sectoral competition, and avoid new lock-ins wherever possible.

4.2.2 Description of the policy avenue

The main goal of this policy avenue is to foster the transformation of the EU economy by actively supporting clean technologies and industries to lower their cost. The EU will identify areas or technologies as essential for the transformation to climate neutrality, support them in so-called 'missions' and align policy instruments towards achieving these missions. The main types of instruments utilised are **investments and standards**. However, at the core lies the coordination of industrial policy.

The policy avenue builds on existing EU climate policy. Major elements of the Fit-for-55-package are assumed to be in force, although some parts will need to be modified over time. The EU ETS remains to be an important component of the EU's instrument mix – it provides a marginal incentive to switch to cleaner forms of energy. Moreover, the ETS' generates revenue that can be used for clean technology investments. Performance standards, like the vehicle emission standard for cars and vans or energy efficiency standards for appliances will be ratcheted upwards. The targets of the Renewable Energy Directive will be aligned with Paris-compatible emission pathways and consequently revised upwards. The revision of the Energy Taxation Directive will help to phase-out environmentally harmful subsidies and align taxation with climate targets.

Existing elements of industrial policy, like InvestEU, the Innovation Fund or the EU's battery and chips strategy are important hooks for this policy avenue. Since 2010, the EU has launched six industrial strategies, laid out in numerous communications. The latest industrial strategy was meant to contribute to the implementation of the Green Deal and the pandemic recovery. Consequently, there are numerous initiatives and building blocks that this policy avenue can build on. However, while these initiatives do not lack ambition, the actual measures they contain are

not adequate to deliver on these ambitions.[13] Therefore, the industrial policy approach in this pathway would rapidly scale up existing initiatives (including InvestEU) and integrate them in a coherent strategy.

Core policy instruments

An essential building block of the policy avenue are coordination mechanisms and bodies. So called climate neutrality "missions" are the main mechanism for coordinating the industrial policy mix. A mission can be understood as a coordinated effort by public and private actors to achieve progress in a certain (technological) area that is identified as central in the transformation to climate neutrality. A mission can refer to a technology area, such as carbon capture and storage (CCS) or heat pumps; to an end use, such as decarbonisation of industrial heat; or to a piece of infrastructure, such as an EU-wide charging infrastructure for electric vehicles or upgrading EU-wide electricity transmission. Missions are not limited to R&D or the "invention" of new solutions, they will also augment existing solutions and drive their deployment and commercialisation. For something to qualify as a mission, (a) it should have the potential to significantly reduce emissions and (b) markets must be incapable of developing or scaling the solution on their own. A mission is considered successful if the industry or technology makes an important contribution to climate neutrality and becomes competitive without any direct government support.

Some form of a Mission Coordination Board (MCB) will be established either as part of the EU Commission or as an intra-institutional body with an executive secretariat in an agency like CINEA. Other governance options include the identification of key focus areas at the political level (e.g., the European Council) or, alternatively, the creation of an independent expert body to advise on and/or choose missions (e.g., a working group of the European Scientific Advisory Body on Climate Change). The Mission Coordination Board is tasked with identifying missions and drafting the industrial policy mix based on rigorous impact assessments and public consultations.

There are two main categories of instruments, that are – in different forms and configurations – the main drivers for technological change: investments and standards. They target both the supply of clean technologies as well as demand for cleaner solutions. However, the policy avenue draws on numerous other policy instruments that fulfil important supporting functions.

[13] For example, the EU's Green Deal is supposed to "mobilise" EUR 1 trillion in additional investments by 2030 (European Commission, 2020). However, the total EU guarantee in the Multiannual Financial Framework (MFF) 2021-2027 for InvestEU, which is the main investment fund to deliver on this goal, is only EUR 26.2 billion of which only 30% is earmarked for climate spending (InvestEU, 2022). While this sum may mobilise a multiple in private investments, it is hard to see how it will mobilise more than a 30-fold in private investments. Usual estimates for public-private investment ratios are 1:4 to 1:5 (Darvas and Wolff, 2021). InvestEU is supposed to leverage EUR 279 billion towards the EUR 1 trillion target (based on a total guarantee of EUR 26.2 billion). The MFF is supposed to directly account for EUR 503 billion from 2021 – 2030 (European Commission, 2020).

A Transformation Fund for public investments in climate neutrality

Generally, public investments can address both the supply of clean technologies and their demand. In their different forms they play an important role in this policy avenue (e.g., as direct investments or as investment support by way of tax credits). Moreover, public investments are important in infrastructure development, which is characterised by especially myopic conditions for private investments with large sunk costs and unclear rewards.

Numerous investment programmes exist in the EU, including *inter alia* InvestEU (the former Juncker Plan), Horizon Europe for R&D funding, the Innovation Fund, Cohesion Policy, or the Connecting Europe Facility, which is the main vehicle for infrastructure funding. At present, most industrial policy spending takes place on the national level, and most EU funds are also implemented nationally (e.g., member states apply with projects to the European Fund for Strategic Investments (EFSI), which accounts for the majority of the EU's industrial policy spending) (Landesmann and Stöllinger, 2020). By one estimate, the EU and member states combined spent only about 1.1% of EU GDP on industrial policy (in 2014-2017), which is low by historical standards (ibid, p. 5). Moreover, the investment programmes of the EU are not all aligned, targeted at the transformation, and at times contradictory. In consequence, to deliver technology breakthroughs and accelerate the roll-out of known solutions, existing programmes must be streamlined and (public) investments must increase substantially. The Mission Coordination Board will integrate the different investment programmes into a coherent framework and set up a Transformation Fund, which may be partially implemented by the EIB.

The Transformation Fund will have three pillars:

1. Research, development, and demonstration (RD&D) targeting innovation and the supply of novel clean technologies. The support under this pillar includes project-based grants and loans for private and public RD&D, base-funding for research institutes, funding of demonstration projects, or establishing (regional) research clusters. It will build on and expand Horizon Europe.

2. The second pillar will accelerate the take up of known solutions. This pillar is about creating the necessary demand for clean alternatives by giving investment support to businesses and private households. The pillar will, for instance, subsidise the replacement of fossil heating systems with heat pumps or other decarbonised heating. Or it will provide concessional loans to firms that want to replace inefficient (manufacturing) equipment with low-carbon alternatives (e.g., industrial process heat). The goal of the different investment support measures will be to bridge the cost-premium of clean alternatives and make them widely affordable to households and businesses.

3. The third pillar tackles climate-neutral infrastructure. Missions will come with new infrastructure needs (or the infrastructure is a mission in its own right) that must be addressed. Infrastructure usually has unfavourable investment profiles, with frontloaded payments, high risks, long lead times, and uncertain benefits. In many cases, there are

important arguments for infrastructure to remain in public hands. Consequently, the state must take the lead when it comes to investing in infrastructure like transmission grids, EV charging networks, CCS, or district heating.

For the realisation of missions, all three pillars will play an important role. The MCB will identify the investment needs as part of their mission identification and structure the programmes of the Transformation Fund accordingly. This integrative approach should ensure that innovations will quickly move from the research and demonstration stage to commercialisation and diffusion, all the while ensuring the right infrastructure is in place.

Standards play an important role in directing and incentivising innovation as well as guiding private investments. They do this, first, by creating clear guardrails in which firms and technologies can compete for the best solutions. Second, they reduce uncertainty about future technological developments. For example, a phase-out date for internal combustion vehicles sends a clear signal to market participants and provides a degree of certainty as to where technologies must develop towards. Third, sufficiently ambitious standards can create demand for products at the technological frontier, i.e., low-carbon or resource-efficient products, and help them to achieve market maturity faster. Standards, moreover, are important for setting-up investment programmes, for example, when it comes to deciding on which projects are eligible for funding and which ones are not.

However, when setting standards in the Green Industrial Policy, these should support rather than hinder the competition for the best solution, and thus define the goalposts for medium to long-term development, rather than micromanaging technological trajectories. Three types of standards will be utilised:

1. *Performance standards* target the operational performance of products and services as well as buildings performance. Different performance standards are in force in the EU, for example, the vehicle emission performance standards, energy performance standards for buildings, or the energy efficiency and eco-design requirements for electric appliances. Existing standards will be reviewed and aligned with a climate-neutrality pathway. New performance standards, for instance zero-emission requirements for industrial process heat below 500°C, will be introduced.

2. *Carbon Product Requirements* (CPR) are limits on the emission intensity of carbon-intensive products, like steel or cement (see Gerres *et al.*, 2021). Unlike performance standards, they do not address the operational performance of an appliance, but instead regulate the material and carbon intensity of *production processes*. They will gradually be ratcheted upwards until they effectively amount to a phase-out of emission-intensive products.

3. *Technology standards* directly regulate what technologies are allowed at all, or which specifications technologies must meet. In the Green Industrial Policy Avenue, their main use is in the form of *negative* standards, which prohibit the use of certain technologies

from a given date, thus defining their phase-out date. Such standards will be relevant, for instance, to phase out the use of fossil heating systems in the buildings sector.

Standards will be set with a long-term vision and have a clear ratcheting mechanism, periodically increasing the ambition of standards. This effectively means that there will be clearly defined phase-out dates for fossil-based technologies and emission-intensive products. Phase-out dates will create certainty over the general direction of technological development and create the necessary conditions to drive investment into clean technologies (Chang and Andreoni, 2020b). Adhering to certain standards will also be a condition for accessing public funding.

Standards, green public procurement (see below), investments, and subsidies will create effective demand for final and intermediary low-carbon products. The creation of demand is important to reduce uncertainty and incentivise private investments in innovation and manufacturing capacity (Grubb *et al.*, 2021).

Beyond investments and standards, a key role for the EU is the coordination of public and private efforts and the creation of an ecosystem of innovation (see Mazzucato, 2013). The MCB will therefore facilitate research consortia of public and private organisations that collaborate on the development and deployment of key technologies for realising missions. Moreover, as part of its effort to scale up solutions, the EU will facilitate the creation of industrial hubs, to diffuse knowledge more effectively and to improve the coordination of infrastructure planning and the geo-location of, e.g., renewable energy, CCS, or green hydrogen infrastructure. Both, industrial hubs, and research consortia are meant to improve the collaboration among private actors and between public and private actors.

Support Instruments

The core instruments of the policy avenue – large-scale investments and stringent standards – are supported by numerous other policy instruments to improve their functioning.

- **Green public procurement** is an important instrument for creating demand for cleaner products. The state is a major consumer of emission-intensive commodities, like steel, cement, and aluminium - through its infrastructure projects, public buildings, or the development of public housing. Ambitious standards and conditions for procurement can guarantee a minimum level of demand for clean products, which in turn makes it less risky for investors to build up the necessary supply chains. This not only ensures that the production of new infrastructure has a low emission and material footprint, but by providing certainty to investors also allows them to cover learning costs and reap economies of scale, bringing down the cost of clean alternatives. GPP conditions will be set by the EU institutions and are binding for all member states. Their ambition will gradually increase, in line with the climate-neutrality goal.
- Standards and investment programmes rely on robust **certification and labelling schemes**, as well as underlying monitoring, verification, and reporting systems.

Therefore, the MCB will commission the development of robust, science-based certification systems where none exist, and review and revise existing ones. These systems require time to develop and are prone to regulatory capture. Therefore, a permanent institution for the development of standards will be created, which will facilitate the development of standards with the help of industry and science.

- The policy avenue is predominantly based on phasing-in clean technologies and products. To this end, removing counteracting measures is crucial – especially the **removal of environmentally harmful subsidies**. The revision of the Energy Taxation Directive will also be important, as well as a fundamental reform of the Common Agricultural Policy including a transition to results-based payments. Phasing out environmentally harmful subsidies will be conducive to phasing-in clean technologies and products and will also liberate public resources to support investments instead.
- Developing new infrastructure and upgrading existing infrastructure will be important for realising missions.[14] The MCB will identify infrastructural needs and coordinate the development of infrastructure in close cooperation with member states in the form of **integrated infrastructure planning**.
- Direct support for sectors and technologies must be combined with active market management, especially when clean technologies become the norm. This includes the enforcement of market competition where necessary, anti-trust policies, and competitive mechanisms in support programmes.
- The transition to a climate-neutral economy will create structural change with winners and losers. To mediate conflicts and ensure a just transition, **regional and structural transition policies** will be important. This means identifying what industries will be most affected by the transition and how impacts may be geographically distributed. Public investments in sunrise industries should ideally be directed, or at least matched with investments into regions with a high concentration of sunset industries. Equally important are active labour market policies to reskill and reallocate workers. Lastly, a robust social welfare system will be tantamount to provide a good safety net and dampen the resistance towards change by workers and their unions.

The policy instruments will necessarily need to be sequenced over time. Though generally, it is important to frontload decisions and the implementation of measures as much as possible to send clear and early signals to market participants and provide the time for cost reductions to materialise. Two important first steps are setting up the institutional framework for realising the missions, e.g., the Mission Innovation Board, streamlining investment programmes, establishing the administrative capacity. And second, to identify the first set of missions. Following from this,

[14] For example, most missions rely on a fully decarbonised electricity system. This necessarily implies an improved transmission grid, grid-level energy storage, and the coupling of different energy use-sectors.

the detailed policy measures will be drawn up (i.e., what investments are necessary? What standards are required? What infrastructure needs to be in place?). This entails establishing standards and effective phase-out dates including ratchet mechanisms, certification and labelling systems, and the investment programs to address the supply of innovations.

A continuous monitoring of the progress on missions is important; regular review and revision mechanisms ensure that the policies in force are adequate. If not, they will be revised. This includes the standards, subsidies, and investments. Equally, the mission's selection will be reviewed over time. New missions may be selected and once a mission is complete – i.e., deemed no longer in need of active support – it will be gradually phased-out in a predictable and orderly fashion. Likewise, it may be the case that a mission has become obsolete – because the supported technology turned out to be infeasible, or because cheaper and better alternatives have emerged.

Another important mechanism that will become important in the medium-term are sunset mechanisms, i.e., the deliberate and predictable phase-out of support measures for firms, sectors, and technologies. Moreover, support programmes come with clear conditionalities with regards to results. The goal of sunset clauses is to ensure that subsidies and other support measures are not extended indefinitely, to avoid subsidy dependence. Thus, they are a mechanism to prevent excessive rent-seeking, to induce competition and limit the risk of regulatory capture. Sunset clauses as part of support programmes signal to investors from the start that support is finite and conditional on existing market failures and competitive-disadvantages vis-à-vis dirtier incumbent options. The goal of industrial policy is to have competitive industries that can survive by themselves where clean technology diffuses on its own. Safeguards to ensure this will need to be installed by design.

4.2.3 Tackling the 4i's

4.2.3.1 How will the policy avenue address innovation?

Innovation, and the belief that new technologies will be key to addressing climate change, are at the heart of the Green Industrial Policy Avenue. Delivering on the innovation challenge means tackling the supply of innovation, creating demand for innovation, and establishing the right ecosystem for innovation.

Addressing the supply of innovation will be done in several ways. Most important will be large scale research development and demonstration funding (RD&D). This RD&D funding will be provided project-based in the context of the missions through research grants, and – for private-led development and demonstration – concessional loans or taking a stake in a company. Equally important is an increase in the base funding of universities and applied research institutions. RD&D support will therefore be targeted to specific areas, but also spread widely to stimulate and support research into areas that are much less known and may not be perceived as promising

solutions yet. This amounts to an extension of the Horizon Europe programme as well as national research programmes along EU guidance.

Standards and phase-out dates define the goalpost and provide direction for innovation. In doing so, however, standards need to be open to new technologies and innovative solutions: for this reason, performance standards are preferred over technology standards. Also, standards need to be defined in such a way that they encourage competition, rather than creating a barrier for market entry of new competitors.[15]

As technology matures, the emphasis of policy needs to shift from supply-side targeted policies, i.e., 'technology-push' policies, to 'demand-pull' policies. Technology costs strongly correlate with cumulative deployment, which highlights the role of demand (Grubb *et al.*, 2021). Demand creation will be achieved through subsidies and standards, as well as public procurement. These will incentivise investments in manufacturing capacity and induce processes of learning in production and economies of scale.

Innovation is not limited to the 'invention' of new technologies but includes all stages in the innovation chain to bring new innovations to the market, i.e., to market diffusion. Innovation therefore also encompasses customisation and manufacturing and is therefore about skills and capabilities in commercialisation (Nahm, 2021b, p. 36). Demand creation will consequently play an important role in supporting 'innovative manufacturing' and the rapid scale-up of solutions.

In addition to technology-push and demand-pull policies, facilitating collaboration and knowledge-exchange is important for innovation. This means creating the right 'ecosystem' for innovation. The policy avenue therefore encourages public-private and private-private collaboration through encouraging research consortia, funding for applied science institutes, and the formation of industrial hubs.

By making cleaner options more affordable, norms and values will adapt – self-sustaining market forces will scale up innovative solutions, once they are fully commercialised.

4.2.3.2 How will the policy avenue address investment and finance?

There are two premises of the policy avenue with regards to investment. First, that transitioning to a climate-neutral economy requires large-scale investments. And two, that due to fundamental uncertainty, due to the liquidity preference of financial actors, and due to path-dependencies, private investors are unlikely to invest at the scale necessary, resulting in an incomplete and chaotic transition (Mason, 2021; Krahé, 2022). There is thus a much greater need for the government to step in and conduct transformational investments and reduce uncertainty for private actors.

[15] By setting standards, governments can even create completely new markets. For example, standards on hydrocarbons and carbon-monoxide resulted in the creation of a market for catalytic converters (Vollebergh and van der Werf, 2014).

The state can reduce two main sources of uncertainty that hamper private investments (Chang and Andreoni, 2020b). First, it can reduce uncertainty about future technological developments by setting clear standards and phase-out dates. For example, an emission performance standard that effectively phases-out internal combustion engine provides clarity to manufacturers and investors that any future (re-)investments must be directed towards electric mobility or other non-fossil fuels. The policy avenue will therefore make use of (performance) standards to not just induce innovation and phase-out fossil technologies, but also to provide clear signals to investors about the direction of development.

The second source of uncertainty that the state can address concerns demand. In the absence of certainty about future demand for a certain good, manufacturers and investors are unlikely to invest in capacity to produce that good. Therefore, the state will step in to create demand through subsidies and tax credits for clean alternatives, green public procurement, labelling and certification, as well as standards. Reducing uncertainty about future technological developments as well as demand, will reduce market volatility and ensure that the transition happens in an orderly fashion.

Public investments do not have the same structural constraints as private investors do (Mason, 2021). It is therefore much more adapted to commit patient and high-risk finance of the kind necessary to fund breakthrough innovations and roll-out capital-intensive solutions (e.g., renewable energy, EV charging infrastructure, bike infrastructure, etc.) (UCL Institute for Innovation and Public Purpose, 2021). Public investments should not be reduced to 'de-risking' of private investments, i.e., to improve the risk-return profile of private investments by absorbing the risks fully on public balance sheets. Directly funding infrastructure projects will be more efficient and cheaper in most cases (Kedward, Gabor and Ryan-Collins, 2022). Member state development banks and the European Investment Bank (EIB) will be the main institutional channels for making transformative investments.

Importantly, the EU's funding schemes must be aligned and integrated into one comprehensive fund, dedicated to the transformation to climate neutrality – the Transformation Fund. This applies to parts of the different regional funds, parts of the innovation funding infrastructure (Horizon, Innovation Fund, and other R&D funding schemes) and new funds like the Social Climate Fund or exnovation funds, that support structurally affected regions and industries. A common fund will allow for coherence and streamlining of EU investment towards climate neutrality. Access to funding must be simplified. The funds will use different means to directly fund RD&D and other public goods like infrastructural projects, partially de-risk private investments through, e.g., loan guarantees, or direct project-based subsidies e.g., in the form of Carbon Contracts for Difference.

To mobilise the necessary financial resources, two reforms are important. First, the EU's fiscal rules will need to be reformed to allow member states to use more public borrowing for investments in a climate neutral economy (e.g., through introducing a 'green' golden rule). The current fiscal rules are unnecessarily restrictive and a barrier to the transformation to climate neutrality (Darvas and Wolff, 2021; Baccianti and Steitz, 2022). Second, common EU borrowing

is another source of funding that may enable more transformative investments. This could be modelled on the NextGenEU programme, although with more grants and better conditions on the loans. Conditionalities that the funds must be used for transformative investments will apply and will be set by the Mission Coordination Board. The MCB may even directly allocate some of the resources, especially when it comes to pan-European research or infrastructure projects. All this would also require a better alignment of fiscal and monetary policy.

Beyond these reforms to the EU's fiscal capacities, the policy avenue will reform the budget allocation in the MFF. Specifically, it will phase-out environmentally harmful subsidies (e.g., under the CAP) and redirect the funds to the Transformation Fund. New own resources for the EU will also increase the capital base of the Fund. These stem from, for example, the introduction of CBAM or the introduction of a financial transaction tax. Moreover, in the medium term, high prices in the EU ETS will result in increasing revenues that will however decrease as decarbonisation progresses.

A new approach to sharing the risks and benefits of public investments lies at the heart of the approach (see Mazzucato, 2013). This means the public sector will recoup some of its investments through appropriate corporate tax rates and / or taking an ownership stake in an enterprise or intellectual property where appropriate.

The regulation of the financial sector and monetary policy is another important element in the policy avenue for redirecting financial flows towards climate-friendly activities. This is done through, on the one hand, prudential regulation that requires financial actors to improve transparency, incorporate climate-related risks into their financial disclosures, or capital requirements. The aim of prudential regulation is to improve the internalisation of climate-related risks into the market pricing of private actors to ensure the stability of financial institutions and the financial system as a whole.

