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Developing Pathways for a Sustainable Future:

Preliminary List of Transition Scenarios

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Please note:

Use of Artificial Intelligence based tools: This report was written independently, with AI tools such as ChatGPT and DEEPL used for editing, proofreading, and extracting information relevant to the cluster analysis (see Section 2 of this report). AI-assisted inputs were critically reviewed and incorporated only where they contributed to clarity and precision. The analyses, interpretations, and conclusions are the authors own.

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1 Executive Summary

This report presents the first steps towards the development of new transition scenarios that are consistent with the assumptions and narratives of alternative growth paradigms in the MultiFutures project. It systematically maps the key features of four paradigm clusters that are in the focus of the MultiFutures project, Green Growth, Post-Growth, Mission Economy, and the Great Mindshift, in relation to prominent existing transition scenarios, such as the IPCC Shared Socioeconomic Pathways (SSPs), the Word Energy Scenarios of the World Energy Council (WEC), and others. This mapping process assesses how well existing scenarios capture critical assumptions about economic growth, governance structures, technological innovation, and societal priorities, and identifies both areas of alignment and significant gaps.

Mainstream transition scenarios focus primarily on emissions reductions and economic growth and rarely incorporate broader societal goals such as well-being, equity, and sufficiency. To address these gaps, this report lays the foundations for developing new multidimensional transition pathways that reflect the broader goals of sustainability paradigms while ensuring compatibility with existing modeling frameworks.

The report presents four alternative transition scenarios and one baseline scenario (EU Ref Scenario), each reflecting a different paradigm cluster for achieving sustainability and presents the process that led to their preliminary design. This is an extract of the four narratives.

Green Growth: Market-driven sustainability through innovation and efficiency

Green Growth envisions a market-led transition in which governments play a minimal regulatory role while businesses and financial markets drive decarbonization through technological innovation, trade liberalization and carbon pricing. Economic growth remains central, with efficiency gains expected to decouple emissions from prosperity. However, this trajectory prioritizes profitability over equity, leading to uneven distributional impacts.

Post-Growth: Keeping the economy within planetary limits

Post-growth challenges GDP-driven models by prioritizing well-being, social equity, and ecological stability. Economic activity is deliberately reduced through sufficiency policies, strict resource limits, and redistribution mechanisms. Work is reorganized around shorter hours and cooperative structures, reducing reliance on productivity-driven growth. This approach ensures strong environmental protection and social cohesion but requires fundamental economic restructuring and faces resistance from entrenched growth-dependent systems.

Mission Economy: A government-led industrial transition to sustainability

Mission Economy relies on strong government intervention to guide the sustainability transition. Governments set binding decarbonization targets, mobilize large-scale public investment, and drive industrial transformation through strategic workforce planning and public-private partnerships. While this model ensures rapid technology deployment and economic stability, it also risks bureaucratic inefficiencies, fiscal burdens, and reduced trade flexibility as governments prioritize industrial and climate goals over market competition.

The Great Mindshift: A Bottom-Up Transformation for Sustainable Societies

The Great Mindshift envisions community-driven sustainability, where power shifts from centralized markets and governments to participatory governance and cooperative economies. Social well-being replaces financial wealth as the primary measure of success, and environmental sustainability is maintained through cultural values rather than government regulations or market incentives. While this model fosters resilient local economies and strong civic engagement, scaling decentralized governance to address large-scale sustainability challenges remains a key uncertainty.

Implications and next steps

By systematically integrating paradigm-specific goals into transition scenarios, this report lays the groundwork for new, multidimensional sustainability pathways that go beyond conventional growth-centric models. The next phase of the MultiFutures project will be to translate these qualitative narratives into quantitative modeling frameworks that allow for comparative assessment of their feasibility, trade-offs, and policy implications.