Since prudential regulation may not be sufficient for redirecting financial flows on their own, a more promotional approach may be necessary where monetary policy actively supports industrial policy goals (Kedward, Gabor and Ryan-Collins, 2022). This can take the form of active credit policies by the ECB, which restricts credit to "dirty" (i.e., fossil-intensive) sectors and directs it to clean sectors. This will be done through adjustments in the ECB asset purchase programmes, capital requirements for allocations to dirty sectors, credit quotas for green/brown sectors, portfolio restrictions, or dual interest rates.[16]

All funding schemes rely on sound criteria for demarcating "green" and "transformational" investments from those that are not. For example, credit quotas rely on a clear definition of non-eligibility. These definitions can be partially set through the standards described above. Another mechanism will be the EU's taxonomy, which will be aligned with the missions that are identified by the MCB. The missions, therefore, will constitute a core element of any financial taxonomy.

[16] See Kedward, Gabor and Ryan-Collins (2022, 18) for an overview of active credit policy instruments.

The MCB will coordinate these efforts but mandate the ECB in cooperation with the Expert Advisory Body of Climate Change to draw up criteria to avoid politicisation.

4.2.3.3 How will the policy avenue address infrastructure?

The missions will serve as the major EU coordinating mechanism for infrastructure development. A central goal will be to ensure that all the necessary infrastructure is in place to realise that the missions can be successful. When a mission is identified, an "infrastructure check" will be carried out to identify mission-related needs in that area. Integrated infrastructure planning will ensure that infrastructure enables integration across sectors and sector coupling. Member states will be mandated to implement integrated infrastructure planning and an EU-wide institution will be established to ensure the transboundary coordination of national infrastructure plans, where such coordination is necessary. The latter will build on the Trans-European Transport Network (TEN-T) and the Connecting Europe Facility, but as an own institution it will have the administrative capacity to coordinate the necessary infrastructure, and if necessary, also accelerate the planning and deployment of infrastructure to avoid bottlenecks. The financial volume of the Connecting Europe Facility will moreover be increased through a capital raise.

Since infrastructure development tends to be capital-intensive and requires long-term commitment, the emphasis of this policy avenue on public investments will be adequate to the task. Public investments will be channelled especially into those areas that are relevant for the transformation of industry like waste management infrastructure for industrial complexes, carbon capture and storage, or hydrogen infrastructure. In any way, there will be strong complementarities between infrastructure that primarily benefits industry and that benefits households, e.g., when it comes to district heating networks, transmission networks, or grid-level batteries.

As the state is the main developer of infrastructure, setting stringent green public procurement goals will guarantee that new infrastructure is constructed using climate-neutral materials, and also adhere to other sustainability criteria. All infrastructure projects that may be unrelated to a direct climate-neutrality mission will still be scrutinised to see whether they are aligned with the transformation. This concerns, for instance, the development of new road infrastructure.

While the policy avenue emphasises the public development and funding of infrastructure, it will also make sure that the costs and benefits of infrastructure will be fair and adequate. Charges for the use of infrastructure will be introduced where appropriate. This may be particularly relevant with regards to infrastructure for individualised mobility so that the external cost is borne by the beneficiaries of that infrastructure through, for example, the introduction of road or congestion charges.

4.2.3.4 How will the policy avenue address integration?

The industrial policy that is at the core of this policy avenue requires substantial coordination and the integration of different sectors. In addition, integration ensures that policy outputs are coherent, improving the efficiency and effectiveness of policymaking. One main integration mechanism will be the Mission Coordination Board, which identifies climate neutrality missions, defines standards, and sets targets. It identifies infrastructural needs and coordinates the efforts that are happening in different sectors. The high-level planning ensures that all potentials of sector coupling are realised, and measures are taken that are efficient from the perspective of the system as a whole. The MCB will also be responsible for coordinating EU with member state efforts.

Another instrument that facilitates integration is the Transformation Fund. It streamlines what used to be isolated funding mechanisms into one integrated mechanism for strategic investments in climate neutrality. The combination of MCB and Fund will ensure the coherence of regulatory policy with the EU's investments and infrastructural development. Another mechanism to integrate climate policy will be green public procurement, ensuring that all state expenditure is aligned with the climate neutrality goal.

Since the transformation to climate neutrality will result in structural change, the industrial policy approach must also include a strategy for regional transformation. This is particularly relevant in areas that used to be dominated by "brown" industries and where just transition mechanisms are needed. The mission framework allows for the strategic support for certain regions. It can, for example, consider how the localisation of new green industrial hubs may contribute to the just transition. Moreover, the mission framework will be aligned with cohesion policy, a key element of the EU's structural support policies.

Finally, the policy avenue is embedded in a strategic and coherent foreign (economic) policy approach. This requires *inter alia* actively pursuing technology partnerships, enshrining high environmental standards in free trade agreements, and pursuing an environmentally friendly reform of WTO rules. As a mechanism to ensure the competitiveness of its industry and to phase-out free allocation, CBAM will be introduced by 2025. Moreover, all standards, e.g., product carbon requirements, will also apply to importers to level the playing field and to diffuse high environmental standards to the EU's trade partners.

4.3 Policy avenue 3: Directed Transition

The Directed Transition Policy Avenue was developed around ideas from the planned transition paradigm described in section 3.2.3.

4.3.1 Core ideas and principles of the policy avenue

The Directed Transition policy avenue aims to reach climate neutrality through fostering **systemic change** that scales up and locks in clean technologies, and in parallel phases out fossil fuels. This is achieved through **science-based government intervention** at EU and national levels, in the form of a mix of targeted policy instruments that is well integrated across all sectors, flexible and just. Through this comprehensive policy integration as well as the provision of new infrastructure**,** nascent technologies become reliable. Governments regularly evaluate and adapt the policy mix to ensure that they follow an effective and efficient pathway towards climate neutrality, deploying clean technologies in line with changing market conditions and advances in technology and infrastructure.

In the Directed Transition Policy Avenue, **directed technological change** is the cornerstone of decarbonising our energy systems and of reaching the Paris Agreement. Market forces alone are insufficient to drive the transition to climate neutrality. Instead, government intervention – through a comprehensive and consistent framework of targets and standards – provides strong and effective guidance for the transition of our energy systems and economies, as well as funding.

Before new technologies move from the laboratory into commercial markets, they emerge in niche markets (Grübler, Nakićenović and Victor, 1999; Grubb, Hourcade and Neuhoff, 2013). Nascent technologies are more expensive as they provide a new function or service that does not match with incumbent technologies (Grübler, Nakićenović and Victor, 1999). In addition, to function reliably and at affordable costs, they require infrastructure – yet the existing infrastructure is geared towards the incumbent technologies. For these reasons, high up-front investment is needed to move a technology from its early, pre-competitive phase into the mainstream and to scale up deployment. Market mechanisms alone are unable to bridge this technological "valley of death" (Grubb, 2014 p. 320). Therefore, governments need to direct this transition by creating the necessary regulatory pull effect, driving the phase-in of clean technologies and the phase-out of high-fossil incumbent ones through targets, standards, and mandates, and by providing the necessary infrastructure. As standards become increasingly ambitious over time, they foster both the switch to clean alternatives, as well as the market exit of incumbent technologies (as currently practiced in the EcoDesign Directive or the Vehicle Emission Performance Standards).

Network effects triggered by a "directed" implementation of an array of multi-sector policies and support mechanisms drive down the cost of new technologies, which improves technological performance. The adoption of the technologies will eventually become a market-driven process. Strategic government support does not end once the technologies have left the niche market, but instead, remains until the new technologies have sufficiently matured and have become the

dominant option. To respond to technological and market developments, governance frameworks and policy mixes must be evaluated and adapted regularly.

In the Directed Transition Policy Avenue, price-based mechanisms such as carbon taxes or the EU Emission Trading System (ETS) can still be useful to support and accelerate the change – but they are not considered as an essential driver of the transition. For instance, price-based instruments can generate revenue for public investments, but they are not seen as sufficient, for instance, to break-out of a lock-in of fossil fuel technologies. Moreover, the distributional effects of carbon pricing make it hard to see how prices could reach the levels needed for transformative change without losing public support.

The logic of the Directed Transition Policy Avenue is based on the following principles:

- **Governments actively direct change, based on science:** At the heart of this policy avenue is the assumption that, to achieve climate neutrality, governments must change economic behaviour and structures. This involves making choices about technologies that can deliver and screening technologies for their probability of success. Acquiring detailed and up-to-date knowledge of market developments and technologies is a challenge for regulators – close and ongoing exchange between science and policy is therefore needed.
- **Targets, planning, and standards are at the core, complemented by support:** Governments must set binding targets and develop economy-wide strategies as well as sectoral roadmaps to provide guidance for market actors and policymakers on how to meet these targets. Infrastructure must be an integral part of these roadmaps. As the key tool to realise the roadmaps and achieve the targets, increasingly ambitious standards are an effective tool to foster alternatives and innovation, complemented by targeted support mechanisms.
- **Regular updating is a core feature:** Regular evaluation and revision of these instruments are a must for an effective directed transition, in order to adapt the policies to evolving circumstances. This involves putting in place the necessary tools to a) provide information on the speed and direction of structural change and technology development and deployment and b) assess the effectiveness of policies. These mechanisms ensure implementation of a policy mix that is responsive to socio-economic developments and changes in the political landscape, but at the same time continues to set a clear and shared long-term vision of the way forward.
- **Member states are in the lead:** While targets and standards are derived from the encompassing strategy in a top-down way, bottom-up action and experimentation remain important. Member state policies have a key role in triggering such changes at national, regional, and local level. Different approaches across member states enable experimentation and can help find effective policies.

4.3.2 Description of the policy avenue

To reach climate neutrality, policy makers set ambitious **targets** and establish **cross-sectoral roadmaps** towards them. Targets can take many different forms and become integrated into instruments (e.g., as caps or as standards). But in any case, they should derive from the scenarios and roadmaps. Targets are set at EU level – and while Member States are responsible to develop their domestic regulatory policies, the European Union has far-reaching authority to issue guidance for the determination of policies and control their implementation. An EU-wide carbon budget compatible with the global 1.5°C warming limit are established based on comprehensive scientific assessment. In line with this, the Effort Sharing Regulation (ESR) is further developed to establish comprehensive annual emission targets for each Member State, as well as indicative sectoral carbon budgets.

In line with their country-specific energy mixes and geographical infrastructures, member states then adopt ambitious national targets and strategies, laid out in their National Energy and Climate Plans (NECPs). EU scrutiny is to ensure that the national strategies remain consistent. This is particularly relevant where transboundary coordination is required to implement them (e.g., where transboundary energy infrastructure is concerned). Economy-wide **long-term planning** through technological and sectoral roadmaps helps the EU and member states to achieve these set targets. In these mandatory strategies, member states must lay out emission targets for each sector, in line with the available carbon budget. A core element of these plans will be phase-out dates for fossil energy carriers and for fossil-based technologies and value chains, in agreement with these emission reduction pathways.

Governments will intervene early in the technological development phase. The sectoral strategies will develop phase-out dates for fossil-based technologies, amounting to direct bans of technologies and, by extension, the value chains and business models they support. Implemented in the form of standards, they provide certainty to the sector and send clear signals to investors. Moreover, phase-out dates give greater certainty that emission reductions will materialise, and control for rebound effects – guaranteeing the environmental effectiveness of the strategy.

Standards are also an effective tool to drive and direct innovation. As **performance standards**, they lay out minimum operational requirements that products need to achieve, to reduce their carbon footprint during production, the energy consumption, and emissions during their use, but also e.g., compatibility with the requirements of a circular economy (durability, reusability, repairability, recyclability). Apart from fostering the development and deployment of lower-carbon technologies, standards also provide guidance and transparency to market players about the installation, utilisation, and maintenance of new operating systems.

This avenue requires a **capable public administration**, with significant capacity to carry out the (in part) detailed, cross-sectoral planning processes, and ensure effective implementation, as well as compliance monitoring and enforcement. Standards and other interventions must be science-based and draw on up-to-date information. Compared to other types of regulation, this

requires that regulators must have robust, objective, and up-to-date knowledge about existing and emerging technologies, their expected costs, and their performance. To avail of this information in an objective and transparent way, regulators must be in close exchange with different domains of science and research, suggesting an important role for public research agencies and coordination bodies that work at the interface between science and policy.

For a phase-out of fossil fuel technologies to be economically and socially feasible, reliable, and low-cost non-fossil alternatives must be available, along with the infrastructure and business models to support them. To commercialise new clean technologies and lead them to the mainstream, **public research, development, and demonstration funding (RD&D)** plays an important role. Financial resources allow researchers and developers to experiment and improve existing technologies, paving the way for commercialisation.

Public investment funds help to provide the high up-front capital that is needed to move immature and uncertain technologies from niche markets into widespread deployment. State funds can help to fund, for instance, the roll-out of the necessary infrastructure, to support transformative investments (e.g., through Carbon Contracts for Difference), but also to leverage private funds for technology firms and start-ups. Likewise, mandatory quotas for the use of low-carbon technologies or **green public procurement (GPP)** rules create demand for such products and give greater certainty for investors.

To ensure compliance with these standards and their effective implementation, it is important that governments introduce **evaluation and enforcement mechanisms**. This process, in addition to the adoption of stringent standards, helps to mitigate delays in the transition, and contains the risk of a possible rollback towards fossil fuel technologies.

Once governments have implemented a cross-sectoral policy strategy through which they guide the transition, **regular evaluation and revision of the strategy and the instruments** are crucial. Evaluation and feedback mechanisms provide information for policymakers on the speed and direction of structural change, technology development, and deployment. This may require new tools, such as net-zero indicators to assess progress on needed structural changes that align economic development with climate neutrality. The function of such net-zero indicators is also to ensure that, amid the flexibility required to changing circumstances, the longer-term vision remains clear, and that the regular evaluation and revision does not undermine the long-term certainty for consumers, investors and innovators.

While many climate-neutral solutions will lower cost and increase well-being in the long-term, ambitious standards and targets will often incur higher cost in the short-term, particularly where technological alternatives are at an earlier point on the learning curve. To sustain societal support for the transformation, governments must implement support mechanisms for sectors or low-income households that are most affected by these standards and provide them with feasible and affordable alternatives.

4.3.3 Tackling the 4i's

4.3.3.1 How will the policy avenue address innovation?

Innovation involves taking risks and making investments in uncertain developments. Therefore, investment and innovation go hand in hand. In this policy avenue, governments intervene and spur innovation at the different stages of the technology lifecycle. This takes various forms.

In the beginning, researchers and developers need high volumes of capital that allow for invention and experimentation. At this stage, public funding can have considerable leverage by providing (preferential) funding for particular technologies. Technology-specific research and development funds (R&D) serve as an effective instrument to cover the high up-front costs for innovation and experimentation (Grubb, 2014; Polzin and Sanders, 2020).

In the demonstration phase, new technologies emerge from niche markets to become mainstream. Governments can accelerate the commercialisation of breakthrough innovations, for instance, by supporting pilot and demonstration projects, real-life laboratories, or by creating lead markets for novel technologies. This allows to develop technologies further and lead them to market maturity. Usually, this is the moment when private investors realise the potential for future profits and become more eager to invest (Grubb, 2014; Kemper, 2015).

An important aspect of the Directed Transition Policy Avenue is cross-sectoral government intervention in innovation. For innovation to help overcome existing path dependencies that favour incumbent technologies, innovation needs to extend across sectors and disrupt business-as-usual.

If they are defined dynamically – i.e., with increasing ambition over time – standards can provide a strong stimulus for innovation, and give direction to the innovation process. Standards lay out the minimum requirements that products must fulfil to have market access. In the Directed Transition Policy Avenue, these standards become increasingly stringent over time – and thus also increasingly difficult, and eventually impossible to meet for conventional (i.e., fossil-based) products or processes. Standards thus foster both innovation (phase-in of new solution and continuous improvement), but also exnovation (phase-out of conventional technologies).

At the national level, governments push innovation processes further through, for example, quotas, auctioning mechanisms, or feed-in-tariffs. National and local governments further support the roll-out of these new technologies by ensuring that the necessary infrastructure for the new technologies is in place, and by creating the regulatory framework conditions so that new business models can emerge around these new technologies.

4.3.3.2 How will the policy avenue address investment and finance?

The sectoral roadmaps and transition scenarios provide a good understanding not only of the technological and infrastructural changes required, but also of the critical investment gaps for the

transformation to climate neutrality. Therefore, in the same way that standards and mandates direct technological change, an investment framework can give incentives to leverage private investment, provide public investment where private investment is not feasible or appropriate – and last not least also drive the disinvestment of private and public funds from fossil-based assets that will not become obsolete.

At the EU level, financial support takes place through overarching support mechanisms such as the European Investment Fund. At the same time, member state governments will execute most programmes. Therefore, state investment banks (SIBs) play a key role in guiding investments into net-zero projects.

In the same vein, the EU is limited in its capacities to reform member states' markets – this takes place at the national level. National governments foster bottom-up experimentation by introducing regulatory instruments such as feed-in-tariffs (FITs), quotas and auctioning. As demand-pull policies, these are important for commercialisation. Fossil-fuel or production subsidies, such as tax credits will be redirected from carbon-intensive forms of energy production to climate-neutral ones.

In the Directed Transition Policy Avenue, public sector procurement serves as a lever to create green lead markets. By serving as a "real-life demonstration of a technology's viability" (Hourihan and Atkinson, 2011, p. 8) , government procurement ensures guaranteed demand for climate-neutral products, and therefore incentivises investment into climate-neutral production and value chains.

However, it is not just public funding that supports the transition to a climate-neutral future. **Private investment** is also needed, for instance to provide the necessary capital for new infrastructure that supports the deployment of new, climate-neutral technologies. Yet to mobilise capital from, for instance, institutional investors such as sovereign wealth funds, pension funds or insurance companies, investment opportunities need to have a suitable risk profile. To attract investments from such actors requires tools to de-risk investment through public support. This can be achieved through different instruments, depending on the technologies in question: for widely available, mature technologies that are more costly but not highly risky, accelerated depreciation rules or investment tax credits offer suitable instruments. For less mature technologies with greater risks, price guarantees for low-carbon products in the form of Carbon Contracts for Difference (CCfDs) can provide the needed incentives and lower the risk for investors. Additionally or alternatively, large institutional investors could be mandated to fully align their portfolio into investments that are aligned with the transformation to climate neutrality, including a certain proportion of spending on climate-neutral infrastructure investment.

Effective phase-out dates provide private investors with the necessary certainty to plan their (dis-)investments accordingly. Through the adoption of science-based standards, moreover, economic actors have access to data that helps them to evaluate climate risks and make informed decisions about future investments (Vikas and Aiyer, 2021). The EU Taxonomy Regulation can have such an effect by providing a classification system of sustainable economic activities. Yet, in the same

vein as technological standards and mandates for clean technologies, the taxonomy needs to be reviewed and updated to ensure that it remains in synch with technological, economic and political developments. In this way, green financial standards can accelerate the re-direction of capital into clean technologies.

Investment support for end users will facilitate the adoption of climate-neutral technologies and help citizens adapt to stringent standards and ambitious targets. This is especially important in the buildings sector, where the renovation of buildings requires large sums of capital. 85 per cent of Europe's building stock are residential buildings of which half were built before the first thermal regulations entered into force (European Commission, 2022b). Governments can support households through, for example, grants, concessional loans, or tax credits.

4.3.3.3 How will the policy avenue address infrastructure?

New system infrastructure and institutions are necessary to adopt new technologies and effectively integrate them in the existing systems. Without these, incumbent (i.e., carbon-intensive) technologies will continue to dominate – they are "locked-in" and supported by the existing system of infrastructure and institutions (Unruh, 2000). Electric vehicles, for instance, would not diffuse beyond their current niche without a sufficiently developed charging infrastructure. In addition, new "carbon neutral" infrastructure will be rolled out. This means removing roads, or reassigning roads as bicycle lanes, removing concreted areas, creating parks, restoring ecosystems, and providing low carbon transport infrastructure. In the Directed Transition Policy Avenue, governments – especially at the national level – play a key role for the development of different types of infrastructure.

The provision of supporting infrastructure and networks has long lead times and demands planning, particularly since different types of infrastructure may affect each other. The cross-sectoral roadmaps offer a solid basis for integrated infrastructure planning: by specifying the envisaged / expected changes in energy, mobility, housing, and industry, they also allow an assessment what type of infrastructure will be needed at what point in the transformation – which allows to back-cast when infrastructure planning must be concluded.

Infrastructure thus must be an integral part of cross-sectoral roadmaps. In the case of spatial planning for public transport infrastructure, there is also a need for integration across governance levels, involving national, regional, and local governments. Targets are set for energy grid operators (TSOs and DSOs) to expand infrastructure that is necessary to accommodate new energy technologies on the supply and demand side (including storage and power-to-X), as well as IT infrastructure for effective coordination. The identification of projects of common interest (PCIs) that are necessary for the transition to zero-emission technologies can accelerate planning, improve access to (public) funding and facilitate the transboundary coordination.

Green public procurement (GPP) is an effective policy tool to build climate-neutral infrastructure as can be seen in the Nordic European countries such as Finland and Denmark. For example, in

Helsinki, the government advances climate-neutral development through public procurement, whereas the city of Copenhagen has rigorous standards for construction and civil works (Turley, Casier and Bechauf, 2022). Standards need to ensure that infrastructure is also compatible with the requirements of a circular economy, e.g., to facilitate the re-using or repurposing of existing infrastructure, as well as rolling out infrastructure to manage material and resource streams.

4.3.3.4 How will the policy avenue address integration?

Successful integration of new technologies, products or processes requires intensive coordination across different levels of governance, across national boundaries, and across sectoral sub-systems such as energy, mobility, and buildings. Targets and strategies, as described above, provide the framework to ensure that different processes remain aligned and coherent. Sectoral roadmaps are a core tool to facilitate sector coupling. They not only set clear targets for phasing-out carbon-intensive technologies and processes, but also describe the process for phasing-in new technologies. This includes identifying what infrastructure will be needed where and when, how supply and demand of energies can be best met, how synergies between sub-systems can be best harnessed, or what institutional changes may be needed.

In the case of electricity production, sector-coupling is an effective means to achieve smart energy consumption across sectors. The digitalisation of end uses through, e.g., smart-meters and accompanying pricing schemes and business models can enable effective electricity demand management and help balance the system, making the most efficient use of existing infrastructure. Yet sector coupling also increases the complexity of managing the overall energy system, as different parts of the system interact more strongly.

Member states and their local governments play a key role to facilitate sector coupling, for instance by providing the necessary cross-sectoral infrastructure. Electrification of heating through the installation of heat pumps (individually or as part of district heating networks), and decentralised energy production processes such as urban prosumer models will play an important role in achieving climate neutrality. Municipal heat planning offers one option to integrate these different approaches and to ensure that they are aligned and integrated. This implies the effective integration of supra-, national, regional, and local strategies.

To be able to respond to technological progress and market changes and to ensure up-scaling, policymakers must allow for the flexible adaption of sectoral roadmaps and instruments. The review and evaluation mechanisms will ensure that standards do not over-regulate private players and that incentives are in line with the goal of climate neutrality. Institutional support for private actors to achieve the targets and comply with standards will be provided. Similarly, governments will establish channels for collaboration and cooperation among private and public actors to improve information flow and ensure effective sector coupling.

4.4 Policy avenue: Sufficiency and Degrowth

The Sufficiency and Degrowth Policy Avenue incorporates ideas from the post-growth / degrowth, and ecological economics paradigms described in section 3.2.4.

4.4.1 Core ideas and principles of the policy avenue

The policy avenue "sufficiency and degrowth" aims to achieve human well-being and address climate change by reducing material and energy use, including via methods that could reduce economic activity. The policy avenue is based on two core premises: first, that the overall footprint of the economy on natural ecosystems is too large – efficiency improvements are necessary to reduce the size of this footprint but will not be sufficient to decouple economic activity from climate impacts in the time that remains. Second, the notion of economic growth (in particular when measured as GDP growth) is based on a fundamentally flawed understanding of human well-being, as it fails to account for many of the most important facets of human flourishing. The sufficiency and degrowth approach is synergistic with addressing two other major environmental crises at the global level – biodiversity loss and resource consumption, problems that – like climate change – are mainly caused by human economic activities.

Sufficiency and degrowth are approaches that fall outside mainstream EU environmental policy, which has focussed primarily on increasing efficiency and using technological change as the means of decoupling economic activity from environmental impacts such as resource consumption and pollution. In its Communication "'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality European Green Deal", the European Commission makes clear that the European Green Deal is the EU's "growth and competitiveness strategy", aiming to foster ambitious climate-emission reductions while growing the EU economy (European Commission, 2021).

However, a growth-based strategy for eliminating GHG emissions by 2050 remains a dramatic departure from recent historical experience. As can be seen in Figure 2**Error! Reference source not found.**, global GDP growth and resource use have been tightly coupled over the last 50 years while decoupling of GHG emissions from GDP has been modest, with GHG emissions continuing to rise in absolute terms, taking the world further and further from net-zero emissions.

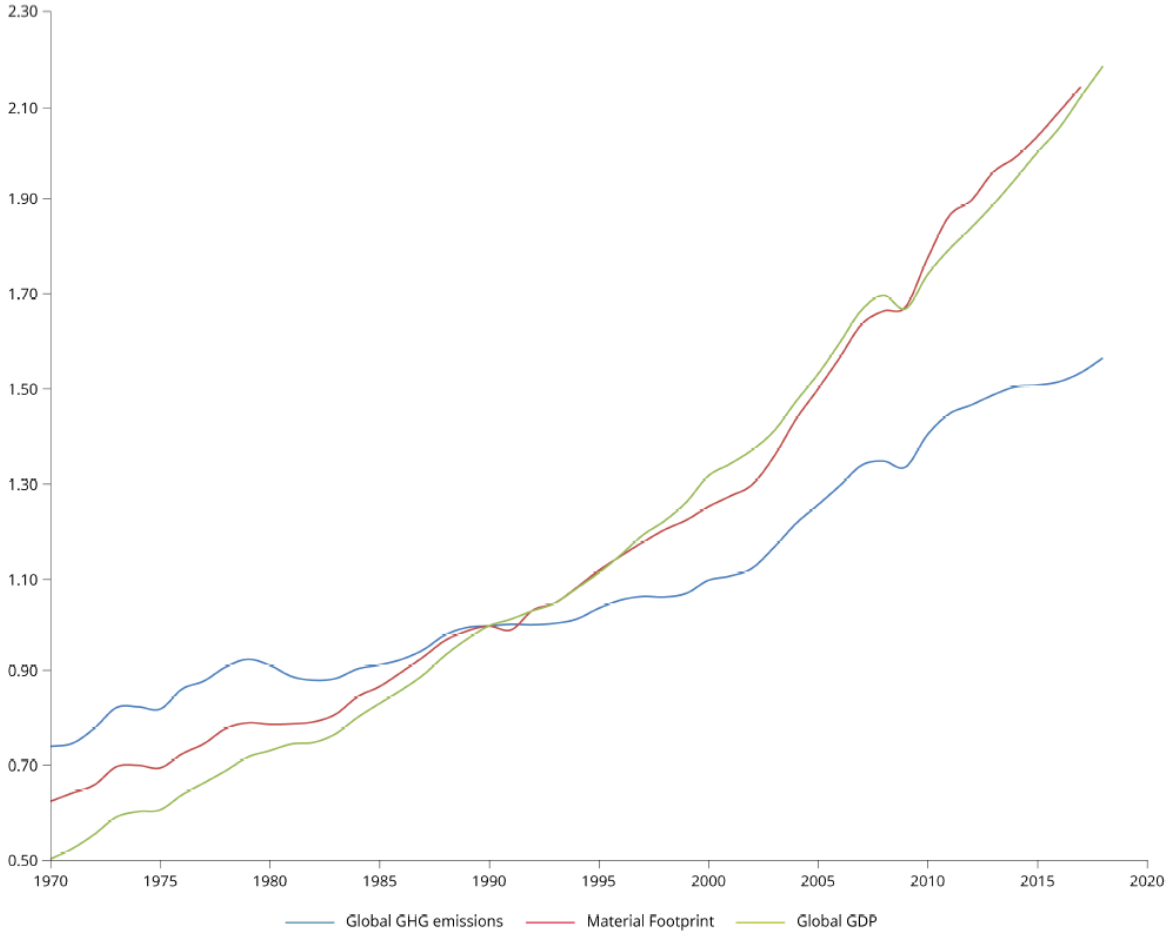

Figure 2 Global decoupling trends: relative change in GDP, greenhouse gas emissions and material footprint from 1970 to 2018

Notes: Indexed on 1990 values. Source: Reproduced from EEA (2022, p. 4). Modified from Wiedmann et al. (2020). Reproduced under the terms and conditions of the Creative Commons CC BY 4.0 licence (https://creativecommons.org/licenses/by/4.0/). Data from Olivier and Peters (2020) for greenhouse gas (GHG) emissions; UNEP and IRP (2018) for material footprint; and World Bank (2020a) for GDP.

The two concepts of sufficiency and degrowth are distinct but related. Sufficiency approaches focus on seeking "enough" and could help the overall economy deliver human well-being without growth.

Sufficiency is the active seeking of "enough" as a means of pursuing well-being within ecological constraints, even when "more" production and consumption are possible (Princen, 2005). Sufficiency is not synonymous with self-sacrifice. Sufficiency entails reimagining ways to meet human needs and aspirations, often by reconceiving the frameworks and infrastructure made available to individuals, thereby providing people with new and desirable options for living in ways that require fewer resources (BUND, 2022).

Degrowth is "the planned and democratic reduction of production and consumption as a solution to the social-ecological crises" (Fitzpatrick, Parrique and Cosme, 2022). Cosme *et al.* (2017) found

that degrowth policy proposals relate to three broad goals: (1) reducing the environmental impact of human activities; (2) redistributing income and wealth both within and between countries; and (3) promoting the transition from a materialistic to a convivial and participatory society. Degrowth is not synonymous with reducing GDP but does entail shifting away from the dependence on growth that characterises the contemporary economy (Hickel, 2020).

Addressing rebound effects

Rebound effects have been a persistent challenge for policy frameworks relying on efficiency and technological change to achieve environmental aims. Rebound effects occur when advances in technology and efficiency lead to lower costs, which in turn encourage additional consumption (i.e., a rebound), thereby undermining the original environmental aims.

Sufficiency and degrowth policies for mitigating climate change aim squarely at reducing rebound effects by addressing the underlying driver that leads to their emergence, namely that as the price for something harmful to the Earth's climate drops, demand for it increases. This can be done by 1) instituting policies that offset such price drops, e.g., taxes; and 2) changing consumption and production functions via other means, e.g., systemic, or infrastructural changes that affect the relative appeal of low-carbon versus high-carbon choices.

It should be noted that rebound effects are likely wherever significant populations remain interested in using the resources "left on the table" by others, can afford to use them, and are not prevented from doing so by policy constraints. To be effective, a sufficiency and degrowth strategy requires some means of preventing significant forms of such "leakage".

These underlying principles lie behind the sufficiency/degrowth policy pathway:

- **Economic growth is incompatible with decarbonisation.** Growth leads to higher energy and resource consumption, which then needs to be resolved with ever more efficiency. As the EU is headed for climate emergency, a more fundamental rethink of its economic model is needed – towards a more regionalised, circular economy that is geared at the common good. This rethink needs to result in systemic changes – not pushing the responsibility for sufficiency approaches onto individuals' shoulders, but rather changing economic and social institutions to facilitate stronger collective climate action at all levels.
- **Scepticism towards markets and efficiency.** Scepticism is warranted because a reliance on markets to increase production and consumption has led to significant environmental problems. Efficiency alone is not adequate, due partly to rebound effects, but also because policies that focus too narrowly on carbon efficiency may jeopardise other environmental and social goals (resource use and biodiversity in particular). Planetary boundaries apply, and thus absolute reductions are needed.
- **Flawed metrics of human well-being.** The scepticism towards markets also relates to the fact that conventional economic logic is based on a very limited and biased

understanding of human well-being, in particular regarding the use of GDP as an indicator of economic welfare.

- **A shaping role for institutions and governance.** Strong and value-based governance is needed to change underlying structures. Governance must be inclusive and participative but cannot offload responsibility onto the individual: the growth imperative is a structural problem that requires a structural solution.
- **Bottom-up, inclusive community-based climate action.** Successful climate action requires not merely public acceptance, but broad public support. As a social movement, the transformation to a climate-neutral society should mobilise the ingenuity of broad and diverse set of actors, to deliver social innovations and new economic models that prioritise well-being. Empowering local communities to develop their own solutions in an inclusive way is key to this.
- **Explicitly addressing norms and values.** Social behaviour is guided by norms and values. Sufficiency and degrowth requires have the explicit objective to facilitate the evolution of social norms through an inclusive, bottom-up process. This includes a more holistic approach to well-being –to improve both the mental and physical well-being of society, creating numerous benefits for productivity, health, and the economy at large.
- **Explicit recognition of social justice and equity.** Transformative climate policies need to ensure fairness and justice for all of society, including through the redistribution of wealth and minimising the distributional impacts associated with the green transition. As growth can no longer compensate for inequality, the equitable distribution of resources becomes more relevant. This also includes the explicit recognition of a right to have basic needs met – but no right to luxury.
- **Concerns about current EU climate and energy policy.** The imperative of (short-term) GDP growth is deeply embedded across EU policies, treaties, indicators, mindset, and with it a flawed concept of economic welfare. Decoupling of growth and emissions is considered an achievement, whereas absolute cuts are needed.
- **Convictions regarding policy mix.** Policy design needs to prioritise decarbonisation over growth. Policy options include measures to change behaviour and lifestyles, to degrow certain industries or transition them to circular modes of production and consumption, and to limit demand for emission-intensive goods and services. The policy mix should thus not only seek to reduce emissions, but also address values and norms and promote new concepts of well-being. Policies must create public goods and opportunities for convivial forms of living.

4.4.2 Description of the policy avenue

Building off the planned 'Fit for 55' policy package, which aims to achieve a 55% reduction in GHG emissions in the EU by 2030, the sufficiency and degrowth policy pathway adds further measures to achieve the EU's net-zero target by 2050.

Core policy instruments

The core instruments in the sufficiency and degrowth pathway include the following:

- **Pricing climate harm** – Continue existing market-based instruments that put a price on GHG and expand the instrument list (e.g., personal carbon budgets). Fully implement polluter-pays environmental pricing. Remove environmentally harmful subsidies. Ensuring the price of emitting GHG reflects its harms is a cornerstone of this policy pathway, as it is one of the most effective means of disincentivizing consumption and preventing rebound effects.

- **Just transition and social equity** – Deploy social equity instruments that support those negatively impacted by the transition to climate neutrality. This includes those segments of the population in lower income groups that are impacted by higher prices, as well as targeted support to individuals whose employment is threatened by the transition, or communities losing income.

- **Shifting public funding** – Shift EU funding toward low-consumption system innovations and away from subsidising high-consumption systems. Stop any state aid that benefits fossil fuels and nuclear power. Redirect public funding and investment based on criteria that directly relate to low-carbon lifestyles and production methods, while creating public infrastructure conducive to low-carbon lifestyles.

- **Systems innovation** – Promote systems innovations so that low-carbon lifestyles are attractive, and related innovations emerge sooner. Adjust infrastructure and social arrangements so that individual sufficiency decisions do not entail sacrifice, e.g., walkable cities, cycle paths and capable and effective public railways.

- **Bans** – Quickly phase out specific high-emitting technologies where lower-emission options exist, e.g., banning the use of coal and short-haul flights. Ban advertising for products that are the targets of phase-outs, e.g., for fossil-fuels, internal combustion engine vehicles or fossil-based heating systems.

- **Investment** - Refine the EU taxonomy for sustainable activities, creating investment criteria to guide both public and private investment to be in line with sufficiency and degrowth.

Supporting policy instruments

Present-day societies, governance, culture, and economics in the EU are deeply rooted in economic growth. The sufficiency and degrowth pathway thus entails paradigmatic change. In order to pursue sufficiency and degrowth within a democratic context, this pathway must appeal to a majority of voters. In addition, via its aim to remould individual and group behaviour around new preferences, the pathway entails important questions about how to respond to individuals and groups that retain values and preferred lifestyles contrary to the paradigm.

The supporting policy instruments listed here enable paradigmatic change:

- **Education** – Use education systems to mainstream sufficiency and degrowth approaches, providing young people with the perspectives and skills that can help them make sustainable life choices, choose careers, and find fulfilment in ways that will have lower negative effects on the Earth's climate.

- **Societal welfare** – Reform welfare initiatives for a post-growth society (e.g., universal basic services/income). Adopting universal basic income creates an effective safety net for all of society. Such welfare reform would reduce poverty and inequalities, improving the wellbeing of society.

- **Work-life balance** - Reduce working hours (e.g., a 4-day workweek) and encourage greater work-life balance with options for a good life outside the work-to-consume paradigm. A four-day workweek would enable society to place greater values on personal development, relationships, and education, whilst improving productivity levels.

- **Reduce labour taxes –** Policies will be needed to address the tendency for low economic growth to cause higher unemployment. Shifting the tax base from taxing labour towards taxing resource use and environmental harms would help maintain employment levels while creating incentives to use fewer raw materials and generate less pollution (Raworth, 2017, pp. 278–9).

- **Better measurements** – Prioritise and improve measurements of well-being to better understand the drivers behind it and monitor societal progress towards it. The EU must move beyond GDP growth as its primary measure for economic health, towards those that better capture the wellbeing of society within the constraints of the planetary boundaries.

Policy sequencing

Building on Fit for 55, existing core policies are continued and strengthened to include sufficiency and degrowth elements. Funding streams are aligned to sufficiency and degrowth criteria. The EU takes measures to ensure systemic innovation makes low-consumption lifestyles attractive. Policies in this phase could include:

- Continue existing core instruments of the Fit-for-55 policy package, e.g., ETS, ETS2, CBAM and Social Climate Fund.
- Refine the EU taxonomy for sustainable activities to be in line with sufficiency and degrowth. For example, by labelling the construction of new fossil-based infrastructures as unsustainable.
- Align the European Resource Adequacy Assessment with climate targets (this is a yearly review of adequacy of power plants for demand), to ensure that the EU's energy system can remain flexible and secure when faced with the transformation to renewable energy. Moreover, while uncertain growth potentials may hamper private development, the adequacy assessment must consider the energy system needs of meeting societal welfare.
- Align the Ten-Year Network Development Plan with climate targets (this is a biannual review of the European transmission network), to ensure that the required energy infrastructure for the transition has been planned for and implemented before the transformation takes hold.
- Full implementation of "polluter pays" environmental pricing for climate mitigation by 2030. This would be implemented by increasing stringency of existing market-based policies and use of new instruments (e.g., by tightening levels of the EU ETS cap, ending free allocation of emissions allowances, expanding sectoral coverage to fully include buildings and transport, or by implementing personal carbon budgets and trading).

The period after 2030 is characterised by deeper economic adjustments that embed sufficiency and degrowth in the economic framework. The work week is shorter, universal basic services and/or incomes are in place, and the education system is less growth centric. Policies in this phase could include:

- Reform the EU's Work-life Balance Directive. This may include, for example, strengthening policies to address gender inequalities in unpaid care and unequal pay).
- Encourage a shorter workweek (e.g., 4-days per week) with the EU encouraging, coordinating, and helping to finance this.
- Mainstream sufficiency/degrowth thinking into education (e.g., through mandatory subjects in school curriculums and university courses, or provide subsidised trainings for the general public through workshops and volunteer opportunities).
- Implement universal basic services and/or universal basic income (reform of welfare initiatives for a post-growth society), providing a safety net for all of society, encouraging participatory and collaborative climate action. This includes free access to key public goods and services such as education and health services but may also include access to culture.

- A strong social welfare net is underpinned by redistributive policies to address inequalities of income and wealth. This includes progressive income taxation, but more so a strong focus on the taxation of wealth including by progressive inheritance taxes. Moreover, taxes on luxury consumption (e.g., private jets, yachts, frequent flying etc.) will be introduced, addressing both overconsumption and inequality at the same time.

4.4.3 Tackling the 4i's

4.4.3.1 How will the policy avenue address innovation?

The sufficiency and degrowth pathway pursues systems innovations so that low-carbon lifestyles are attractive, and the necessary innovations emerge sooner. A challenge that will need to be addressed is how to mobilise funding for such systems innovations given that a sizeable part of its returns take the form of positive externalities.[17] Likewise, innovation support instruments in the EU need to be retooled to avoid an overly narrow focus on technological or business model innovation, and instead also promote social innovations, i.e. novel social practices that allow for more inclusive and participatory climate policies.

Innovation policies could include:

- Speed up implementation of circular economy initiatives with sufficiency in mind, fast tracking the regulatory measures proposed in the Circular Economy Action Plan (CEAP).
- Provide EU funding for low-consumption systems innovations, including low-technology ones.
- Include bans and phase-outs as part of innovation policy – these ensure that old, high-carbon activities are intentionally discontinued, thereby enhancing opportunities for new approaches.
- Introduce a "climate plus" service scheme wherein the EU makes pension contributions for time spent working on climate- and sufficiency-related endeavours.

4.4.3.2 How will the policy avenue address investment and finance?

The Sufficiency and Degrowth Policy Avenue redirects funds based on criteria that directly relate to low-carbon lifestyles and means of production. Compared to other policy avenues, overall investment needs as well as financial returns on investment will be lower in the sufficiency and degrowth avenue. There are three main reasons: 1) lower or negative economic growth decreases

[17] Systems innovations with synergistic benefits do occur as a by-product of respective actors pursuing their private interest (this is Adam Smith's well-known "invisible hand" observation). However, many of the systems innovations in the sufficiency and degrowth pathway will not be of this type, requiring instead intentional joint effort over the long term to bring them about.

the size of the future market for an innovation; 2) redistributive measures related to income, profit and wealth levels may decrease the size of potential gains; and 3) emphasis on social innovations, and behavioural solutions (and by implication less technological innovations), as well as more efficient use of existing assets, suggests less need to invest in new infrastructure. Investment and finance policies to incentive investments could include:

- Provide EU Cohesion Funds for local, participative sufficiency initiatives and climate adaptation.
- Accelerate building renovation by e.g., funding reskilling of labour, adopting green public procurement (GPP) for sustainable materials and compact/efficient construction through setting standards.
- Extend transition plan obligations for companies (extend obligations beyond transparency obligations to include enforcement of plan achievements; extend obligations beyond large/listed companies to include smaller ones).
- Oblige banks to have transition plans and to ensure that these are regulated, including a transparency requirement.

A further element are policies that aim to shift investments away from non-essential consumption / overconsumption. For instance, progressive and annually increasing consumption taxes for non-essential goods, progressive property taxes that increase with square metres per person of a dwelling, or car registration taxes based on vehicle weight and surface would all reduce demand for such non-essential consumption, and thereby also make them less appealing to invest in.