2 Introduction

Tackling global challenges such as climate change, resource depletion, and rising inequality requires innovative approaches that extend beyond traditional frameworks. Transition scenarios, such as the Representative Concentration Pathways (RCPs) and the Shared Socioeconomic Pathways (SSPs), offer a structured framework to assess the long-term consequences of today's decisions. They have long been an essential tool for exploring pathways to a sustainable future and allow researchers and policymakers to explore different possible futures amidst deep uncertainties (B. C. O'Neill et al., 2014; Van Vuuren et al., 2011). However, many existing scenarios continue to prioritize greenhouse gas (GHG) emissions reductions and economic growth, often at the expense of broader societal objectives such as well-being, equity, and respect for planetary boundaries.

To address these limitations, it is essential to incorporate alternative narratives that challenge the dominant, growth-centric assumptions of existing transition models. This report aims to contribute to this effort by proposing the development of new transition scenario approaches consistent with alternative growth paradigms. Therefore, we will develop a macroeconomic system and describe with causal diagrams how important policy instruments (drivers) affect the environment. Moreover, the scenarios include a description of OECD well-being indicators, including an assessment of likely changes. It presents a systematic approach for their integration into scenario research, outlines a structured evaluation of existing scenarios, identifies conceptual gaps, and proposes a methodology for incorporating broader sustainability indicators into scenario narratives. Our approach aims to bridge the gap between qualitative visions of these paradigms and the quantitative rigor of established scenario methodologies, such as the SSPs, to provide a more holistic exploration of different scenarios toward sustainability.

The research activities described in this report are part of the MultiFutures project and build on the taxonomy of transition paradigms developed in MultiFutures by Slingerland et al. (2024) to integrate narratives such as Mission Economy, Post-Growth, Green Growth, and the Great Mindshift into an actionable scenario framework. These paradigms challenge the traditional focus on the growth of the gross domestic product (GDP) as the central measure of progress.

To achieve this, the report systematically evaluates 14 prominent existing scenarios developed by internationally recognized institutions, identifying the socio-economic drivers that underpin their assumptions. By documenting similarities and differences across these frameworks, we highlight where current models do not account for key dimensions of alternative paradigms, such as well-being, equity, and environmental limits (Bauer et al., 2017). This includes the integration of 'Beyond GDP' indicators—metrics that capture well-being, social equity, and environmental sustainability—into mainstream scenario narratives.

Finally, we propose preliminary alternative transition scenarios that reflect these dimensions, addressing identified shortcomings and providing a comprehensive foundation for future research within the MultiFutures project. To translate these paradigm-specific features into dynamic system representations, we employ **causal diagrams**. They help identify and visualize how changes in one part of a system—such as policy interventions or value shifts—affect other dimensions directly.

The work presented in this report is an important step in the broader MultiFutures project, laying the basis for the development and modeling of new transition scenarios. It aims to directly inform subsequent research activities, including the design of innovative policy options and the evaluation of their effectiveness using quantitative models. By systematically bridging qualitative and quantitative approaches, this report contributes to the development of multidimensional tools that support the urgent need for sustainable and equitable transitions.

We follow a structured process to develop transition scenarios aligned with alternative growth paradigms. Section 2 introduces the topic and defines the key terms used in MultiFutures. Section 3 compiles an inventory of existing transition scenarios, extracting and classifying key assumptions to identify dominant trends and gaps. Section 4 qualitatively assesses the core features of the four paradigms—Green Growth, Post-Growth, Mission Economy, and Great Mindshift—focusing on economic structures, governance, technology, and societal change. Section 5 maps these scenarios against paradigm narratives, assessing alignment and highlighting missing elements. The gap analysis shows the need for the development of preliminary new transition scenarios that incorporate underrepresented sustainability dimensions in Section 6. Section 7 concludes this report.

2.1 Definition of key terms used in MultiFutures

Scenarios and paradigms play distinct yet interrelated roles in addressing complex societal and environmental challenges. While scenarios focus on depicting possible future developments, paradigms provide the overarching frameworks that shape these depictions. Scenarios provide both narrative and quantitative representations of possible futures, focusing on pathways and key drivers that make these futures plausible (Colin et al., 2019). They are essential tools for exploring uncertainties, facilitating communication among stakeholders, and supporting strategic decision-making (B. C. O'Neill et al., 2017). For example, the SSPs integrate socio-economic narratives with quantitative projections of population growth, economic growth, and urbanization to examine mitigation pathways, adaptation strategies, and climate risks (Van Vuuren et al., 2011).

Paradigms, on the other hand, define the underlying societal values and priorities that guide scenario development. They shape perspectives on what constitutes progress, sustainability, and equity (Frantzeskaki et al., 2019). By embedding paradigms within scenario frameworks, visionary concepts can be translated into practical tools that policymakers can use to design and evaluate robust strategies for sustainable development.

Scenario development is a technique for navigating the complexities of an uncertain future. According to Garvey (2022), a scenario is a narrative depiction of how a specific issue might evolve, accompanied by the developmental path that makes such evolution plausible. Unlike forecasts or predictions, scenarios emphasize an exploratory approach, analyzing the implications of events and disruptions to uncover normative relationships (Grabtchak, 2021). This allows for the structured examination of uncertainties, helping to identify critical drivers of change and potential policy responses.

Scenarios typically serve one or more of four key functions: exploration, communication, decision-formation, and decision-making. First, the exploratory function involves investigating possible futures, identifying uncertainties, and analyzing critical factors shaping future developments. This provides a systematic approach to clarifying what is known and unknown. Second, the communication function facilitates shared understanding of complex issues by integrating diverse perspectives and enhancing discussions among stakeholders and experts. Third, the decision-formation function supports the process of establishing normative goals and visions by enabling reflection on desired outcomes. Finally, scenarios fulfill a decision-making function when used to evaluate the robustness of policies and strategies under varying conditions, thereby informing strategic planning.

While many scenarios prioritize one of these functions, the challenges of climate change mitigation and adaptation demand a more integrated approach. Recognizing this, the Intergovernmental Panel on Climate Change (IPCC) has developed comprehensive tools that combine hundreds of scenarios, pathways, and models to project plausible futures and guide interdisciplinary research (Pirani et al., 2024). The scenarios included in the IPCC Sixth

Assessment Report (AR6) serve several critical purposes. They project climate outcomes for varying levels of greenhouse gas emissions, offering policymakers a range of futures, such as the "1.5°C scenario" or the "2°C scenario," which aim to limit global warming to these thresholds. These scenarios also assess risks, providing insights into short- and long-term impacts on ecosystems, human systems, and economies. For example, near-term scenarios explore risks up to 2040, integrating socio-economic uncertainties and climate variability to assess potential vulnerabilities and adaptation needs. Additionally, they inform mitigation strategies, such as "non-overshoot scenarios," which illustrate pathways that avoid exceeding specific warming thresholds. By integrating socio-economic pathways with mitigation and adaptation strategies, these scenarios also help identify which impacts are avoidable or reversible, guiding the creation of effective action plans (Pirani et al., 2024; Shukla et al., 2022a).

Every scenario is inherently shaped by an underlying paradigm, yet this connection is often left implicit, which may give the impression of objectivity. To develop more comprehensive scenarios, it is essential to make these linkages explicit. By consciously integrating paradigms into scenario development, researchers and policymakers can move beyond a narrow focus on GHG emissions and economic growth. Instead, they can design approaches that incorporate well-being, equity, and environmental sustainability as fundamental dimensions, ensuring that future scenarios better reflect societal values and priorities.

Box 1. Definition of key terms used in this report

The term **'scenario'** is used in this report as a description of a plausible future that offers an internal consistency and is coherent with the set of assumptions and quantitative projections used to develop this vision, where key driving forces and their interlinkage are explained. The term **'pathway'** instead refers to a long-term trajectory that will most likely lead to a given scenario.

Consistent with the scenario definition stated in this report, the term ***'transition scenario'*** is used to refer to the representation of a future state of development, where environmental sustainability considerations are given central relevance.

Accordingly, the term ***'alternative transition scenario'*** refers to transition scenarios developed within the MultiFutures' project with the aim of exploring the conditions needed to materialize the principles and long-term ambitions of the alternative growth paradigms discussed within the scope of this project.

Within this project, a **'paradigm'** is defined as a distinctive set of concepts, principles or thought patterns (which encompasses theories, methodologies, ambitions, postulates, etc.), constituting a framework guiding theoretical and practical scientific research. According to this, we use the term **'paradigm cluster'** to refer to the four groups of similar paradigms, each of which share a core set of elements that makes them distinctive in relation to the other paradigms that fall under another cluster.