4.4.3.3 How will the policy avenue address infrastructure?

The sufficiency and degrowth pathway involves phasing out and banning several climate-damaging technologies – with corresponding implications for infrastructure – while creating infrastructure conducive to low-carbon lifestyles. Land-use planning and transportation systems represent promising areas where a sufficiency and degrowth approach could meet a high degree of public acceptance vis-a-vis present-day modes of living and transport. Overall, the new infrastructure that is required under this policy avenue should be more localised, more modular, and more flexible to allow repurposing for different uses. Successes in these realms could serve as catalysts for sufficiency and degrowth approaches in other areas. Infrastructure policies could include:

- Align gas market reform with gas phase-out directive and regulation, ensuring that new fossil-based infrastructure is phased out as soon as possible.
- Mandate an EU-wide coal phase-out from the electricity system by 2030 and introduce an immediate ban on coal-plant construction.

- Invest in EU energy infrastructure so it serves climate objectives (6th List of Projects of 2024 Common Interest).
- Ban short-haul flights while investing in transborder railway infrastructure.
- Scale back EU funding for construction of new roads.
- EU stimulus for walkable cities (e.g., the "15-minute city" wherein most daily necessities are within a walkable or bikeable distance).

4.4.3.4 How will the policy avenue address integration?

By fostering systems innovation, the sufficiency and degrowth pathway makes low-carbon lifestyles an attractive and easy choice for those living in the EU. Integration is quite central to the paradigm. Concerted thinking is needed regarding how to foster the requisite paradigm shift in society while minimising unintended side effects. Integration policies could include:

- Transform Common Agricultural Policy (CAP) for climate and sustainability, encouraging organic farming, agroforestry, and provision of land for biodiversity.
- Expand "cities missions" of EU to include sufficiency-specific elements and advance research in areas such as green urban planning required for reaching climate neutrality
- Introduce Energy System Integration Regulation (reform of the Energy Union toward increased synergy, efficiency, and solidarity), ensuring that an increasing share of renewables can be securely and flexibly accommodated into the European power grid.
- Refashion the European Bauhaus initiative to have a sufficiency-specific focus on redesigning city systems and the built environment.
- Change impact assessment methodologies so that certain requirements must be met/achieved including climate-consistency assessments.
- Encourage recycling banks and repair cafes; support right to repair initiatives to create an integrated EU circular economy.
- Regulate advertising, e.g., institute a ban on fossil-fuel ads, including for products that run on fossil fuels, as well as red meat.

The sufficiency and degrowth policy pathway is described above as a primary paradigm for EU climate policy to 2050. As mentioned, it is the furthest departure from existing EU policy and faces acceptance challenges among elected politicians, voters, and the public. Should these be too great for its implementation as the primary policy pathway, elements of it may have adequate acceptance for their adoption as elements of a different policy framework.

5. Core policy instruments across the avenues

A number of key policy instruments are featured in several policy avenues. Table 1 indicates in which policy avenues they feature and what relative importance it is assigned to them. They are briefly described below.

Table 3 Importance of Selected Policy Instruments across the four Policy Avenues

Policy Instrument	1. Green Economic Liberalism	2. Green Industrial Policy	3. Directed Transition	4. Post-/De-growth
Public Procurement	Low	**High**	**High**	Not mentioned
CCfD	**High**	Low	Not mentioned	Not mentioned
Prudential regulation	Not mentioned	Medium	Low to Medium	Medium
Technology Bans	Low	**High**	**High**	**High**
Integrated Infrastructure Planning	Medium	Medium	**High**	Medium
EU Transformation Fund	Low	**High**	Low*	Low*

Note: Own representation. *The policy avenues mention some form of investment fund but are less explicit that this should be a transformation fund.

Climate-neutral public procurement

The state is a major consumer of carbon-intensive materials through its public procurement. EU government's spending on public procurement accounts for 14% of the EU's GDP (European Commission, 2022c). This includes spending on infrastructure (roads, railways, etc.), public housing, other public buildings, as well as consumer goods. This means public spending is a major source of demand over which governments have discretion. Introducing sustainability criteria and standards for public procurement can therefore induce a substantial demand demand-pull effect for low-carbon products (Sapir, Schraepen and Tagliapietra, 2022). This can be a step towards creating lead markets and, by giving greater certainty to investors and innovators, may drive innovation and investment.

Carbon Contracts for Difference (CCfDs)

Carbon prices in the Emission Trading Scheme can fluctuate considerably. But since the carbon price determines which investments into emission-reducing technologies are financially viable, this leaves potential investors with the uncertainty if their investment will pay off. Besides this, for some of the more advanced emission reduction technologies to become viable investments, the carbon price would need to rise to very high levels – creating a problem for existing installations. Carbon Contracts for Difference are a variable project-based subsidy that is intended to address both issues. First, it guarantees a carbon price to investors: emission reductions that arise from the supported investment receive a fixed price, e.g., in the form of an add-on to the carbon price. Second, this guaranteed price – as a remuneration for emission reductions – is above the current carbon price, set at a level required to make the investment economically viable. It thus eliminates the price uncertainty and helps to bridge the cost gap between conventional technologies and low-carbon alternatives. To conclude a CCfD, public authorities agree with businesses about a fixed carbon price for a specific investment project and a defined period, the so-called strike price, which reflects the mitigation costs of the investment. If the carbon price on the market is lower than the strike price, the CCfD covers the difference. If the market price for carbon emissions is higher, there is no CCfD payment, but business may need to return any additional revenue from selling allowances (Gerres and Linares, 2020; Agora Industrie *et al.*, 2021).

Prudential regulation

(Macro-)Prudential regulation applies to banks and other financial institutions like insurance companies. It mandates financial organisations to systematically assess climate transition risks and physical risks from climate change and integrate these into their risk planning, in addition to the conventional prudential requirements. In practice, this requirement is implemented in the form of stress-tests, capital requirements, disclosure requirements, or transition plans for financial actors. The ECB has launched a supervisory climate risk stress test in 2022 to assess how prepared banks are for dealing with financial and economic shocks stemming from climate risk. Moreover, as part of the Corporate Sustainability Reporting Directive, large companies including banks may be obliged to develop and publish transition plans in which companies lay out how the transformation to climate neutrality affects their business, and how they intend to manage the transition. These macro-prudential instruments can play decisive roles in shifting financial flows form brown to green investments.

Mandated phase-outs of fossil technologies - technology bans

Technology or performance standards can be an effective instrument for phasing-out fossil technologies. Where it is certain that technologies, like oil or gas boilers for heating, or coal-fired power plants, are incompatible with any scenario for the transformation to a climate-neutral economy, standards can be effective to mandate the phase-out. This can either be done explicitly

– by banning the sale or use of certain technologies from a given date – or implicitly, by setting standards in a way that effectively prohibits the use of certain technologies by a given date.[18] The latter can take the form of performance standards that define requirements with regards to the operational emissions or energy use of a technology. Such standards provide clear signals to market participants. Mandated phase-outs therefore help to reduce uncertainty about future technological developments and direct innovation (Rosenbloom and Rinscheid, 2020). Relatedly, they can create demand for cleaner solutions, as dirty technologies are effectively banned from the market.

Integrated Infrastructure Planning

A climate-neutral energy system must integrate high levels of renewable energy sources that tend to be decentralised and variable. Moreover, energy supply must be matched intelligently with energy demand (4i-TRACTION, 2022). The electrification of end-use sectors requires new infrastructure – both by updating and expanding the existing electricity grid to accommodate new demand, but also for vehicle charging infrastructure. Likewise, the use of green hydrogen (e.g., in industry), or carbon capture and storage will only be a feasible option if the necessary infrastructure is available. In addition, much of the existing fossil-based infrastructure will need to be repurposed or decommissioned and dismantled – but in synch with the roll-out of new infrastructure. Finally, these infrastructure transitions also need to be coordinated with neighbouring countries, as different national transition plans will interact. Since the different types of infrastructure are interdependent – sometimes complementing each other, in other instances as alternatives - the respective networks and infrastructures must be planned in an integrated way. Currently, this integration is still lacking – planning of the electricity and gas grids is still done separately in the EU member states.[19] Moreover, there are both national and EU-wide planning processes.

An EU Transformation Fund

All policy avenues featured different investment programmes and funds. The EU has established EU funding mechanisms, like the Cohesion Policy, the Innovation Fund, or the Connecting Europe Facility. However, the EU has only limited own resources that it commands directly, and all funds are financed through member state contributions to the Multiannual Financial Framework. A dedicated (debt financed) fiscal capacity, in the form of an EU Climate Investment Fund or a Transformation Fund would help alleviate some of the shortcomings of the existing programs, most notably their small size and lack of focus on the climate transition. A fund could help fiscally constraint member states to make transformative investments into climate neutrality and alleviate some of the woes of the EU's fiscal rules (Baccianti and Steitz, 2022) (see Section 6.3). The

[18] While they may run on synthetic fuels or hydrogen…
[19] At EU level, there are the ten-year network development plans (TYNDPs) developed by the European Network of Transmission System Operators for Electricity (ENTSO-E) for the electricity and the European Network of Transmission System Operators for Gas (ENTSOG) for the gas network.

European Investment Bank may be tasked with managing the fund. In its design the fund could be modelled on the Recovery and Resilience Facility that was set-up in response to the pandemic's impact and financed through common EU debt (Darvas and Wolff, 2021; Baccianti and Steitz, 2022). In addition to its climate benefits, a Transformation Fund represents a fiscal capacity and can therefore also counteract some of the imbalances that emerge in the Eurozone and contribute to macro-financial stability, as pointed out by the IMF (2022).

6. Governance implications and political context

Based on the description of the four policy avenues, the following section discusses some of their implications for EU climate governance, and places them in the context of EU policy discussions. Drawing on some of the learnings from discussions held at the policy lab, it aims to highlight some commonalities and differences among the four avenues regarding their political implementation.

6.1 Political feasibility

All policy avenues have profound implications for EU climate policy and politics as it exists today. The implications for EU governance and its institutions will be discussed below in section 6.3. Preceding these considerations are questions around the political feasibility. The exercise to construct policy avenues was explorative and hypothetical. And while this necessary requires some abstraction from political realities, one must pose the question of their feasibility. Three aspects that relate to political feasibility came up repeatedly in the policy lab: the question of social and political legitimacy; the ability to administer the process, i.e., to what extent EU institutions are capable of implementing such policy; and the EU's ability to overcome policy lock-in and avoid regulatory capture.

For policies to pass and survive, they must have political support. This is true for individual policy instruments but even more relevant when it comes to broader reforms, as some of the policy avenues imply. For example, while the first avenue (Green Economic Liberalism) would connect well to the status quo of EU policymaking, the second (Green Industrial Policy) with its strong intervention in EU markets and large-scale public investment would require more sweeping changes of EU institutions and governance. This raises the question whether such widespread political change would find public support. Some working groups considered the question of political legitimacy extensively and discussed whether a larger involvement of expert advisory bodies (i.e., a technocratic solution) or climate assemblies (i.e., participatory and deliberative solutions) could be a solution. Furthermore, some policy avenues explicitly internalise the logic of building coalitions that will generate long-term political support for decarbonisation. This is the case with regards to the Green Industrial Policy Avenue, which assumes the supported green

industries will eventually pose an economic counterweight to brown industries (see Meckling *et al.*, 2015).

All but the first policy avenue (Green Economic Liberalism) rely heavily on government coordination, and suggest a stronger role for public policy to drive and direct the transition. A central question is therefore whether or not the EU institutions and its bureaucracy as they exist today are capable to deliver this coordination. This becomes relevant with regards to investment programs, the setting of standards, the development and enforcement of labelling and certification, infrastructure planning, the integration of different programs, and more. At the moment, the EU Commission and subsidiary agencies have limited resources and (personnel) capacities that are already exhausted by the current legislative processes and their implementation. Additional competencies and programs would add further strains. An obvious response would be to increase and improve institutional capacity (Meckling and Nahm, 2018, 2022). But even with increased administrative capacity, the question remains if the state is capable to coordinate the transformation. The first policy avenue (Green Economic Liberalism) is most sceptical of this.

Another related question is whether that of subsidiarity and whether coordination and implementation happen at the EU or are delegated to the member state level. In this respect, the second policy avenue (Green Industrial Policy) is premised most explicitly on greater centralisation of legal competencies, administrative capacities and budgetary resources at EU level, whereas the third and fourth policy avenue (Directed Transition, Sufficiency and Degrowth) would see less centralisation, or even a decentralisation of political decision-making.

The third dimension of political feasibility haunts all policy avenues equally, and politics more generally: the problem of path-dependency and the opposition by vested interests towards policy change (Seto *et al.*, 2016). Institutional arrangements structure the political contest and confer advantages to certain actors, or coalitions of actors. Other actors or coalitions therefore constantly contest these institutional arrangements and "new institutions or policy regimes are often the main prizes awarded to the victors" of political conflicts (Pierson, 2016, p. 134). Importantly, present political and economic institutions are the product of past conflicts, which confer significant advantages – in other words, power – to incumbents. In consequence, incumbents have not only the incentive, but also the political position to obstruct policy changes that are to their disadvantage, resulting in strong political and institutional path-dependency. This is a particularly acute issue in the realm of climate policy as the transformation to climate neutrality affects all areas of the economy and is bound to affect the interests of the actors who benefit from the status quo.

The privileged political position of incumbents moreover creates the risk of regulatory capture. All types of policy instruments are prone to capture: emissions trading systems can have generous free allocation rules (as is the case in the EU ETS), carbon taxes often include exemptions for certain types of emitters, performance standards can provide loopholes (as is the case in the EU's vehicle emission performance standards), and subsidies are granted to activities that do not need

them or should not receive them (e.g., company car taxation rules in many EU Member States). A key question for all policy avenues is therefore how they can overcome existing path dependencies and avoid that new regulations will be captured by incumbents. Moreover, policy must avoid future economic and technological lock-ins. While some policy avenues consider how their policies can build political coalitions that can sustain ambitious climate policy (e.g., Green Industrial Policy, see also Jenkins, Stokes and Wagner, 2020), all of the policy avenues must find ways to tackle the issue of path-dependency and regulatory capture. Meckling et al. (2015) argue that coalition building is an important pre-requisite for institutional change. Moreover, designing policies in a way that they are stringent, while at the same time adaptable considering new information is seen as an important feature of policy.

6.2 Robustness in turbulent times

The EU has been in crisis mode ever since the 2008/2009 financial crisis and the ensuing Eurozone crisis. Since then, the pandemic has tested the EU's ability to respond to crises. With Russia's attack on Ukraine, the associated geopolitical fallout, and shifts in domestic politics, EU policy has faced short-term pressures, asking for long-term responses. Systemic competition with China further complicates the political situation. Domestically, the EU is challenged by the rise of movements opposed to further EU integration (or to EU membership) and opposition to stricter climate policies. These geopolitical and domestic shifts make transformative climate policy in the EU challenging.

Nonetheless, citizens across the EU continue to express strong support for ambitious climate policies. In 2021, three quarters of Europeans expressed the view that European governments should do more to tackle the climate crisis. Nine in ten Europeans agreed with the goal of climate neutrality, and three quarters maintained that the cost of investing into the transition to climate neutrality would be cheaper than suffering the damage from climate change (EUROSTAT, 2021). But faced with increasing energy prices, it is all but certain whether public support for climate ambition remains at current levels, and whether the abstract support for climate goals also translates into acceptance of concrete policies – particularly if these policies visibly increase consumer prices. This poses a problem, above all, to policy avenues that strongly rely on carbon pricing, especially the Green Economic Liberalism.

The distributional effects of climate policy are discussed more prominently in the debate around the Fit for 55 packages than was the case with previous climate policy. This is because there is a perceived risk that distributional impact can cause political backlash and stifle opposition. Policymakers now consider support measures to compensate distributional effects, such as the proposal for a Social Climate Fund. In addition to fairness and equity issues within EU member states, there is also the solidarity dimension (i.e., addressing imbalances) between Member States. Both dimensions have played a role in the debates in the policy lab and can therefore be found in proposals in all four policy avenues.

A further facet of the ongoing crises is the heightened willingness of governments to intervene in markets. Likewise, governments tend to bypass normal procedures if these are considered too slow and cumbersome in the face of crisis or do not deliver desired results. In the early phase of the pandemic, this included state-led initiatives to manufacture or procure masks and other personal protection equipment, as well as ventilators, but also state support for the development and production of vaccines.

Following Russia's attack on Ukraine and the attempts to weaponize Russia's gas supply to Europe, interventions in gas and other energy markets have proliferated in the form of price caps, nationalisation of gas supply companies and of energy infrastructure. In the logic of the different policy avenues, the assessment differs as to whether this is primarily a cause for concern, or a reason for optimism: in the Green Economic Liberalism view, it is key that markets can function relatively undisturbed (within the confines set beforehand by regulation), as is the acceptance of the outcomes of market processes. By contrast, in the Green Industrial Policy and to some extent the Directed Transition avenues, public intervention into markets is not only acceptable, but in fact desirable: recent experiences in response to the pandemic and the energy crisis provide ample evidence of the risks and benefits of such interventions.

6.3 Whither reform? Implications for EU politics

The EU's fiscal architecture

Achieving the EU's climate goals will require massive investments.[20] All the developed policy avenues include some form of public investment or – at the minimum – funding facilities to de-risk private investment. However, the EU's fiscal rules, which are geared towards fiscal consolidation, impose a harsh constraint for the needed increase of green public investments.[21] The EU's fiscal rules have been critiqued numerous times for mandating fiscal restraint and consolidation when the opposite would be needed (Darvas and Wolff, 2021; Humphreys, 2021; Baccianti and Steitz, 2022; IMF, 2022). The compliance mechanisms, moreover, are said to be counterproductive for meeting criteria like the debt-to-GDP ratio, as fiscal consolidation may result in lower GDP growth. At present, most fiscal rules that emanate from the Stability and Growth Pact (SGP) are suspended in response to the pandemic and Russia's aggression against Ukraine. Many EU member states are currently non-compliant. However, in the absence of reform, many member states will soon need to implement fiscal consolidation measures with potentially detrimental effects for climate investments. Therefore, stakeholders in the policy lab have

[20] The *additional* public investments required in this decade to meet the EU's climate goals are estimated at between 0.5 percent and 1 percent of GDP per year.
[21] Most notably the prescription for a long-term debt-to-GDP ratio of no more than 60% and a maximum 3% budget deficit.

repeatedly highlighted the need to reform the EU's fiscal rules and the need for more financial resources.

There are numerous proposals for reforming the EU's fiscal rules, primarily the Stability and Growth Pact. Some are more fundamental, while others are targeted amendments to accommodate more climate investments. The proposal for a 'green golden rule' is an example of a targeted policy: it would exempt all net green public investments from the debt and deficit calculations of the SGP (Darvas and Wolff, 2021). Other, more fundamental, proposals include replacing fiscal rules by fiscal standards, the introduction of expenditure rules, introducing country-specific debt pathways, increasing the benchmark values (60% debt & 3% deficit limits) or the wholesale abandonment of debt and deficit limits (Humphreys, 2021; Baccianti and Steitz, 2022; CAN Europe and Finance Watch, 2022).

In addition to a reform of fiscal rules, stakeholders stressed the need for a new EU fiscal capacity and the possibility for common borrowing – something also proposed in the policy discourse (e.g., Baccianti and Steitz, 2022; CAN Europe and Finance Watch, 2022; IMF, 2022). Initiatives like an EU climate fund could be financed through member states contributions (which has implications for fiscal rules) or through common borrowing. In response to the pandemic, the EU for the first time has set up a fund (NextGenerationEU, NGEU) that is financed via a common borrowing facility called the Recovery and Resilience Facility (RRF). A climate investment fund could be modelled on NGEU, where member states must submit climate investment plans that are approved by the Commission (Baccianti and Steitz, 2022).

Lastly, the policy avenues and their fiscal needs have substantial implications for monetary policy. In 2022, central banks across Europe, most notably the ECB increased interest rates in the hope that it will stymie inflation. Higher interest rates will affect governments' ability to invest in climate neutrality due to both higher debt-servicing costs but also because capital costs for projects will be higher. The latter obviously affects private investments as well. This is a particular challenge for most investments into climate neutrality: investments into renewable energy generation, energy efficiency but also electrification of heating or mobility typically incur higher capital expenditure but are overall cheaper thanks to their lower operating expenditure. Higher interest rates clearly diminish the cost advantage and make such investments less attractive. A successful transition would imply the need for better fiscal and monetary coordination and a monetary strategy that accommodates the EU's transition to climate neutrality (van 't Klooster, 2022). However, a clear shift in policy would be needed to support the transformation *inter alia* through micro-prudential regulation, differential interest rates, the use of Targeted Longer-Term Refinancing Operations, or the ECB's collateral framework (de Boer and van 't Klooster, 2021).

In addition to the ability for more EU and member state borrowing for the transition, policy lab participants frequently raised EU own resources and state aid rules. While environmental taxation, auctioning of emission allowances and a Carbon Border Adjustment Mechanism are actual or potential sources of additional revenue, and can thus unlock spending, there is no reason why the budgetary space for public climate investments should be limited to revenues from climate-

related policy instruments. Likewise, a reform of the Multiannual Financial Framework will be important to shift funding from environmentally harmful activities (e.g., direct payments in the CAP) to climate-neutral ends. An active industrial policy, as is implied by different policy avenues (esp. 'Green Industrial Policy' and 'Directed Transition') may also require adjustment of state aid rules.