Paradigms emphasize specific categories, concepts and thought patterns. For comparative purposes, the term ***'paradigm features'*** is used in this project to refer to the categories characterizing any given paradigm or paradigm cluster.

3 Analysis of Existing Transition Scenarios: Foundations for Scenario Development

Sustainability transitions require fundamentally different pathways, depending on how economies, governance structures and social systems are organized. To develop robust transition scenarios that reflect a broad range of possible futures, it is essential to build on the wealth of existing climate and energy transition scenarios developed over the past decades. These provide standardized and widely accepted frameworks grounded on extensive modeling expertise, enabling structured and comparable assessments of alternative transition trajectories.

In the following chapter, we present the results of an analysis of a selection of existing transition scenarios to assess their key assumptions and identify gaps and inconsistencies in relation to the alternative paradigm narratives that are in the focus of the MultiFutures project - Green Growth, Post-Growth, Mission Economy, and the Great Mindshift. These results serve as a foundation for the development of new transition scenarios (see Section 6), ensuring that the assumptions used in MultiFutures' future modeling efforts are well grounded in both existing scenario frameworks and the broader paradigm narratives.

For this aim, this chapter:

- Selects and reviews existing transition scenarios based on clearly defined criteria (e.g., geographic scope, sectoral coverage, modeling approach) in Section 3.1,
- Extracts key features of the scenarios using a structured artificial intelligence (AI) based methodology combined with manual validation in Section 3.2,
- Identifies key economic, social, environmental and governance assumptions embedded in current transition scenarios in Section 3.3,
- Clusters scenarios based on their reliance on GDP growth, technological innovation, governance structures, policy instruments, and other key transition drivers in Section 3.3.1 and
- Prepares the ground for matching existing scenario assumptions and alternative paradigm narratives, see Chapter 5.

3.1 Selection of Representative Transition Scenarios

To provide a robust and representative basis for the analysis of transition pathways, we selected a set of existing climate and energy transition scenarios based on clearly defined criteria. These scenarios come from leading international organizations, ensuring methodological rigor, transparency, and policy relevance. The criteria are:

- **Geographical Scope:** Scenarios with a global or European perspective were included, avoiding regional limitations to ensure broad applicability.
- **Temporal Horizon:** Scenarios projecting trends to at least 2030, with most extending to 2050 or beyond, were prioritized.
- **Release Date:** Only the most recent reports (at the time of writing) from each organization were considered to ensure up-to-date insights.
- **Modeling Approach:** No restrictions were placed on quantification or modeling methodologies to capture diverse approaches.
- **Sectoral Coverage:** Scenarios comprehensively representing the energy system, including demand, supply, and transition dynamics, were included.

- **Research Independence:** Only scenarios developed by non-profit organizations with proven transparency in data, methods, and findings were selected.

Based on these criteria, we selected a total of 14 transition scenarios from the following five organizations. These scenarios reflect diverse narratives and modeling approaches relevant to the objectives of this report (see Table 1). A brief description of these scenarios is provided in Appendix 9.1.

Table 1: Overview of selected Representative Transition Scenarios

Organization, Report	Scenarios	Time horizon
EC (2020), EU Reference Scenario 2020	• EU Reference Scenario 2020	2050
IEA (2023), World Energy Outlook 2023	• Net Zero Emissions by 2050 (NZE) • Announced Pledges Scenario (APS) • Stated Policies Scenario (STEPS)	2050
IRENA (2023), World Energy Transitions Outlook 2023: 1.5°C Pathway	• Planned Energy Scenario (PES) • 1.5°C Scenario	2050
IPCC (2022)	• SSP1-1.9 • SSP1-2.6 • SSP2-4.5 • SSP3-7.0 • SSP5-8.5	2050
WEC (2019), World Energy Scenarios 2019	• Modern Jazz • Unfinished Symphony • Hard Rock	2040