Coordination and subsidiarity

The developed policy avenues have implications for the powers and competencies of the EU institutions. Relations between EU and member states follow the principle of subsidiarity. Many of the policy options proposed in the avenues would have consequences for subsidiarity and the relative powers between the EU and its member states. This is the case with regards to own resources and potential new revenue streams from CBAM, for example. Closely related to this are concerns among stakeholders that the EU's unanimity requirements in tax policy are a major barrier to an environmentally sustainable reform of taxation.

Another area that may be affected are EU competencies in the areas of energy and infrastructure planning. While EU infrastructure projects and a dedicated agency (CINEA) exist, this is mostly limited to pan-European projects. Integrated infrastructure planning across infrastructures and across borders suggests a need for greater transboundary coordination, either bilaterally among neighbour countries, or at EU level. Similarly, the Energy Union remains an incomplete project. Improved transmission and a better integration of the EU's electricity market(s) has been identified as an important requirement for a transformation to climate neutrality. The Connecting Europe Facility has been facilitating and funding the development of some crucial pan-European energy projects, like the Biscay Gulf France-Spain interconnection. Nevertheless, energy and infrastructure planning remain member state competencies and there is only limited EU coordination. This means that the EU does not maximise its potentials when it comes to cross-border cooperation, especially in the energy sector where interconnection and flexibility will be key for climate-neutrality.

In addition to own resources, energy, and infrastructure, EU rules and regulations for public procurement feature in all policy avenues. The EU already sets minimum common public procurement rules that are transposed into national legislation. These rules mostly relate to the *how* of procurement and less to *what* is procured. In most cases, public procurement authorities only consider lowest price as the criterion for awarding contracts. Climate concerns play a secondary concern. The EU has made some efforts to improve the uptake of strategic concerns in public procurement, but this has been limited to providing guidance and the legal opportunity to consider innovation or climate considerations. Green Public Procurement in the EU remains voluntary and limited to certain goods. Enshrining climate standards in public procurement legislation would have clear implications on member state competencies and shift power from national to EU level. It naturally also relates to discussions on fiscal rules. Still, strong and EU-

wide harmonised standards for green public procurement is an important lever and something that must be deliberated in the EU institutions.

All in all, the policy avenues have implications for the sharing of powers between EU and member states. It is neither necessary, nor wise, to centralise competencies with the EU in all of these areas (e.g., infrastructure planning or energy). There are clear benefits in decentralisation and multi-level governance. However, there is a clear need for stronger coordination and institutional capacity for planning at the EU level. In some areas, it is wise to give more powers to the EU (e.g., public procurement) to level the playing field. Here, a debate on EU competencies will be unavoidable.

7. Conclusion

This report summarised four policy avenues that describe distinct climate policy choices for attaining climate neutrality in the European Union: Green Economic Liberalism that rests on emission trading and other market-fixing instruments; Green Industrial Policy, where the state pushes and diffuses clean technologies through investments and standards; Directed Transition, which leverages the role of standards and sector pathways to reach climate neutrality; and, lastly, Europe beyond Growth, that fosters lifestyle changes through sufficiency policies.

These four policy avenues were developed in collaboration with external experts and they each adhere to different design principles that follow from various traditions of (climate) policymaking. They highlight the different paths the EU could take to climate neutrality and can inform policymakers in their decisions going forward. In the course of developing the policy avenues, several challenges in EU policy and politics emerged that will be tantamount to address for any transformative climate policy. They relate to the EU's fiscal capacities and rules, the balance of power and competencies between EU institutions and member states, and the challenge of path-dependencies and vested interests.

Future work in the 4i-TRACTION project will analyse core instruments of the different policy avenues and provide an integrated assessment of the different policy avenues.

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Annex A: Policy Lab material

Participating organisations

Experts from the following organisations participated in the policy lab.

- 2050 Pathways Platform
- Agora Energiewende
- Breakthrough Energy
- CAN Europe
- CEFIC
- Client Earth
- Danish Council on Climate Change
- E3G
- European Climate Foundation
- European Commission, DG CLIMA
- European Commission, DG ENER
- European Environment Agency
- European Environment Bureau
- German Environmental Agency (UBA)
- IASS Potsdam
- International Energy Agency
- Jacques Delors Institute
- OECD Environment Unit
- OECD Foresight Unit
- Transport & Environment
- University of Ghent
- University of Münster
- University of Sussex

From the 4i-TRACTION consortium, experts from the following organisations participated:

- CE Delft
- Climate Analytics
- I4CE
- WISE Europa

Policy lab agendas

Workshop #1 – Setting the Scene

Date: 16 September 2022, 09:30 – 12:00, Online

Background and Objective

This first of three workshop introduces the structure and the objectives of the policy lab process, the four policy paradigms and the four cross-cutting transformation challenges that the policy avenues need to address: innovation, infrastructure, investment & finance, and integration across sectors. It will discuss to what extent the different paradigms are embodied in the current EU climate policy, and how this assessment may change through the Fit for 55 package and current political and economic trends. The online event will be recorded for the benefit of experts that cannot attend the first workshop of the policy lab.

Agenda

	Time	Agenda item	Presenter
1	9.30 – 9.45	Welcome and Introduction	Benjamin Görlach, all participants
2	9.45 – 10.00	Structure and objective of the policy lab process	Benjamin Görlach & Aaron Best
3	10.00 – 10.30	Key concepts: ▪ Four transformation challenges (the "4i's) ▪ Four policy paradigms	Benjamin Görlach
4	10.30 – 10.50	Q&A and feedback on the paradigms	
5	10.50 – 11.00	Break	
6	11.00 – 11.15	Input: How can EU climate policy be characterised, and where is it headed?	Benjamin Görlach
7	11.15 – 11.50	Discussion	
8	11.50 – 12.00	Outlook and next steps	Benjamin Görlach & Aaron Best

Workshop #2 – Constructing Policy Avenues

Date: 23 September 2022, 09:30 – 17:30

Venue: Brussels School of Governance (BSoG) Boulevard de la Plaine 5, 1050 Brussels Floor -1, Room "Lisbon" and "Rome". (More detailed instructions below. Google Maps.)

Background and Objective

This workshop is the core part of the policy lab. Experts will develop the four policy avenues in small working groups, with each policy avenue consisting of a mix of policy instruments, combined to embody one of the four paradigms. Policy instrument packages will be sequenced over time (before and after 2030) and structured around the 4i challenges. Finally, groups' will discuss the main implications of their policy avenues for the EU and present their results in the plenary.

Agenda

	Time	Agenda item
0	From 9:00	Arrival and Registration
1	9:30 – 10:30	Welcome and Introduction Introducing the workshop and formation of working groups
2	10:30 – 10:45	Break
3	10:45 – 12:30	Working Group Session I Selecting policy instruments for climate neutrality
4	12:30 – 13:15	Break
5	13:15 – 14:30	Working Group Session II Addressing the 4i challenges
6	14:30 – 14:45	Break
7	14:45 – 16:00	Working Group Session III: Addressing the 4i challenges
8	16:00 – 16:45	Working Group Session IV: Governance Implications
9	16:45 – 17:00	Break / Reconvene in Plenary
10	17:00 – 17:30	Gallery Walk and Close

Workshop #3: Review, refine, and consolidate

Date: 30 September 2022, 09:30 – 12:00, Online

Background and objectives

This last workshop brings the results of the policy lab together. This session is aimed at validating results, giving all the experts an opportunity to discuss and assess the policy avenues developed by other groups. The group will also discuss what implications the policy avenues would have for the future of the EU.

Agenda

Time	Agenda item	Format
9:30 (10')	**Welcome and introduction**	Plenary
	Parallel break-out session 1: Economic Liberalism | Green Industrial Policy	
9:40 (10')	Presentation of policy avenue by moderator	2 break-out groups
9:50 (20')	Scrutiny and plausibility check (discussion)	
10:10 (20')	Feasibility and robustness (discussion)	
10:30 (5')	*Break/transition*	
	Parallel break-out session 2: Directed Transition | Degrowth and Sufficiency	
10:35 (10')	Presentation of policy avenue by moderator	2 break-out groups
10:45 (20')	Scrutiny and plausibility check (discussion)	
11:05 (20')	Feasibility and robustness (discussion)	
11:25 (5')	*Break/transition*	
11:30 (30')	**Implications for EU governance framework**	Plenary

Paradigm descriptions provided to policy lab participants

Participants were provided with descriptions of the policy paradigm in two forms: A more neutral description and a persona.

Neutral Descriptions

	**Paradigm 1:** **Harnessing markets to drive deep decarbonisation** **(Green Economic Liberalism)**
What is the core of the problem?	Climate change is the result of a market failure. Since external costs are not internalised, prices do not tell us the ecological truth. As a result, markets do not function efficiently, and mis-allocate resources to harmful economic practices. The main function of climate policy is to correct this market failure.
Attitude towards markets	Markets are the most powerful driver for change – and if put to the right use, can be a highly efficient and effective tool, discovering new solutions and delivering rapid change. They are also an extremely powerful coordination mechanism to orchestrate efforts of numerous players across sectors. If prices are corrected and externalities accounted for, there is no reason to be concerned about the outcome of the market process.
Role of institutions and governance	Less government intervention is generally preferable. Where governments intervene into markets, it should be to correct market failures and allow markets to work better. Government bureaucracies often lack information and incentives to make efficient choices, rent-seeking and regulatory capture further exacerbate this.
Concerns about current EU climate and energy policy	An over-reliance on heavy-handed regulation, and a poorly aligned mix of many different instruments makes current EU climate policy unnecessarily costly. A more streamlined and more efficient policy would make climate protection cheaper for society. This would enable greater ambition and ensure public acceptability.
Convictions regarding policy mix	The policy mix should be as lean as possible – complexity and overlaps create friction and inefficiencies; they reduce the transparency of policies and encourage rent-seeking. The policy mix should be organised around market-based instruments (including carbon pricing). Complementing instruments are justified where they support and enhance the functioning of market-based instruments, remove barriers, or where they specifically mitigate undesirable side-effects.

	**Paradigm 2:** **Climate neutrality as the EU's Moonshot Project** **(Green industrial policy, green Keynesianism)**
What is the core of the problem?	Because of fundamental uncertainty and coordination problems, private players will not invest sufficiently into the transformation to climate neutrality. As a result, solutions will not scale fast enough. The regulator therefore needs to step in to strategically restructure the economy to climate neutrality and take on part of the transition risk.
Attitude towards markets	Markets can be powerful to scale up solutions, and private initiative and investment will be needed to master the transformation. But without active guidance and support from the public sector, markets will not develop solutions at the necessary scale and pace. Also, markets require directionality and enabling conditions (e.g., infrastructure, regulatory framework).
Role of institutions and governance	Governments and public institutions should assume a central coordination role in restructuring individual sectors. The state should enable and support private initiative by investing in innovation, creating conditions that allow technological solutions to scale up, re-distributing risks, creating demand for low-carbon solutions, and stepping in where private player cannot or will not invest. Also, government has a role to manage / resolve distributional conflicts.
Concerns about current EU climate and energy policy	The EU is too cautious and punches below its weight as a provider of key technologies. Through its economic basis, its (public and private) research landscape and its public institutions, the EU has the potential to shape technologies and markets globally. But to do so, it must assume a greater role in directing structural change.
Convictions regarding policy mix	The regulator should coordinate private and public players, scale technological solutions, provide direction for markets, and shape industrial ecosystems. Policies should promote competition to drive down costs, but also make sure competition leads into the right direction. As the outcomes cannot be known in advance, some redundancy in the policy mix is unavoidable. Since policies are meant to incentivise investments into key technologies and supporting infrastructure, regulation cannot be technologically neutral. Instead, the challenge is to find approaches that are open to new technologies, as well as efficient ways of sharing the risks and the returns of transformative investments between private and public actors.

	**Paradigm 3:** **Directed transition to climate neutrality**
What is the core of the problem?	Technological and economic path dependencies and vested interests lock the economy onto a fossil- and emission-intensive path. Overcoming these path dependencies requires strong regulatory guidance – including policies that explicitly address fossil-intensive value chains. Changing the status quo through regulations involves a risk of not getting the solution exactly right – but that is preferable to losing more time.
Attitude towards markets	Faith in markets is limited – markets can be effective, but to deliver desirable and acceptable outcomes, they need strong regulatory guardrails. All too often, enthusiasm for free markets is a thinly disguised effort to delay necessary interventions and preserve the status quo. Strong faith in government to set regulatory guardrails in the right way.
Role of institutions and governance	Transformative policies need strong coordination, which only governments can (legitimately) deliver. This includes planning in the form of sectoral and regional strategies, scenarios, roadmaps etc., as well as (sectoral) targets and carbon budgets. These tools should send clear signals to the market – where to invest, but also where to disinvest.
Concerns about current EU climate and energy policy	Current EU climate and energy policy is too committed to economic efficiency, to the detriment of effectiveness and efficacy. Technological openness is invoked by those that are opposed to greater climate ambition (and thus favour weak regulation). Reliance on pricing as the main driver of change is highly risky in light of distributional impacts, and risks undermining social acceptance.
Convictions regarding policy mix	At this point, picking winners is unavoidable. While surprises are inevitable in this process (including the risk of getting it wrong), this risk is negligible compared to the risk of delayed action. Also, in many instances the solutions are becoming clearer, and technological races can be called (e.g. electrification of transport and space heating). As a flipside to picking winners, policies also need to address the phase-out of technologies that do not have a future and manage their decline. Policies therefore can be technology-specific, but also need to be resilient to changing circumstances and unforeseen events. Strict norms and/or bans are warranted to set guardrails, give clear orientation for the market, and reduce emission with certainty.

	**Paradigm 4:** **Europe beyond growth** **(Ecological economics, de-growth and sufficiency)**
What is the core of the problem?	Economic growth is incompatible with decarbonisation. It leads to higher energy and resource consumption, which then needs to be resolved with ever more efficiency. As the EU is headed for climate emergency, a more fundamental rethink of its economic model is needed – towards a more regionalised, circular economy that is geared at the common good.
Attitude towards markets	Scepticism is warranted, markets got us into this mess in the first place. Efficiency alone will not save us – due to rebound effects, but also since policies that target carbon efficiency may jeopardise other environmental and social goals (in particular resource use and biodiversity). Planetary boundaries apply, and thus absolute reductions are needed.
Role of institutions and governance	Strong and value-based governance is needed to change underlying structures. Governance must be inclusive and participative but cannot offload responsibility onto the individual: the growth imperative is a structural problem that requires a structural, collective solution.
Concerns about current EU climate and energy policy	The imperative of (short-term) GDP growth is deeply embedded across EU policies, treaties, indicators, mindset, and with it a flawed concept of economic welfare. Decoupling of growth and emissions is considered an achievement, whereas absolute cuts are needed.
Convictions regarding policy mix	Policy design needs to prioritise decarbonisation over growth. Policy options include measures to change behaviour and lifestyles, to degrow certain industries or transition them to circular modes of production and consumption, and to limit demand / reduce overconsumption of emission-intensive goods and services. The policy mix should thus not only seek to reduce emissions, but also address values and norms and promote new concepts of well-being. Policies must create public goods and opportunities for convivial forms of living.

Persona Decriptions

Paradigm 1: Harnessing markets to drive deep decarbonisation

FEMKE

42, studied economics in Tilburgh and at LSE

two kids, passionate cyclist and kite-surfer

Completed her PhD on the effects of EU financial market liberalisation

worked for the Dutch Central Bank and ECB before joining the EU Commission in 2014

After DG Ecofin and DG Grow, now member of Timmerman's cabinet

Ambition: demonstrate that economics and climate policy can and must be aligned

When it comes to climate change, what do you see as the core of the problem?	The core of the problem: prices do not tell us the ecological truth, external costs must be internalised. Therefore markets fail to deliver socially optimal outcomes and misallocate resources, creating unnecessary welfare losses and stranded assets.
What is your attitude towards markets - are they part of the problem or of the solution?	Markets are the most powerful driver for change – and if put to the right use, can be a highly efficient and effective tool. If prices are corrected, markets will drive change into the right direction, and there is no reason to be concerned about the outcome.
How do you see the role of governments in climate policy?	The function of governance is to correct market failures, to realise the full potential of market-based instruments. Beyond that, less government intervention is preferable - businesses know more about abatement options, while governments are vulnerable to lobbying and rent-seeking.
Looking at current EU Climate Policy, what is your biggest concern?	Current EU climate policy is too heavy-handed and interventionist. Such regulation makes climate policy unnecessarily costly - make policy means more efficient means climate protection at lower cost, which means greater ambition becomes possible.
What should the ideal instrument mix for climate policy look like?	It should be as lean as possible - overlaps create friction and inefficiencies, they limit transparency and accountability. Carbon pricing should be at the core - and once externalities are corrected for, the state should not mess with the price mechanism.

Paradigm 2: Climate neutrality as the EU's moonshot project

Aadam

44, studied engineering and data science in Tallin and Aachen

worked for HSBC (NY), joined green venture capital funds in Tel Aviv and Singapore before moving into consulting in 2009

Advised the Estonian, Finnish and Swedish governments on green transformation strategies

In 2021, elected vice-chair of Uvdl.'s Advisory Body for implementing the European Green Deal

Ambition: find ways for governments to scale climate solutions and collaborate with the private sector

When it comes to climate change, what do you see as the core of the problem?	Mitigating climate change is a massive coordination problem. Many solutions are known but under conditions of fundamental uncertainty, private actors are unlikely to invest in them. Shifting from brown to green industries needs macro-level management and a risk-taking state.
What is your attitude towards markets - are they part of the problem or of the solution?	Markets can be powerful to scale up solutions. But before that, they need support, clear guardrails, and direction. Moreover, the transformation will need innovation and a lot of new infrastructure that markets are unlikely to deliver on their own.
How do you see the role of governments in climate policy?	The state must actively create a green economy by formulating a mission, making transformative investments into key technologies, and coordinating public and private initiatives. It should also support the skills and infrastructure required for climate neutrality.
Looking at current EU Climate Policy, what is your biggest concern?	EU policymakers have too much hope that private actors will invest in low-carbon technologies and infrastructures on their own - it won't happen, not at the scale needed. The EU has what it takes to be a global green leader, but it is held back by old industries and dogmas fearing change.
What should the ideal instrument mix for climate policy look like?	Policy should facilitate the creation of green technologies and industries by making transformative investments and coordinating public and private initiatives. Industrial policy is at the core of the mission but in the end, we need an 'all of government' approach.

Paradigm 3: Engineering the transition to climate neutrality

Giacomo

53, studied chemical engineering in Milan and Montpellier

Three children and one grandson, opera lover, passionate about cooking

Environmental manager at Eni for 5 years, then head of unit at the Italian Institute for Environmental Protection and Research (ISPRA)

Joined the EU Commission in 2014, first Head of Unit at DG ENV, since 2018 at DG Clima

Recently appointed to lead the Commission's Initiative for Deep Decarbonisation of EU Industry

Ambition: set conditions to drive the change that we know is possible - together with industry, but with government in the lead.

When it comes to climate change, what do you see as the core of the problem?	Many solutions are known at this point, and time is running out - systemic change takes time. But in the economy there are powerful forces that resist change since they profit from the status quo. Governments need to step up and give clear direction and guidance.
What is your attitude towards markets - are they part of the problem or of the solution?	My faith in markets to deliver change is limited. Markets will only deliver desirable results if they are embedded in stringent regulation, if the goals and the rules are clearly defined and enforced. Only government can do that, left to themselves markets create chaos and injustice.
How do you see the role of governments in climate policy?	Governments must set a clear framework and targets for sectors and for technologies - this includes directly mandating the phase-out of fossil technologies. This will not be perfect, but don't let perfect be the enemy of the good. We know what needs to be done, so let's do it.
Looking at current EU Climate Policy, what is your biggest concern?	We have run out of time for a technology-open search process where competition will deliver the optimal outcome. Yet this is still the dominant mindset. Relying too much on carbon pricing is a very risky bet, in the light of distributional impacts and public resistance.
What should the ideal instrument mix for climate policy look like?	We will not get around directly regulating and phasing-out dirty technologies. We will need to pick winners and losers. This actually provides clarity and orientation so the market can invest. There will be surprises, so we need to factor in some flexibility too.

Paradigm 4: Europe beyond growth

Aurelie

39, studied political science in Grenoble, Barcelona and Louvain

Organised the post-growth youth congress in 2004 - 2015

Member of the French Council for Sustainable Development and the European Scientific Advisory Board on Climate Change

Parallel to completing her PhD, Worked as campaigner for WWF Europe and FoEE

sold 1.3 million copies of her popular science book "better life, healthier planet, smaller economy"

Since 2018, holds the first professorship for post-growth economics at Toulouse University

Ambition: system change, not climate change - and portray a positive image of the fundamental change that is ahead

When it comes to climate change, what do you see as the core of the problem?	The underlying logic of our global economic system is built on an impossibility—never-ending economic growth on a finite planet. Present efforts to decouple economic activity from climate impacts will proceed too slowly unless we also reduce our total economic metabolism.
What is your attitude towards markets - are they part of the problem or of the solution?	Market capitalism is driven by a growth imperative, with capital markets currently designed around chasing the highest *financial* returns. We need markets that chase the highest *well-being* returns. Non-market activities (like unpaid household labor) are also essential for well-being.
How do you see the role of governments in climate policy?	Governments need to address the systemic problems that keep everyone hooked on growth. An honest look at the facts shows that systemic change is inevitable—will we implement constructive change responsibly? The alternative is terrifying.
Looking at current EU Climate Policy, what is your biggest concern?	Current policy is based on the illusion of maintaining high levels of GDP growth while effectively addressing the climate crisis. Politicians tell us we can press the accelerator and brakes at the same time. But efficiency alone cannot save us - nature sets an absolute, finite limit.
What should the ideal instrument mix for climate policy look like?	Our policies need to counter rebound effects where efficiency improvements just lead to more growth. The ideal policy mix will meet basic needs, reduce inequality and respect planetary boundaries. To overcome growth imperatives, policies also need to address norms and values.

Annex B: Policy Avenue posters

The following are digital reconstructions of the posters created at the policy lab.

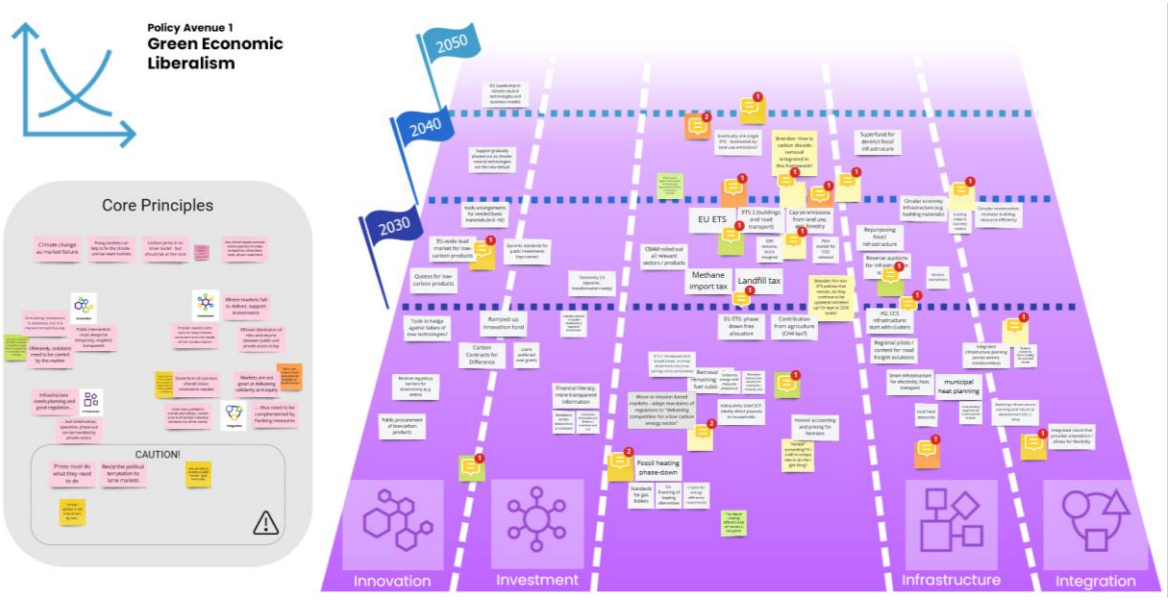

Figure 3 Green Economic Liberalism Policy Avenue

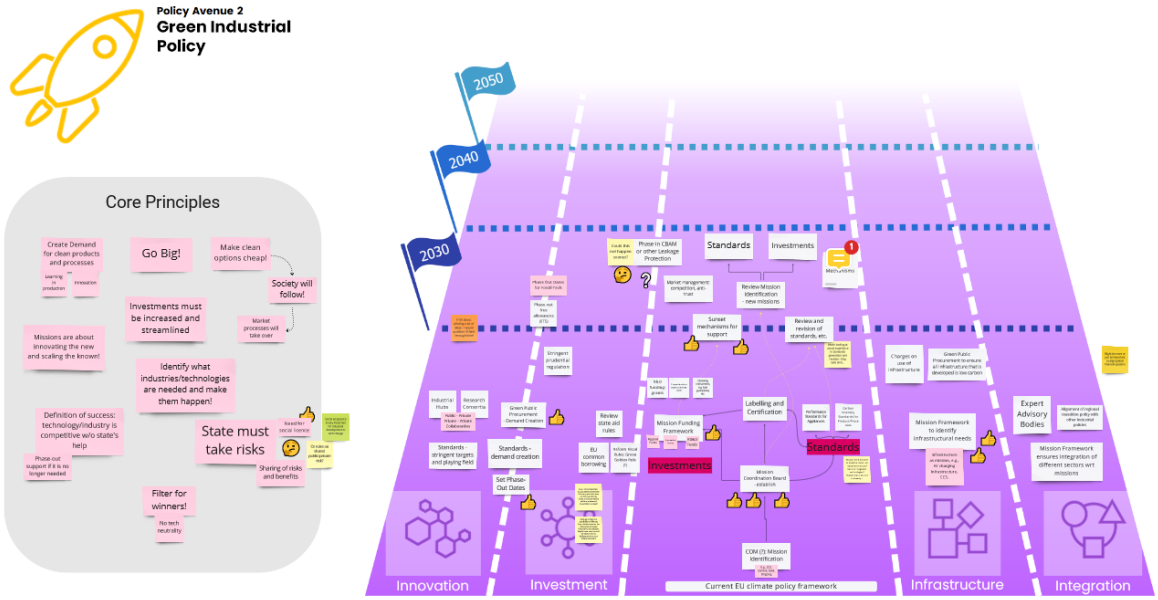

Figure 4 Green Industrial Policy Avenue

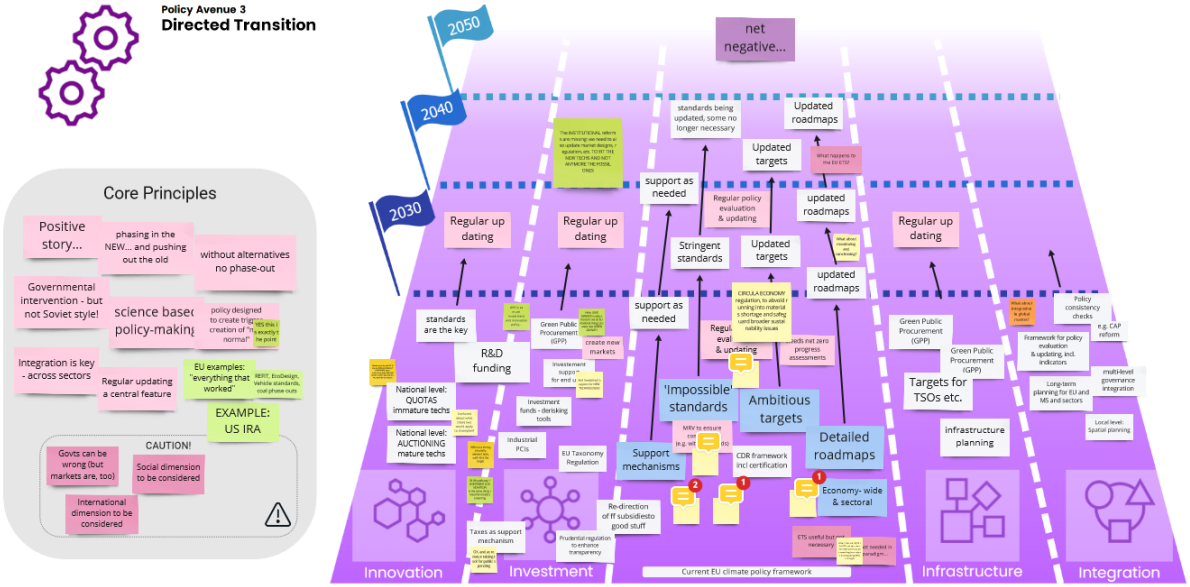

Figure 5 Directed Transition Policy Avenue

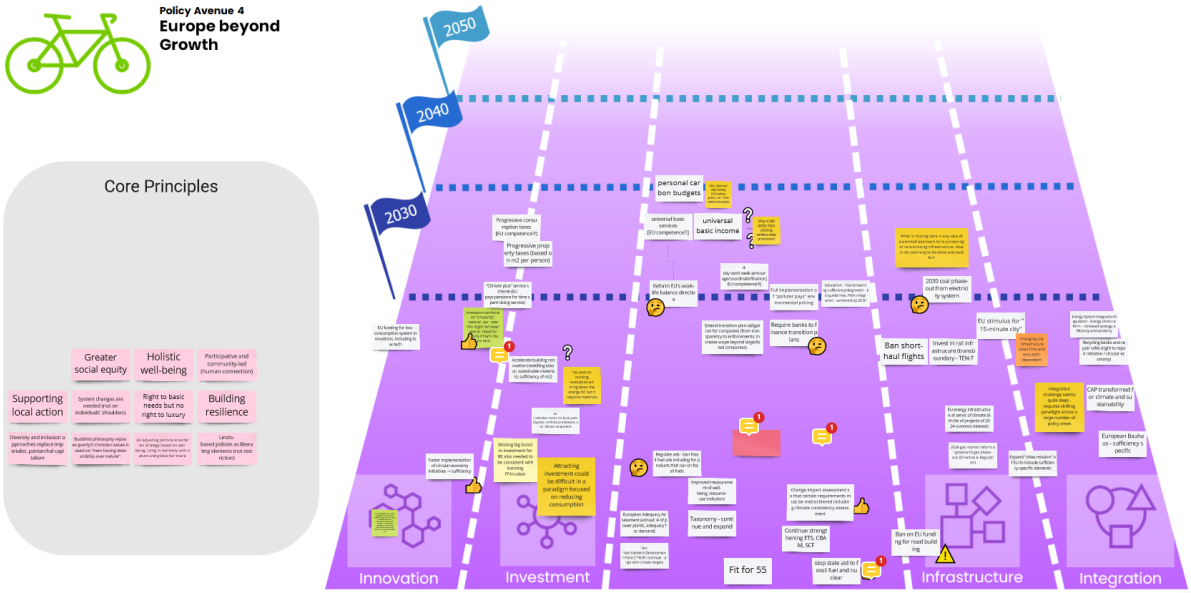

Figure 6 Sufficiency and Degrowth Policy Avenue

Annex C: List of policy instruments

The following instrument list was provided to participants of the policy lab. It is meant to generate ideas and provide inspiration.

Introduction

The present document with a proposed list of policy instruments is a support tool for the participants in the policy lab through which different the policy avenues will be defined. The list contains a mix of instruments, some already part of the current EU climate policy framework and some that are used in other countries/regions or suggested by the academic literature.

The list is meant to help get started and provide some inspiration, but it should not condition in any way the decisions about which is the most adequate instrument mix based on the different paradigms. Participants are encouraged to modify the definitions of these instruments as they deem necessary, and they are welcome to introduce any new instruments that could contribute to the achievement of climate neutrality from the assigned paradigm's perspective.

The document has two sections. The first is a summary table of policy instruments with a very brief description of the instrument and indication to which of the 4i the instrument is relevant for. The second section elaborates on the brief descriptions and includes:

- A longer description of the instrument
- Its use in the EU or in the Member States
- Key instrument design considerations
- The instrument's relevance for each of the "i's"
- Some links to additional information

The list tries to be as neutral as possible. The description of the instrument are written in positive terms to inform on what could be accomplished by the instrument according to its proponents. This in turn implies that not all limitations of each instrument are stated. They should still be taken into consideration, however, especially considering the perspective of the assigned paradigm.

To facilitate navigating the document each instrument in the summary list has a direct link to its longer description. From the longer description section links to go back to the summary table are also provided.

As mentioned above, many of the instruments, for example the EU ETS, are already part of the current policy mix. Naturally, when selecting instruments, one should consider that the EU will not start anew but from a set of policy instruments and targets.

Summary Table

	Instrument	Brief description	Innov.	Invest.	Infrast.	Integr.
1. Trading instruments						
1	Emissions trading systems	A central authority sets a limit on the quantity of emissions which are then divided in tradeable emission permits that are allocated according to specific rules. The cap is progressively reduced in order to achieve the set emission reduction goal.	X	X		X
2	Tradable green certificates for renewables	Green certificates represent certified generation of one unit of renewable energy. They can be traded and used to meet renewable energy obligations of consumers and/or producers. Regulated entities can buy and sell certificates to meet their obligations.	X	X		
3	Tradable energy efficiency certificates (white certificates)	White certificates represent a unit of energy saved. Regulated entities must submit enough certificates to fulfil their energy saving obligation. Regulated entities can buy and sell certificates to meet their obligations.	X	X		

4	Renewable energy auctions	A call for tenders to procure a certain capacity or generation of renewables-based electricity. Project developers who participate in the auction typically submit a bid with a price per unit of electricity at which they are able to realise the project.	X	X	X	
5	Carbon budget for citizens	In this variant of an ETS, citizens annually receive a certain carbon budget, to be spent on activities involving GHG emissions. They can use their budget completely or sell parts of it to other participants.	X			X
2. Fiscal Policy Instruments						
6	Tax on inputs or outputs of production process	Taxes linked to the carbon content of products like in carbon taxes or fuel taxes or based on the unit/product like in vehicle registration taxes which can be discriminated by efficiency level.	X	X		X
7	Border Carbon Adjustments	Tax or other obligations on imports based on carbon intensity of the products. It is usually a measure used by countries with emissions related policies that aims to address the risk of carbon leakage.	X	X		X
8	Charge on consumption of carbon intensive materials/products	The climate contribution is a weight-based charge on consumption of carbon-intensive materials sold for final use. The charge is applied internally, removed for exports and applied to imports.	X	X	X	

9	Economics support mechanisms for the use and consumption of low-carbon products and services	An economic incentive is given to buy lower-carbon products, choose a less polluting service, facilitate the switch to cleaner energy or, among others, carry out energy efficiency improvements.	X	X	X	X
10	Removal of environmentally harmful subsidies and other incentives	Phasing out of direct or indirect measures that provide preferential treatment to a specific sector that has a harmful impact on the environment.	X	X	X	
3. Standards and Mandates						
11	Performance standards, technology standards and eco-design requirements	Setting specific standards on energy consumption or fuel efficiency that need to be met for products, buildings or services to be able to be commercialized.	X	X	X	X
12	Environmental standards for access to public lending and investment	A set of climate-related clear standards and practices are defined. These can be made compulsory to get access to public funding or participate in public undertakings. These guide actions and ensure that, if followed, no additional harm is made.		X	X	X
13	Bans and phasing-out products or technology	Establishing a phase-out date by when a product or technology is no longer allowed to be used or sold.	X	X	X	
14	Renewable portfolio standard /quotas	Procurement targets for load-serving entities to source certain portion of generation from RES by a set date.	X	X	X	

15	Infrastructure regulation, requirements, and deployment targets	Related to low-carbon infrastructure, establishing requirements on technical specifications and targets for its deployment to ensure interoperability and coherent implementation	X	X	X	
16	Long-term infrastructure network planning	A governance and planning process to decide on the necessary key infrastructure developments for the coming decades, based on system needs scenarios and updated regularly.	X	X	X	X
17	Establishing green investment coordination mechanisms	Establishing mechanisms that allow coordinating, planning and providing coherence to decision making-procedures related to climate change mitigation.	X	X	X	X
18	Stimulate local production and consumption	Governmental intervention to promote local consumption and thus reduce transport emissions.	X		X	X
4. Active innovation and green technology support						
19	Carbon-contracts-for-difference (CCfD)	Direct (variable) subsidies to bridge cost gap of low-emission technologies to conventional ones. It allows businesses to hedge against volatile carbon prices.	X	X	X	
20	Renewable contracts for difference (CfD)	The CfD is based on a difference between the market price and an agreed "strike price" for renewable energy. If the "strike price" is higher than a market price, the CfD counterparty must pay renewable generator the difference between the "strike price" and the market price and vice versa.	X	X		

21	Green public procurement	Public entities set clear and verifiable environmental criteria for products and services in their public procurement process. They thus use their purchasing power to create demand for cleaner products and technologies.	X	X	X	X
22	Creation of green lead markets	Public procurement of products that have not yet been fully developed or are not available in the market.	X	X		
23	R&D funding	Grants and/or loans to public and private institutions to promote research and innovation in the field of climate change mitigation. From basic research to more advanced Technology Readiness Level (TRL) solutions.	X	X	X	X
24	Investment of carbon-pricing revenue on innovation (Innovation fund)	Creating specific funds using the revenue from the ETS to support projects aimed to the development of low-carbon technologies.	X	X	X	X
	5. Financial Regulation					
25	Taxonomy for sustainable activities	Create a classification system, establishing a list and definition of environmentally sustainable economic activities directed at companies, investors, and policymakers.	X	X	X	X
26	De-risking investments in climate neutrality	Instruments through which public institutions assume some of the investment risks that may be technology, price, or project related in order to set favourable framework conditions to attract private investments towards climate neutrality	X	X	X	X

27	Prudential regulation	Regulation for banks and insurance companies to integrate climate transition and physical risks, includes measures such as stress-tests, prudential supervision, transition plans for financial actors.		X		
28	Credit allocation for green activities	Requirement for banks to attract a minimum share of sustainable investments in their portfolio (for instance according to the EU's taxonomy) or to increase this share annually	X	X	X	
	6. Information and voluntary approaches					
29	Voluntary agreements	Agreements usually between government and industry to reduce emissions by certain amount.	X	X		X
30	Product certification and labelling	Certification or labelling systems to inform about the environmental impact of products and services.	X			
31	Public voluntary schemes	Adoption of voluntarily standards, procedures, targets by companies that were developed by public bodies. Their goal is to guarantee certain environmental standards for private target setting.	X			

32	Information campaigns	Publicly led information campaigns to promote the reduction of the volumes of products and services thus cutting the emissions related to the use, production and transportation.	X			X

1. Trading instruments

1. Emissions trading system

In principle, emissions trading systems create an incentive to reduce emissions where these are most cost-effective (IEA,2020). There are two types: cap-and-trade (e.g., EU ETS) and baseline and credit systems (e.g., the Clean Development Mechanism in the Kyoto Protocol)). In cap-and-trade systems a central authority sets a limit on the quantity of emissions which are then divided into emission permits that are allocated for free and/or auctioned. Regulated entities must cover all their emissions with permits and can buy and sell them on the market. The cap is progressively reduced to achieve the desired level of emission reductions. In baseline and credit systems no maximum amount of emissions is set. Each participant is assigned an emission's baseline and tradeable credits can be claimed when the performance improves the assigned limit.

The EU-ETS has since 2005 been one of the central instruments in EU climate policy. It currently includes CO_2 emissions from energy generation, energy intensive industry and aviation with increasing ambition. The Fit for 55 package, would extend the ETS to maritime shipping and a separate system is foreseen for road transport and buildings (EU ETS2).

Some of the key issues considered in the design of this type of instrument are the role of free allowances (often used to prevent carbon leakage), the timing and intensity of the reduction of the cap, the sectoral coverage, market stability, and the use of generated funds.

4i relevance

Innovation: In principle, setting a price on emissions creates an incentive to innovate cleaner alternatives. Moreover, the funds from the auctioning can be directly allocated to foster innovation as exemplified by the NER 300 initiative and the Innovation Fund.

Investment: If allowances need to be purchased, this positively affects the cost effectiveness of energy efficiency investments; the higher the price of allowances, the more likely the system triggers new private investments in energy efficiency measures (EE). Yet, the variable price of allowances, impedes longer term planning and thus may still not be sufficient to trigger EE investments with longer pay-back periods. Revenue from the auctioning of allowances can be used for climate related public investment or to correct distributional effects caused by other instruments. However, revenues being variable, this makes longer term planning of public spending more difficult. Related to private investments, carbon price changes relative prices and may change risk-return profile of certain investment

Integration: It contributes to sectoral integration if different sectors are included in the system. It also contributes to mainstream climate policy into covered companies' decisions making

References and additional information:

- IEA, 2020. Implementing Effective Emissions Trading Systems: Lessons from international experiences
- European Commission, 2022. EU Emissions Trading System [website]

Back to summary table

2. Tradable Green Certificates for renewables

Green certificate schemes are a market-based mechanism to subsidies renewable energy generation and stimulate investment. Renewable energy generators will receive green certificates for every unit of renewable electricity they produce. Electricity suppliers and obligated consumers are required to purchase certificates that correspond to a specific percentage of annual energy consumption set by law. This obligation creates a demand for certificates and the buying and selling of certificates to meet obligations creates a market-determined subsidy for renewable electricity. Electricity customers pay indirectly for the renewable energy development as costs are passed on.

In the EU they are used by some member states although many opted for direct subsidies through feed-in tariffs instead.

Key aspects of this policy are the stringency of the obligations, sources of energy included, type of producers that are affected by the obligations or that can participate in the market.

4i relevance
Innovation: It can stimulate innovation on RES if incentives and price are right
Investment: If linked to the obligations it can make investments on RES more attractive as those that invest in renewable energy can derive additional revenue from selling the certificates to those that need to comply with the obligations. However, while pertinent under a static efficiency concept, this option could also incentivise obliged parties to perpetuate their classical business model and prevents them from building up internal expertise with regards to RE generation. This increases risks of emission lock in and stranded assets.

References and additional information:

- Verbruggen, A., Laes, E., 2021. Early European experience with tradable green certificates neglected by EU ETS architects. Environ. Sci. Policy 119, 66–71

- KYOS, 2022. What is a green certificate? [Website]
- JRC, 2005. Tradable Certificates for Renewable Electricity and Energy Savings

Back to summary table

3. Tradable energy efficiency certificates (white certificates)

White certificates are a similar mechanism to green certificates but focused on energy efficiency on the demand side. White certificates represent a unit of energy saved. Regulated entities must prove and submit enough certificates to fulfil their energy efficiency obligations. White certificates thus create a monetary incentive to save energy. It is also be linked to a market of tradable certificates.

Implemented by some member states in the EU like France.

Key aspects of this policy are the stringency of the obligations, sources of energy included, type of producers that are affected by the obligations or that can participate in the market.

4i relevance

Innovation: The certificates along with the obligations incentivise the adoption and further development of energy efficient technologies.