3.2 Methodology for Extracting and Assessing Scenario Dimensions

To systematically analyze the selected transition scenarios, we used a structured methodology that integrates AI-powered text extraction, manual validation, and comparative assessments. This approach ensures that key assumptions across scenarios are systematically identified, categorized, and validated against predefined transition dimensions. Each scenario shown in Table 1 was assessed based on the following nine key dimensions:

- **GDP Growth:** Expected GDP trends (high/moderate/low reliance)
- **Role of Technological Innovation:** Market-driven vs. state-directed innovation
- **Governance & Policy Approach:** Top-down (state-led) vs. bottom-up (market/civil society-led)
- **Key Scaling Actors:** Primary drivers of change (government, markets, citizens)
- **Fossil Fuel Dependence:** Degree of reliance on fossil fuels
- **Carbon Pricing Mechanisms:** Use of carbon taxes, emissions trading schemes, etc.
- **International Cooperation:** Extent of global coordination in transition efforts
- **Wealth Redistribution:** Role of income and resource redistribution

- **Norms, Values & Behavioral Change:** Importance of societal and individual behavior shifts

Of these nine dimensions, five were selected based on the paradigm features identified by Slingerland et al. (2024) as key for distinguishing between paradigms: Role of GDP, Role of Technological Innovation, Key Scaling Actors (Top-Down vs. Bottom-Up), Redistribution of Wealth, and Norms, Values, and Behavioral Change. The remaining four - Governance & Policy Approach, Fossil Fuel Dependence, Carbon Pricing Mechanisms, and International Cooperation - were chosen for their critical role in shaping scenario development and defining pathways for transition.

Following the approach of Slingerland et al., (2024) we carefully designed prompts (see Table 2) to extract these dimensions in our list of representative scenarios. In developing our prompts, we followed the principles outlined by (Brown et al., 2020):

- **Clear and simple:** Avoid jargon to minimize misinterpretation.
- **Focused:** Targeted to specific characteristics identified in the paradigm taxonomy.
- **Concise: L**imiting instructions to avoid ambiguity.
- **Scoped:** Instruct the AI to respond with "no information" when relevant details are not available.

Table 2: Prompts used for data and information extraction

Role of GDP Using the provided report, your task is to determine the role of GDP for "[SCENARIO]" as a transition scenario. Avoid using jargon language, be concise and clear, and deliver only information that is retrieved from the text. If available, capture concise details, including any examples or cases. Do not exceed 300 words in your response. If there is no discussion or mention of the topic, respond "No information" and do not elaborate. **Characterizing policies** Using the provided report, your task is to determine what kind of policies or initiatives "[SCENARIO]" as a transition scenario proposes. These may be government policies or actions by other stakeholders, e.g., citizens or businesses. Avoid using jargon language, be concise and clear, and deliver only information that is retrieved in the text. If available, capture concise details, including any examples or cases. Do not exceed 300 words in your response. If there is no discussion or mention of the topic, respond "No information" and do not elaborate. **Role of technological innovation** Using the information provided, your task is to determine the role of technological innovation in "[SCENARIO]". This may include whether and how technological innovation is discussed as a part of achieving "[SCENARIO]" and how its role is perceived. Avoid using jargon language, be concise and clear, and deliver only information that is retrieved from the text. If available, capture concise details, including any examples or cases. Do not exceed 300 words in your response. If there is no discussion or mention of the topic, respond "No information" and do not elaborate. **Redistribution of Wealth** Using the provided report, your task is to determine whether and how redistribution of wealth is discussed in "[SCENARIO]". This may include whether and how redistribution of wealth is discussed in the report and how it is perceived in a "[SCENARIO]" world. Avoid using jargon language, be concise and clear, and deliver only information that is retrieved from the text. If available, capture concise details, including any examples or cases. Do not exceed 300 words in your response. If there is no discussion or mention of the topic, respond "No information" and do not elaborate.

Key Scaling Actor
Using the provided report, your task is to identify whether the primary driver of change for "[SCENARIO]" as a transition scenario is governmental policies or initiatives from markets, businesses, or citizens. Avoid using jargon language, be concise and clear, and deliver only information that is retrieved in the text. If available, capture concise details, including any examples or cases. Do not exceed 300 words in your response. If there is no discussion or mention of the topic, respond "No information" and do not elaborate.