Investment: The obligation creates an incentive to invest in energy efficiency. The tradable certificates follow a static efficiency concept and thus potentially postpone needed EE investments of obliged parties to a later stage.

References and additional information:

- JRC, 2009. Energy Saving Obligations and Tradable White Certificates
- IEA, 2022. White Certificate Scheme & Obligation. [Website]

Back to summary table

4. Renewable Energy Auctions

Through this type of auction, the government issues a call for tenders to procure a certain capacity or generation of renewables-based electricity. Project developers who participate in the auction typically submit a bid with a price per unit of electricity at which they are able to realise the project. The auctioneer evaluates the offers on the basis of the price and other criteria and signs a power purchase agreement with the successful bidder. With the increasing use of auctions, policy makers seek to procure renewables-based electricity at the lowest price and also fulfil socio-economic objectives. (IRENA ,2015). Compared to other instruments in which the support level is established by the government (feed-in tariffs or premium tariffs), in

this case it is the market itself through the bids by the participants in the auction that define the support amount.

In The EU, renewable energy auctions are used at member state level. Some of the countries currently using them are: Denmark, Germany, Greece, Spain, Poland, the Netherlands or Portugal.

Some of the key aspects in designing this instrument are whether the cap is set by volume, by price or both. Also if different technologies (solar, wind) are auctioned together or separately. Also the type of support, how it is implemented and the duration. A potential issue is whether access to bids are equitable for all, small and bigger, producers.

4i relevance

Innovation: By securing a minimum price for a long-term some risk is taken out incentivising investment which contributes to development and diffusion of renewable generation technologies and infrastructures.

Investment: From a private investment perspective, as mentioned above, the auctions contribute to derisking. From a public investment perspective, government investments are arguably more efficient as the bidding process better defines the support level needed by producers.

Infrastructure: In the same line as in investment, by derisking and ensuring a long time commitment the development of infrastructure is promoted.

References and additional information:

- IRENA, 2019. Renewable energy auctions: Status and trends beyond price
- IRENA 2015. Renewable Energy Auctions: A guide to Design
- del Río, P., Kiefer, C.P., 2022. Which policy instruments promote innovation in renewable electricity technologies? A critical review of the literature with a focus on auctions. Energy Res. Soc. Sci. 89, 102501.
- Szabó, L., Bartek-Lesi, M., Diallo, A., Dézsi, B., Anatolitis, B. and del Río, P., 2021. Design and results of recent renewable energy auctions in Europe. Papeles de Energía 13.

Back to summary table

5. Carbon budget for citizens

A trading system applied not only to companies in certain economic sectors, but also to citizens, in the form of tradable personal carbon budget. All citizens would receive an equal annual carbon budget by the government, to be spent on certain activities that involve the use of fossil fuels. They can either use their carbon credits or sell them to other participants.

This instrument has not been implemented in the EU or in any of the Member States.

As acknowledged by Parag and Strickland (2009) "a number of prerequisites for personal carbon budgeting: acceptable budget limits; improved carbon literacy; affordable low carbon alternatives; opportunities to make low carbon choices; information, advice and support; and knowing how to trade." Also the impact on vulnerable population sectors and which mechanisms can be put in place to avoid inequities generated by differences in income levels.

4i relevance

Innovation: This instrument could trigger behavioural changes that lead citizens to choose alternative, less polluting, options thus contributing to the diffusion of innovative products and services.

Integration: It could contribute to mainstream climate policy as different sectors would be involved and stronger focus would be put in climate behaviour.

References and additional information:

- Parag, Y and Strickland, D., 2009. Personal Carbon Budgeting: What people need to know, learn and have in order to manage and live within a carbon budget, and the policies that could support them? UKERC Working Papers
- UKRI Trustworthy Autonomous Systems Hub, 2022. The Citizen Carbon Budget [Project Website]

Back to summary table

2. Fiscal Policy Instruments

6. Tax on inputs or outputs of production process

Environmental taxes' that are meant to internalise the external cost of an activity, be that the combustion of fossil fuels (and release of Co2) or Methane leakage or on other activities where an externality is to be addressed. Often used in transport sector. It can be linked to the carbon content of products like in fuel taxes or based on the unit/product like in vehicle registration taxes which can be discriminated by efficiency level. This Could also take the form of charging based on the use. For example, for road vehicles, on a per km basis.

This type of taxes is widely used at the member state level with different intensities and modalities.

Often times these taxes are not originally or exclusively designed as a climate policy which leaves room for optimization of its climate impact. As with other taxes, there is a risk of distributional effects if no measures to correct them are taken.

4i relevance

Innovation: By increasing the price of more carbon-intensive options uptake of alternatives is incentivised. Taxes can moreover establish a level-playing field between incumbent and clean technologies.
Investment: Such taxes can influence consumer investment decisions towards low carbon alternatives for example when purchasing a car. Tax revenues can be used to shift public investment towards climate change mitigation if they are directly or indirectly earmarked for that purpose. The revenue stream however declines proportionally with the effectiveness of the tax.
Integration: Taxes can play a role in policy integration, ensuring a coordinated approach of the different taxation instruments within the climate policy mix and to integrate climate consideration into sectoral policies such as industrial, investment etc.

References and additional information:

- Trinomics, 2020, Energy Taxes: Energy costs, taxes and the impact of government interventions on investments
- OECD, 2019. Taxes on polluting fuels are too low to encourage a shift to low-carbon alternatives

Back to summary table

7. Border Carbon Adjustments

A tax, or other obligation such as a credit purchase system, on imports based on carbon intensity of the products. It is used as a measure to reduce carbon leakage risks in jurisdictions with more stringent climate policies.

In the EU a Carbon Border Adjustment Mechanism (CBAM) is foreseen as part of the Fit for 55 package targeting the imports of carbon-intensive products. Currently the sectors included are cement, aluminium, fertilisers, electric energy production, iron and steel. This policy is to run alongside with the EU ETS and is meant to eventually replace current carbon leakage prevention measures such as free allowances.

Key aspects in the design of this policy lie in the selection of materials and products affected by the policy. Also the type of mechanism, whether it is a tax or other type of instrument that manages to balance the price difference linked to carbon pricing.

4i relevance
Innovation: Internally, it supports the effectiveness of innovation measures by reducing the incentive to move production away and thus preventing carbon leakage. Externally, the cost added by the tax might contribute to incentivise importers from outside the EU to switch to less carbon intensive materials and production modes.

Investment: The introduction of CBAM allows to generate investment effects such as described under ETS, as free allowances are reduced or carbon taxes can rise higher. Revenues may be directly or indirectly earmarked for climate-related investments or to correct distributional effects caused by other instruments, however they do not represent a steady revenue stream.
Integration: Border adjustment mechanisms contribute to integrate climate and energy considerations into industrial production and policy

References and additional information:

- Resources for Future, 2021. Border Carbon Adjustments 101
- European Commission, 2022. Council agrees on the Carbon Adjustment Mechanism (CBAM) [Website]
- Böhringer, C., Fischer, C., Rosendahl, K.E., Rutherford, T.F., 2022. Potential impacts and challenges of border carbon adjustments. Nat. Clim. Chang. 2022 121 12, 22–29.

Back to summary table

8. Charge on consumption of carbon intensive materials/products

Weight-based charge on consumption or use of carbon-intensive materials sold for final use. Its level would depend on the market prices of emission allowances and product benchmarks. The charge is applied internally, removed for exports, and applied to imports.

This type of instrument is not currently in use in the EU. It is an academic proposal as an alternative to other measures such as the CBAM to mitigate the risk of carbon leakage cause by asymmetrical climate policies.

Some key aspects of this instruments are the level of the charge, the products it applies to, and at which level of the value chain the charge is applied.

4i relevance

Innovation: In itself, as a tax on use it could contribute to promote behaviour change towards the use of less carbon-intensive options. Also, in a similar fashion to the CBAM, it should support innovation policies by preventing price differences related to carbon intensity. The external incentive to decarbonise would also be present with such mechanism.
Investment: The charge can influence consumer investment decisions by improving the price competitiveness of low-carbon alternatives where they exist. Revenue may be earmarked for climate-related investments or to mitigate distributional effects of other policies. The revenue stream however declines proportionally with the effectiveness of the tax.

Infrastructure: When applied to the use of (fossil-based) vehicles, this tax is basically a road tax, which can be used to invest in e.g. charging infrastructure.

References and additional information:

- Climate Strategies, 2020. Climate Contribution and its role in European industrial decarbonisation

Back to summary table

9. Economic support mechanisms for the use and consumption of low carbon products and services

There is a wide range of subtypes of instruments in this category with the common purpose of promoting the use and consumption of products and services that have a smaller environmental impact. They can be classified according to the mechanism they use to provide the support, to the target beneficiary or the purpose of the subsidy or support scheme.

In terms of mechanism, they can be direct subsidies or the price can be modified through the modification of taxes, either a tax exemption or a tax break.

They can be targeted to final users or to different actors along the value chain. For example, there can be subsidies on production such us feed-in tariffs for renewable energy production or directed to the consumption.

There is a wide array of support mechanisms that target different goals within climate mitigation. Some examples are: provide incentives to buy lower-carbon products (e.g. electric vehicles), choose a less polluting service (e.g. public transportation), facilitate the switch to cleaner energy (e.g. installing solar panels) or, among others, carry out energy efficiency improvements (e.g. upgrading buildings). Also they can be used to incentivise local production and consumption if applied to products consumed locally.

This type of instrument is widely used by EU member states.

As with other instruments, the design of the instrument plays a critical role in determining its potential. Among other issues, the timing of the instrument is important in relation to the maturity and market cost of the technology or the products subsidised (e.g., for renewable energy subsidies). Another relevant aspect to consider is the distributional effect: who benefits from the subsidy and who pays for them?

4i relevance

Innovation: By reducing the cost of low-carbon alternatives there is a stimulus to both the design and diffusion of new technologies/solutions. It moreover helps creating a level playing field for new technologies to compete with incumbent more polluting options.

Investment: By themselves subsidies and other support mechanisms could be considered as a public climate-related investment. Also, by reducing the costs, they incentivize private investments with climate impact in low-carbon alternatives.
Infrastructure: Subsidies can play an important role in ensuring the coevolution of technologies and their linked necessary infrastructures. For example, support to build infrastructure for green hydrogen and its derivatives.
Integration: They can contribute to integrate climate and energy considerations into industrial production and policy.

References and additional information:

- Enerdata, 2021. Study on energy subsidies and other government interventions in the European Union
- European Environment Agency, 2019. Tax breaks and incentives make Europeans buy cleaner cars. [Website]

Back to summary table

10. Removal of environmentally harmful subsidies and other perverse incentives

Phasing out of direct or indirect measures that provide preferential treatment to a specific product, activity or technology that has a harmful impact on the environment. A clear example in the context of climate change would be the removal of subsidies to fossil fuel related investments (including exemptions of taxes or charges) as well as direct subsidies on fossil fuel prices for end consumers. In this category, implicit subsidies could be included too. This occur when "the retail price fails to include external costs and/or there are preferential consumption tax rates on energy. External costs include contributions to climate change through greenhouse gas emissions, local health damages (primarily pre-mature deaths) through the release of harmful local pollutants like particulates, and traffic congestion and accident externalities associated with the use of road fuels" (IMF,2022).

Although not a specific instrument in itself, removing environmentally harmful subsidies is acknowledged in the EU climate policy agenda. However, specific targets are not clear. The European Climate Law establishes that "[continued efforts are necessary to ensure a socially fair phasing out of environmentally harmful energy subsidies".

A key question with removing harmful subsidies is when and how. The complexity has become more patent in the context of an energy crisis like the one created by the Russian invasion of the Ukraine. Removing subsidies can have distributional effects and may affect certain groups negatively. Removing environmentally harmful subsidies in a socially sound manner is therefore important.

4i relevance

Innovation: Removing harmful subsidies contributes to creating a level playing field for low-carbon technologies and induce innovation to find cleaner solutions.
Investment: Removal reduces the demand of the supported products/ services and improves the competitiveness of low-carbon alternatives and thus potentially increases private investments. As environmentally harmful subsidies increase the risk of emission lock in and stranded assets, their removal helps reducing these risks. Avoids flow of public investment to environmentally harmful sectors that can potentially be redirected to climate policy related investment.
Infrastructure: There exist still many tax exemptions and other incentives for oil and gas exploration. This always involves infrastructure (pipelines) that creates its own GHG emissions (such as methane leakage).

References and additional information:

- European Parliament, 2017. Fossil Fuel Subsidies: In-depth analysis
- Ecologic, 2021. Conference on the Future of Europe: Phasing out fossil fuel subsidies
- IMF, 2022. Fossil Fuel Subsidies. [Website]
- UNDP, 2021. For every dollar pledged to tackle climate crisis for world's poor, four dollars are spent on fossil fuel subsidies that keep the climate crisis alive according to new UNDP research. [Website]

Back to summary table

3. Standards and Mandates

11. Performance standards, technology standards, eco-design requirements, product carbon requirements

Performance standards target the operational performance of products and services as well as buildings performance. They are traditionally used for combustion engines through emission standards, energy efficiency requirements for electrical appliances and in building codes.
For technology standards, the focus is in the type of technology that can be used so that environmental performance goals are met. Eco-design requirements add to the performance targets other environmental aspects such as recycling and end of life management. these can apply at the product level (emission limits, performance standards) or at the production level (where it is about what manufacturing methods are acceptable and which are not – this can be especially relevant in hard-to-abate sectors where the conventional and low-carbon products can only be differentiated by their production method, but not by their final qualities, e.g., steel)

With a similar mechanism, product carbon requirements can be considered. This would set very restrictive carbon emission requirements for basic materials such as cement, steel, aluminium or plastic in the production process (Gerres et al. 2021).

In the EU, performance standards apply for road vehicles through the Euro emission standards. The standards and their regulations have been updated periodically. Technology standards and eco-design are also present in the current EU climate policy mix through the eco-design framework that sets operational and material efficiency standards. At present, reforms of the eco-design framework are proposed.

Key aspects of this type of instrument design lay on the technical implementation of standards including their stringency, the range of products and production processes it applies to. An important question is if the standards are technology-specific or based on efficiency or emissions targets.

4i relevance

Innovation: Performance standards and technology standards can result in a *de facto* ban of carbon-intensive technologies and incentivise their replacement by more efficient options.

Infrastructure: Some of the requirements from the design and technology sides can require certain infrastructure availability for the deployment and up-scaling to be feasible.

Investment: Performance standards are a very effective way of reorienting private investments decisions as they reduce the range of investment choices by sorting out the options that are non-compliant with the set standards. Yet if the stringency of standards is not in line with climate goals, there remains a risk of emission lock in and stranded assets especially where assets purchased are long-lived (e.g. cars, housing refurbishment, industrial equipment, etc.).

Integration: This type of instrument also contributes to climate policy mainstreaming.

References and additional information:

- European Commission, 2022. Sustainable product policy & ecodesign. [Website]
- European Commission, 2022. Energy efficient products. [Website]
- European Commission, 2022. CO_2 emission performance standards for cars and vans. [Website]
- Vollebergh, H.R.J., Van Der Werf, E., 2020. The Role of Standards in Eco-innovation: Lessons for Policymakers. Review of Environmental Economics and Policy. Volume 8, number 2.
- Gerres, T., Haussner, M., Neuhoff, K., Pirlot, A., 2021. To ban or not to ban carbon-intensive materials: A legal and administrative assessment of product carbon requirements. Rev. Eur. Comp. Int. Environ. Law 30, 249–262.

Back to summary table

12. Environmental standards for access to public lending and investment.

A set of climate-related clear standards and practices are defined. These can be made compulsory to get access to public funding or participate in public undertakings. These guide actions and ensure that, if followed, no additional harm is made.

At the EU level the European Investment Bank has issued a document establishing environmental and social standards which set the requirements the promoter and the project must meet throughout the EIB project life cycle.
Key aspects of this policy are the definition of the standards and the level of stringency of the standards.

4i relevance
Investment: Where stringent standard compliance in order to access public funding, this contributes to shifting investment flows towards low-carbon assets.
Infrastructure: By setting environmental conditions that infrastructure projects must meet in order to receive funding, these standards can ensure that development of the right infrastructures for decarbonisation is achieved.
Integration: This type of instrument also contributes to climate policy mainstreaming.

References and additional information:

- European Investment Bank, 2022. Environmental and Social Standards.
- OECD, 2020. OECD Business and Finance Outlook 2020: Sustainable and Resilient Finance, Chapter 5. Promoting responsible lending in the banking sector: The next frontier for sustainable finance. OECD Publishing, Paris

Back to summary table

13. Bans and phasing-out technology or products

Product of technology bans set a phase-out date by which a carbon intensive product or technology can no longer be sold or used. It is usually used as a long term goal in order to provide a strong and certain signal to market participants and provide time for adjustment. This can also have the form of a moratorium if the measure is not definitive.

Coal power and internal combustion engine phase-outs are common examples of this type of instrument. Sometimes partial bans are used where not the whole technology is banned but restricted. For example, banning older (less efficient) vehicles from entering the city centre.

The EU is currently discussing a ban on the sale of petrol cars by 2035 through its emission performance standard. At member state levels we see many examples of specific dates being set to phase our coal. In Germany, for example, by 2038.

Some of the key aspects of this type of policy are: The time between the announcement and the actual ban. Also, the socioeconomic implications for specific regions and groups of people of banning certain activities and the need for a retirement pacification that takes into account the principle of a just transition. Also, not to forget, as we have seen with the recent crisis in the Ukraine, the geopolitical and energy sovereignty implications, including the risk of push-back of agreed dates for the ban to become effective.

4i relevance
Innovation: It forces the substitution of more polluting options with alternative less carbon-intensive ones.
Investment: Can be an effective instrument to reorient private investment decisions as investment choices are reduced or, in the case of partial bans, the usefulness of investments is reduced.
Infrastructure: First, banning certain technologies or activities requires creating alternatives with accompanying changes to infrastructure (e.g., electricity grids, charging stations). Second, as some physical infrastructure was built around fossil-technologies, the question is what can be repurposed for a climate-neutral economy.

References and additional information:

- IEA,2021. World Energy Outlook 2021: Phasing out coal.
- International Institute for Sustainable Development, 2018. Fossil Fuel Phase-Out and a Just Transition

Back to summary table

14. Renewable portfolio standards (RPS)/quotas

Establishing procurement targets for load-serving entities to source certain portion of generation from renewable energy sources by a set date. The goal of RPS is to increase the use of renewable energy sources in electricity generation.

Applied at national level by some EU members such as Belgium, Romania, Poland, or Sweden.

Important considerations for policy design include what technologies qualify as renewable, the volume of the quotas and their time frame, and how the RPS targets are increased over time.

4i relevance
Innovation: Contribute to widen the implementation of the use of RES in substitution of more polluting alternatives
Investment and Infrastructure: By guaranteeing a specific demand volume, investments in infrastructure can be incentivised

References and additional information:

- IEA, 2021. Renewable Electricity Quota and Assessment Method [Website]
- RESLEGAL, 2012. Legal Resources on Renewable Energy. [Website]

Back to summary table

15. Infrastructure regulation, requirements and targets

Related to low-carbon infrastructure, establishing requirements on technical specifications to ensure interoperability and coherent implementation and also targets for its deployment. This can be applied to different sectors, from residential buildings, transport or energy such as charging points, electricity grid, refuelling points for hydrogen etc.

In the EU, in the context of transportation this aspect has been dealt with through the Alternative Fuels Infrastructure Directive (2014) which is revised in the context of the Fit for 55 package. It could also be extended to cover international rail transport, which suffers from lack of consistence in cross-border technical requirements and operational rules.

Key aspects include the selection of the infrastructure (more oriented or open), the definition of the requirements and specification to ensure coordination and readiness for deployment.

4i relevance
Infrastructure: Allows for long-term planning on needs to enable the timely deployment of low(er) carbon infrastructures
Investment: It can contribute to identify the investment needs of the deployment of infrastructure and potentially attract investors, as they can better anticipate market developments.
Innovation: infrastructure requirements can lead indirectly to technological and business model innovation needed to implement the requirements.

References and additional information:

- European Commission, 2021. Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure. COM(2021)559 Final
- Official Journal of the European Union, 2021. Technical guidance on the climate proofing of infrastructure in the period 2021-2027 (2021/C 373/01)

Back to summary table

16. Long-term network planning (possibly linked to EU-level financial support)

A governance and planning process to decide on the necessary key infrastructure developments for the coming decades, based on system needs scenarios and updated regularly. As infrastructure development usually requires large amounts of time and investment the planning process plays a very important role in the policy process.

In the EU there are examples for the long-term network planning: The Trans-European Networks for Energy (TEN-E) and for Transport (TEN-T). There is moreover, the Ten-Year Network Development Programmes, led by the association of the transmission system operators (ENTSOE).

Similarly, to other infrastructure related instruments, a key aspect is the choice of technologies associated to the infrastructure taking into account the cost-effectiveness but also the achievement of goals at the target dates set. The planning instrument could also include mandatory elements for Member States, for instance the realisation of certain cross-border connections to improve the network quality at EU level

4i relevance
Innovation: similar to bans on carbon-intensive technologies this approach can lead to innovation to address any gaps left by the ban.
Infrastructure: Planning and making long term decisions is one of the key aspects to endure that there is an infrastructure network compatible with carbon neutrality goals.
Investment: The long term planning process provides information on investment needs.
Integration: The coupling of different sectors requires the integrated planning of the respective infrastructures.