Change in Norms and Behavior
Using the provided report, your task is to evaluate whether "[SCENARIO]" as a transition scenario requires a change in current societal norms and values, as well as whether it requires a change in individual behavior (e.g., changes in diet, plane travel, etc.). Avoid using jargon language, be concise and clear, and deliver only information that is retrieved in the text. If available, capture concise details, including any examples or cases. Do not exceed 300 words in your response. If there is no discussion or mention of the topic, respond "No information" and do not elaborate.

Moreover, we manually extracted features like energy mix, carbon pricing, climate targets, and population growth from the reports. While these aspects are not key characteristics of alternative paradigms, they are highly relevant for transition scenario development. These features allowed us to gather insights into how scenarios integrate essential elements of energy transitions and climate strategies. To ensure the accuracy and reliability of AI-generated outputs, all responses were manually reviewed (Haenlein & Kaplan, 2019).

3.3 Clustering of Key Features from the Scenario Inventory

The next step in the analysis was to categorize and cluster the results of the scenario assessment into a structured 'inventory' (see also Table 6 in the Appendix). This step enables alignment with the four paradigm narratives by mapping key assumptions across existing transition scenarios. Through this mapping, we areas of convergence, divergence, and gaps between the selected representative scenarios and the alternative paradigms.

This approach provides a clear and consistent framework for comparison, following best practices in scenario research, such as those used in the SSPs framework (Van Vuuren et al., 2011; O'Neill et al., 2017).

The full inventory can be accessed as a downloadable Excel file via the MultiFutures project website (multifutures.eu).

3.3.1 Clustering results

GDP is commonly used as a key indicator of economic activity and societal well-being. Figure 1 provides an overview of the GDP-related assumptions across the analyzed scenarios. Based on their position towards GDP and the available quantified assumptions, the scenarios are grouped into three categories according to the extent of projected annual GDP growth: **low (≤ 2.2%), moderate (> 2.2 % and ≤ 2.8%), and strong (> 2.8%)**. Where no specific values were available, the category was derived from the qualitative description of the position towards GDP.

- **EU Reference Scenario 2020:** Economic growth is projected through aggregate GDP growth, particularly focusing on long-term trends like population ageing and productivity growth. It considers structural reforms and macroeconomic policy actions like stimulus measures (EC, 2021). The projections are based on various reports, such as the European Commission's 2021 Ageing Report (European Commission. Directorate General for

Economic and Financial Affairs., 2021), and reflect assumptions regarding labor force trends and total factor productivity convergence across EU member states. Significant attention is given to the long-lasting impacts of the COVID-19 pandemic (European Commission. Directorate General for Economic and Financial Affairs., 2021). The GDP projection for 2030 is 2.3% lower compared to pre-pandemic estimates of the 2018 Ageing Report and is characterized by very large uncertainty due to the pandemic. A low but relatively stable annual GDP growth of about 1.3% per year over the period 2019 to 2070 is projected.

- **IEA World Energy Outlook 2023:** Economic growth is characterized by a global GDP growth rate of 2.6% per year until 2050. Until 2030, the average growth rate is projected to be 3%. The economic growth rates are held constant across scenarios to allow for a comparison of the effects of different energy and climate choices with a common background. However, the report outlines the different demographic trends by country and region (IEA, 2023).
- **IRENA 1.5°C Pathway 2023:** The Planned Energy Scenario (PES) anticipates global GDP growth at a compound annual growth rate of 2.8% from 2023 to 2050 (IRENA, 2023). Under this scenario, GDP growth is driven primarily by public and private investments in renewable energy, energy efficiency, and related infrastructure, contributing positively across sectors such as manufacturing, construction, and services. In contrast, the 1.5°C Scenario projects an average annual GDP that is 1.5% higher than the PES over the same period, reflecting the economic stimulus effects of front-loaded investments in the clean energy transition.
- **IPCC:** The highest projected GDP growth among all SSP scenarios is anticipated in the SSP5 scenario. A polarized economic growth is projected in SSP4. High-income regions and elite groups achieve significant GDP growth while low-income regions and marginalized populations experience stagnation. In SSP1, GDP growth is projected to be high but prioritizes equity and environmental sustainability over purely economic expansion. Despite high projected GDP growth rates, there is a strong focus on social justice and environmental sustainability. This means that economic growth is not pursued for its own sake, but as part of a conscious transformation. Investments are directed towards education, health, green technologies and sustainable infrastructure. In SSP2, GDP growth follows historical trends, where developing countries are catching up gradually, but disparities persist. A slow and regionally fragmented GDP growth is anticipated in SSP3, which translates to the lowest GDP growth among SSPs. The narratives describe the main characteristics but are complemented by quantitative projections (Shukla et al., 2022a).
- **World Energy Scenarios 2019 (WEC):** Scenarios vary with a strong annual GDP growth between 2015 and 2060 of about 3.1% in “Modern Jazz”, a steady and moderate growth of about 2.7% in “Unfinished Symphony”, and a slow growth of about 2.2% in “Hard Rock”. “Modern Jazz” is a market-driven scenario, where rapid technological innovation and digitalization weaken the link between economic growth and primary energy demand. In “Unfinished Symphony”, consumers’ socially responsible energy behaviors result in economic growth detaching from energy demand. “Hard Rock” explores the consequences of weaker and unsustainable global economic growth with inward-looking national policies (WEC, 2019).

Figure 1: The position towards GDP for each scenario with respect to growth is categorized into low, moderate, and strong projected annual GDP growth. IPCC scenarios are categorized according to their narratives.

As shown in Figure 2, **population growth** is expected to be relatively low in most EU countries, with a compound annual growth rate of about 0.03% in the 2019-2030 period, and is expected to decline by 0.11% annually over the 2030-2100 period. However, there are wide differences in the long-term national population trends, with the population growing in 13 member states in the 2030-2100 period and dropping in the others. Latvia is the EU country that is projected to have the highest decline in population with a compound annual growth rate of -0.65% in the 2030-2100 period. The EU country that is projected to experience the highest population growth in this period is Ireland with about 0.58%. Low growth is expected to stabilize energy demand, but urbanization may slightly increase energy needs in cities (EU Reference Scenario 2020).

High growth rates are expected in the Middle East and North Africa Region, where also the highest energy demand growth in the world after China and India is anticipated (WEC, 2019). The global population is expected to grow by a compound annual growth rate of 0.7% over the 2023-2050 period. This translates to a growth of about 1.7 billion people by 2050 from 8 billion today to 9.7 billion in 2050 (WEC 2019; IRENA; 2023; IEA, 2023). The IPCC narratives describe varying assumptions regarding population growth.

Figure 2: Compound annual growth rate for each scenario over the mid and long term. No data available for WEC, IRENA, IEA for the 2060-2100 period. While SSP1, SSP2, SSP4 and SSP5 project a decline in the global population over the long-term, SSP3 projects growth

Characterizing policies or initiatives include government-led and stakeholder-driven actions designed to meet climate and energy goals. They vary by scenario and often involve policy frameworks, incentive structures, and regulatory changes to drive the transition to low-carbon economies. For WEC-MJ, IEA-APS, IEA-NZE, IRENA-1.5°C, IPCC-SSP1, IPCC-SSP5, and EU-RS2020 the policy instruments emphasize technological innovation and industrial policies, that might include measures such as smart grids, energy storage, carbon capture, utilization and storage (CCUS), green hydrogen networks. Policies in WEC-HR and IPCC-SSP3 focus on national interests that involve energy security and only limited technological innovation and environmental regulations. IEA-STEPS and IRENA-PES rely on currently existing policies. Some kinds of carbon pricing initiatives are introduced or further developed in all scenarios except for WEC-HR.

Technological innovation is mainly driven by market (bottom-up) and government (top-down) solutions and plays a different role for different scenarios (Figure 3). The classification into low, moderate, and strong reliance on technological innovation is based on a qualitative assessment of factors such as investment levels, policy support, market dynamics, and the speed of technology development and deployment. WEC's "Modern Jazz" describes a world with a high reliance on technological innovation driven by markets where digitalization in energy such as energy blockchain platforms plays a central role. Public-private investments as in WEC's "Unfinished Symphony" enable strong technological innovation. In "Hard Rock", low investments in technology are anticipated as inward-looking governmental policies prioritize national energy security over innovation.