References and additional information:

- European Commission, 2021. Commission adopts new guidance on how to climate-proof future infrastructure projects. [Website]
- European Commission, 2022. Trans-European Transport Network (TEN-T). [Website]

Back to summary table

17. Establishing mechanisms to coordinate green public investment

Considering the magnitude and diversity of public investments related to climate change mitigation, establishing mechanisms that allow coordinating, planning and providing coherence to decision making-procedures related to climate change mitigation. To carry out this task an option could be to create a specific institution mandated to oversee and direct investment in the energy transition and decarbonisation of industry, transport, etc.

In the EU we find examples of advisory services such as the Green Advisory Service for Sustainable Investments Support: GREEN ASSIST but it does not have an overarching overseeing role. In some aspects the EIB plays a role but, although it has an important role in green investment, it does not necessarily coordinate the overall public investment on climate change. The EU has also developed the EU Green Budgeting Reference Framework (GBRF) which is meant to provide advice to Member States.

4i relevance
Innovation: Through the coordination and prioritization of investment decisions investment towards breakthrough innovations can be provided.
Investment: Important role in coordination and strategic decision making on public investments. In the medium term such policies can help build markets and private consumer confidence and thus have an impact beyond the available public budgets.
Infrastructure: As with investment, key role in defining the strategic investments in infrastructure.
Integration: By overseeing and coordinating investments in different sectors sectoral integration as well as sector coupling can be achieved more efficiewntrly

References and additional information:

- European Commission, 2022. Green Advisory Service for Sustainable Investments Support: GREEN ASSIST. [Website]
- European Commission, 2022. Green budgeting in the EU. [Website]

Back to summary table

18. Stimulate local production and consumption

Governmental intervention to promote local consumption and thus reduce transport emissions. This can be done in different stringency levels, from incentivising local consumption to stricter rules applying to trade transactions penalising the increase in distance of the product.

Currently at the EU level there are only soft measures that promote local consumption as for example the ones within the Farm to Fork strategy, part of the EU Green Deal.

Key aspects of this policy can be its level of flexibility, types of products included as well as how to integrate this type of instruments in an open single market.

4i relevance
Innovation: This type of instrument could protect local markets promoting the use and development of higher value added and efficient tools at higher costs which might not be viable in a higher competition environment. Also in terms of business model innovation, the promotion of local versus globalized markets would probably entail changes in terms of business models.
Infrastructure: The decrease of trade distances could potentially have an effect in terms of the intensity of the use of transport infrastructures and of its related emissions.
Integration: This type of instrument also contributes to climate policy mainstreaming.

References and additional information:

- Cosme, I., Santos, R., O'Neill, D.W., 2017. Assessing the degrowth discourse: A review and analysis of academic degrowth policy proposals. J. Clean. Prod. 149, 321–334.
- European Commission, 2022. From Farm to Fork Strategy. [Website]

Back to summary table

4. Active innovation and green technology support

19. Carbon contracts for difference

Direct (variable) subsidies to bridge cost gap of low-emission technologies to conventional ones. The government guarantees producers a fixed carbon price (a "strike" price) for the length of the project. In doing so, the government agrees to pay a subsidy equal to the difference between the strike price and the average carbon price in the ETS (the "benchmark" price). As the market price of carbon within the ETS rises over time, the government's subsidy will fall to zero and, in two way CCfD, if it continues rising the beneficiary pays back.

It is expected for CCfD to be implemented at the EU level through the fit for 55 and RePowerEU strategies.

4i relevance
Innovation: Through this instrument, the government takes away uncertainty over carbon price development (and thus locks-in a profit for an investment) the instrument stimulates investments in novel tech and production processes Also helps creating a level playing field for new technologies to compete with incumbent more polluting options.

Investment: It lowers the cost and risk of investments by providing certainty over long-term carbon prices.
Infrastructure: In case the necessary infrastructure is considered part of a new technology (such as industrial use of hydrogen), CCfD could be a major incentive for developing such infrastructure.

References and additional information:

- Climate Strategies, 2020. Carbon Contracts for Differences: their role in European industrial decarbonisation
- Algarvio, H., Lopes, F., Santana, J., 2020. Renewable energy support policy based on contracts for difference and bilateral negotiation. Commun. Comput. Inf. Sci. 1233 CCIS, 293–301.

Back to summary table

20. Renewable contracts for difference

Contracts for Difference (CfD) are a variable subsidy scheme for generators of renewable energy. CfD are contracts between generators of renewable energy and the government or another public utility where the two parties agree on a "strike price". The subsidy for renewable energy results from the difference between the wholesale price for electricity and this strike price. If the strike price is higher than a market price, the CfD counterparty must pay renewable generators the difference between the strike price and the market price. If the market price is higher than the agreed strike price, the renewable generator must pay back the difference between the market price and the strike price to the CfD counterparty, usually a government or public entity.

Within the EU it has been used at Member State level in Denmark, it has also been used in the UK.

4i relevance
Innovation: Through this instrument, the government takes away uncertainty over carbon price development (and thus locks-in a profit for an investment) the instrument stimulates investments in novel tech and production processes Also helps creating a level playing field for new technologies to compete with incumbent more polluting options.
Investment: It lowers the cost and risk of investments.

References and additional information:

- IEA, 2019. Contract for Difference (CfD). [Website]

- Algarvio, H., Lopes, F., Santana, J., 2020. Renewable energy support policy based on contracts for difference and bilateral negotiation. Commun. Comput. Inf. Sci. 1233 CCIS, 293–301.

Back to summary table

21. Green public procurement

By setting standards and conditions with regards to their public procurement, governments and public institutions can use their purchasing power to create demand for environmentally friendly goods, services and works. As governments are major developers of large scale physical infrastructure, such as roads, bridges, or buildings, they are major consumers of carbon intensive goods such as steel and cement. Changing their procurement can thus stimulate important innovation and investment in cleaner alternatives.

At the EU level Green Procurement is used as a voluntary instrument. Guidance on how to implement it both at the national and EU levels is provided by the EC.

Some key aspects in the design of this policy are whether it is a voluntary versus a compulsory measure. A key challenge is the design of the procurement standards and conditions and their adjustment over time.

4i relevance

Innovation: Considering the major purchasing power of public bodies a critical mass of demand can be generated for lower-carbon products and services, stimulating innovation.
Investment: Substantial investment flows are directed to low carbon alternatives. In the medium term such policies can help build markets and private consumer confidence and thus have an impact beyond the available public budgets.
Infrastructure: Infrastructure spending makes up a large part of the state's spending and is also the most emission-intensive part of state spending (public procurement accounts for 25 – 40 % of the domestic market of steel and cement in countries such as the US or Germany)
Integration: It also contributes to policy integration by integrating climate aspects to procurement decisions.

References and additional information:

- OECD, 2022. Green Public Procurement. [Website]
- European Commission, 2022. Green Procurement in the EU.[Website]

Back to summary table

22. Creation of green lead markets

A demand-side innovation policy instrument "by which a public agency places an order for a product or system that does not yet exist" (Borrás and Edquist, 2013). The main difference with general public procurement is that in this modality the product is not yet finalised or available on the market. It can also include the procurement of R&D services to advance the development of innovative solutions.

The EU is already pursuing this approach as part of its innovation procurement policies. Covid-19 vaccines, although in a different field, are a good example of how the mechanism can work.

A key aspect is the selection of technologies or services. More open or more technology specific approaches can be taken.

4i relevance

Innovation: The state creates a market for a low-carbon technology or product by committing to purchase it once it is innovated. It thus guarantees demand for a low-carbon innovation.

Investment: By guaranteeing a minimum level of demand, this instrument may incentivise investments into the innovation and commercialisation of new technologies. In the medium term such policies can help build markets and private consumer confidence and thus have an impact beyond the available public budgets.

References and additional information:

- European Commission, 2022. Innovation procurement. [Website]
- European Commission, 2022. A New European Innovation Agenda (COM(2022) 332)
- Borrás, S., Edquist, C., 2013. The choice of innovation policy instruments. Technol. Forecast. Soc. Change 80, 1513–1522.

Back to summary table

23. R&D funding

Grants or loans to public and private institutions to conduct research on innovative technologies and processes, and to develop and demonstrate technologies that may contribute to climate change mitigation.

In the EU there are different types of R&D instruments, but most of them are structured around the Research and Innovation Framework Programmes (currently the 9th, better known as Horizon Europe). This covers basic research (through the ERC), as well as more

advanced TRL solutions (RIA, IA in the context of the societal challenges) and more market oriented initiatives (EIC). It also includes public private partnerships.

This is a broad set of instruments that can be designed in many different ways. Among the key aspects are how much R&D is given out in the form of non-refundable grants versus loans and the varying co-funding rates. Linked to this is the question is who bears the risks and who benefits. The scope of the calls and whether they are more (technology) specific or more open is important. Another key consideration is the involvement of public versus private stakeholders.

4i relevance
Innovation: Funds directly aimed at developing innovative solutions to advance towards climate neutrality.
Investment: By providing grants or loans a direct investment is made or the cost of investments is reduced thus incentivising it.
Infrastructure: Parts of the funding can go to building strategic research infrastructure and pilot sites either exclusively from public ownership to shared public-private.
Integration: Sector coupling or integration can be set as one of the priorities in the design of the calls by the funding institutions.

References and additional information:

- European Commission, 2022. Research and Innovation: Horizon Europe. [Website]
- European Commission, 2022. EU support for research and innovation on climate action. [Website]

Back to summary table

24. Investment of carbon-pricing revenue on innovation (innovation fund)

Creating a specific fund dedicated to support projects that develop low-carbon technologies. The resources can come partially or totally from the revenue of carbon pricing instruments such an emissions trading scheme or taxes.

In the EU there is the EU Innovation fund, which was preceded by the NER300 programme linked to the EUTS which has focused on CCS and renewable technologies.

Key considerations are the financial volume, eligibility criteria such as the type and size of projects that can be funded, and whether the type of technology and sectors are predefined or not.

4i relevance
Innovation: Funds directly aimed at developing innovative solutions to advance towards climate neutrality.
Investment: Direct public investment on low-carbon technology.
Infrastructure: Parts of the funding can go to building strategic research infrastructure and pilot sites either exclusively from public ownership to shared public-private.
Integration: Part of the focus can be in developing technologies that allow for integration of sector.

References and additional information:

- European Commission, 2022. NER300. [Website]
- European Commission, 2022. Innovation Fund. [Website]

Back to summary table

5. Financial Regulation

25. Taxonomy for sustainable activities

Taxonomies are classification systems that establish a list and definition of environmentally sustainable economic activities. They are directed at companies, investors, and policymakers with the intention to create a common standard for demarcating (environmentally) sustainable investments from unsustainable ones.

The EU has created a Taxonomy on sustainable finance to steer private capital into activities that are aligned with the transition to a climate neutral economy.

A key aspect of the design of this instrument is which activities are included and which are not. Another consideration is how the taxonomy is put to use, i.e., if it is a purely informational tool or if it is mandatory and if companies will be obliged to report and verify their sustainable finance activities.

4i relevance
Innovation: A taxonomy may result in increased investments in sustainable activities and thus the innovation of clean technologies.
Investment: One of the main goals of this type of instrument is to guide public and private investments and to shift capital flows towards greener sectors. Given, that the taxonomy so far only addresses sustainable assets, it does not provide any information on the risk of emission lock-in and stranded assets of unsustainable assets. The instrument only provides more information to investors, the decision to invest or not in line with the taxonomy is up to the investor.

Infrastructure: A taxonomy listing sustainable activities could also steer the development of certain infrastructure, such as cables for transporting wind power to land or high-speed railways
Integration: This type of instrument also contributes to climate policy mainstreaming.

References and additional information:

- European Commission, 2022. EU taxonomy for sustainable activities. [Website]
- S&P Global, 2021. A Short Guide to the EU's Taxonomy Regulation. [Website]

Back to summary table

26. De-risking and removal of financial barriers for investments for climate neutrality

De-risking is based on the assumption that public investments alone will not be sufficient to achieve climate goals and that private capital may be too risk averse to invest in low carbon assets. Therefore, public institutions must assume some of the investment risks that may be technology, price, or project related in order to set favourable framework conditions to attract private investments. This may include mobilizing public funds for this purpose. Some examples of de-risking instruments are different modalities of co-investment, co-financing, cornerstone stake, loans, or loan guarantees, among others.

As part of its energy policy the EU has a structured dialogue with the finance industry to de-risk efficiency financing. Carbon Contracts for Difference can also be seen as an example of this type of de-risking measures.

Key aspects are the choice of the specific instrument and the level of involvement of the public institution. It can be from a less commitment options such as loans or loan guarantees to directly taking a stake (in varying proportions) in the project.

4i relevance
Innovation: By lowering risk and thus funding costs more investments may flow into innovation.
Investment: By lowering the risk, investment aligned with climate objectives is incentivised
Infrastructure: As infrastructure investments are capital intensive, de-risking is a key instrument to attract private investments.
Integration: This type of instrument contributes to mainstreaming climate policy into financial decision-making

References and additional information:

- European Commission, 2022. De-risking investments. [Website]

- OECD,2021. De-risking institutional investment in green infrastructure
- Schmidt, T.S., 2014. Low-carbon investment risks and de-risking. Nat. Clim. Chang. 2014 44 4, 237–239.

Back to summary table

27. Prudential regulation related to climate transition

Regulation for banks and insurance companies to integrate, additionally to the conventional prudential requirements, climate transition and physical risks: stress-tests, prudential supervision, transition plans for financial actors.

The ECB has launched in 2022 a supervisory climate risk stress test to assess how prepared banks are for dealing with financial and economic shocks stemming from climate risk. As part of the Corporate Sustainability Reporting Directive, the publication of transition plans will become mandatory for large companies including banks, if the standard specifications will be transcribed into European law as proposed by the European Financial Reporting Advisory Group in their draft for consultation. The use of such transition plans within prudential regulation is currently under discussion as part of the "banking package".

Aspects to take into account are which actions financial supervisors can take to push financial institutions towards more ambitious transition plans and if they can require actions if transition plans are not implemented. A key aspect is to clarify the hierarchy between the management of financial risks and environmental risks (double materiality approach).

4i relevance

Investment: Through this instrument, regulators could require financial institutions to reduce carbon lock-in and manage stranded assets. By making the existence of a solid transition plan a precondition for the attribution of bank loans or equity investments, this would massively push companies to develop such transition plans and shift their operations towards low-carbon business models.

References and additional information:

- European Banking Authority, 2022. Discussion paper on the role of environmental risks in the prudential framework. EBA/DP/2022/02
- European Central Bank, 2022. The challenge of capturing climate risks in the banking regulatory framework: is there a need for a macroprudential response?.
- UK Government, 2021. Fact Sheet: Net Zero-aligned Financial Centre. [Website]
- EFRAG, 2022. Consultation on draft for EU Sustainability Reporting Standards (ESRS). [Website]

Back to summary table

28. Credit allocation for green activities

This instrument entails defining sector-specific targets on both quantities and prices of credit to green and brown activities from the private banking system. Based on the work of Kedward et al. (2022) this would include a variety of sub-instruments that can be divided in: indirect price-based policies, direct price based policies and direct quantity base policies. Indirect price-based policies would include, Capital requirement adjustments, credit guarantees, dirty penalising factor or countercyclical capital buffer.

Direct price-based policies could include interest rate floors and ceilings, subsidised credits for housfolds or SME, or Prioritising sectors.
Direct quantity-based policies could include, portfolio restrictions or bans (based for example on a taxonomy), credit quotas, lending ratios or favourable loan to value.

This is not currently applied in the EU. An example of a similar policy can be found in Japan.

Some of the key aspects may be the sectors covered, the role of public institutions, or the sub-instruments selected.

4i relevance
Innovation: The favourable conditions in the access to funds could further promote innovative projects.
Investment: By providing access to funds with advantageous conditions higher investment in climate-related projects would be secured. Also it contributes to derisk investments.
Infrastructure: As infrastructure requires big amounts of resources, this type of instrument would facilitate access to finance from these projects. One of the important aspects would be whether the policy is more technology specific or open.

References and additional information:

- Kedward, K., Gabor, D. and Ryan-Collins, J. (2022). Aligning finance with the green transition: From a risk-based to an allocative green credit policy regime. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2022-11).

Back to summary table

6. Information and voluntary approaches

29. Voluntary agreements

Agreements, usually between governments and industrial sectors (represented by industry associations), whereby industrial parties commit to voluntary emission reductions and governments withhold from binding regulations.

Rare at EU level (e.g., Car CO2 from 1999 replaced by regulation in 2009) but more common on member state level, e.g.,The Netherlands, Germany or Finland

Key issues: The level of stringency, monitoring and sanctions varies among these agreements. There is a risk for them to be used to "forestall or deflect the introduction of more direct approaches" (de Serres 2010,25)

4i relevance
Innovation: Create a conducive context for innovation by private actors
Investment: If ambitious and implemented, they can mobilise private investments in low-carbon alternatives. If the implementation remains below the expected results, they need to be replaced by a regulatory approach, which may need to be more drastic, in order to make up for lost time during the voluntary phase.
Integration: Coordination among public and private actors to achieve climate policy goals

References and additional information:

- European Commission, 2022. Recognised voluntary agreements under the ecodesign legislation. [Website]
- IPCC, 2007. Voluntary Agreements. [Website]
- de Serres, A., F. Murtin and G. Nicoletti, 2010, A Framework for Assessing Green Growth Policies, OECD Economics Department Working Papers, No. 774, OECD Publishing, Paris.

Back to summary table

30. Product certification and labelling

Certifying and labelling the climate and environmental impact of products or services can lead to better transparency and consumers can make more informed decisions. This type of instrument can support and contribute to behaviour changes towards less carbon intensive consumption patterns. Labelling and certification schemes can be managed by public institutions or by independent third parties. A popular example are the energy labels on appliances.

In the EU, a notable example is energy efficiency labelling of appliances. These have been recently updated to be more strict in order to adapt and consider efficiency changes that have already been widely introduced in the market.

Key considerations for policy design include the definition of the categories, the stringency of the labelling criteria, and technical questions regarding certification. The labelling and certification processes can also be linked to obligatory forms of regulation, such as technology standards and requirements.

4i relevance
Innovation: Promote behaviour change in consumption enabling the diffusion of greener products/solutions.

References and additional information:

- European Commission, 2022. About the energy label and ecodesign. [Website]
- Andor, M. et al 2019. How effective is the European Union energy label? Evidence from a real-stakes experiment Environ. Res. Lett. 14 044001

Back to summary table

31. Public voluntary schemes

Through public voluntary schemes companies voluntarily adopt specific standards, procedures, or targets developed by public bodies, such as the EU Ecolabel in which products that meet certain environmental standards are awarded a label.

At the EU level, examples include the EU Ecolabel or the EU Eco-management and Audit Scheme (EMAS). The EU is debating whether to extend the Ecolabel also to financial products.

Key considerations for policymaking with these policies are ensuring the stringency and environmental integrity of the requirements and effective monitoring and verification schemes to guarantee that companies actually fulfil the standards or meet the targets.

4i relevance
Innovation: Parties that commit to the voluntary scheme are incentivised to innovate either in terms of processes or use of resources in order to meet the set requirements.

References and additional information:

- European Commission, 2022. EU Ecolabel. [Website]
- European Commission, 2022. EU Eco-Management Auditing Service. [Website]

Back to summary table

32. Information Campaigns

Publicly led information campaigns to promote the reduction of the volumes of carbon intensive products and services thus cutting the emissions related to the use, production and transportation. These can be focused for example on higher use intensity, reutilization and recycling existing products. Also the promotion to shift to lower carbon intensity options such as use of public transportation etc. Depending on the philosophical approach this could also be promoted as absolute reductions that do not consider substitution but that aim at the decrease in the levels of consumption.

This sort of policy is embedded in the circular economy approaches of which the EU partakes with its Circular Economy Action Plans and other provisions in the Green Deal. Also the use of less carbon intensive options is also present in current policies though not necessarily as a reduction but rather as a shift.
Another example, though more as an exceptional instrument to react to the challenges to energy security and not as a climate policy, are the current calls for savings in gas consumption. In this specific case, the limitation to gas and the possibility to temporarily shift back to more polluting sources as coal show that the motivation is more related to energy sovereignty.

Key aspects of this type of policy is be whether specific sectors or products are targeted based on their carbon intensity or if it is a more general approach. Also the need to accompany this type of measure with coherent policies in terms of distribution of work, promotion of alternative jobs linked to new generated needs and their respective business models.

4i relevance
Innovation: This type of measure is linked to business model innovation. Clear examples are business models that facilitate shared use for example of cars or other products and services.
Integration: This type of instrument contributes to sectoral integration, specifically in the integration of climate considerations in trade policy.

References and additional information:

- European Commission, 2022. EU Circular Economy Action Plan. [Website]
- European Commission, 2022. Citizen support for climate action. [Website]
- Cosme, I., Santos, R., O'Neill, D.W., 2017. Assessing the degrowth discourse: A review and analysis of academic degrowth policy proposals. J. Clean. Prod. 149, 321–334.

Back to summary table

About the project

4i-TRACTION – innovation, investment, infrastructure and sector integration:
TRAnsformative policies for a ClimaTe-neutral European UnION

To achieve climate neutrality by 2050, EU policy will have to be reoriented – from incremental towards structural change. As expressed in the European Green Deal, the challenge is to initiate the necessary transformation to climate neutrality in the coming years, while enhancing competitiveness, productivity, employment.

To mobilise the creative, financial and political resources, the EU also needs a governance framework that facilitates cross-sectoral policy integration and that allows citizens, public and private stakeholders to participate in the process and to own the results. The 4i-TRACTION project analyses how this can be done.

Project partners

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