A moderate reliance on technological innovation is projected in an IEA STEPS world. It relies on existing policies that enable the development of technologies like electric vehicles, heat pumps, and improvements in industrial efficiency contribute to reducing emissions but at a slower rate compared to more ambitious scenarios. A strong reliance on technological innovation driven by governments is expected in IEA's APS scenario. This scenario highlights innovation in areas such as electrification, renewable energy, and energy storage supported by energy, climate and industrial policies. IEA's NZE enforces rapid emission reduction and a global shift to clean energy supported by policies especially when it comes to critical areas such as CO_2 pipeline infrastructure and hydrogen-based energy systems but also for scaling up mature technologies such as solar, PV, wind, and EVs.

The Planned Energy Scenario by IRENA builds on existing governmental energy plans to drive innovation which involves investments in industrial processes such as hydrogen and CCUS. In the IRENA 1.5°C scenario innovation in technological solutions, such as green hydrogen for heavy industries and advanced carbon capture, utilization, and storage (CCUS) technologies, is integral. This scenario anticipates substantial growth in renewable energy technologies and smart grids, alongside breakthroughs in energy storage and efficiency. Supportive policies and targeted investments are projected to create an environment that accelerates technological advancements.

The IPCC SSP1 scenario projects significant investments in environmental technologies driven by governments and markets, and a high rate of technology transfer and diffusion e.g. from industrialized to developing countries. In SSP2 moderate rates of technological progress are anticipated, reflecting historical trends. Innovation is neither rapid nor transformative, with gradual improvements in energy efficiency and deployment of renewables. Technological progress in SSP3 is hampered by regional rivalries and fragmented governance. Investments in education and technological development decline. Technological development in SSP4 is highly unequal, reflecting economic and resource disparities. In high-tech economies and -sectors a strong reliance on technological innovation is anticipated whereas low-income countries rely on traditional technologies due to the limited access to modern technologies and infrastructure. Driven by governments and markets, SSP5 anticipates rapid technological progress.

Key technologies in the EU reference scenario include renewable energy sources, such as solar and wind, which have seen cost reductions due to "learning-by-doing" and economies of scale. Battery storage and hydrogen infrastructure also play significant roles, with advancements supported by public policies that encourage faster adoption through research funding, incentives, and regulatory support.

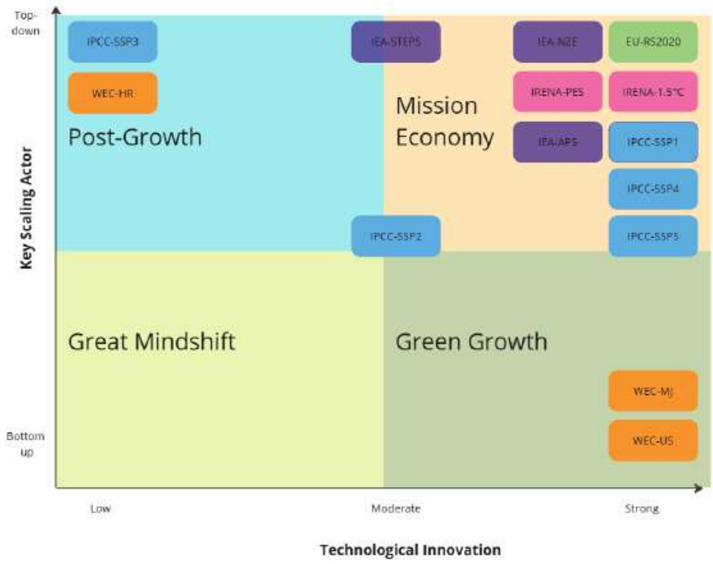

Figure 3: Exemplary clustering of key assumptions of the representative transition scenarios in the dimensions "Technological Innovation" and "Key Scaling Actor. Source: Own illustration

Figure 4 below shows the importance of fossil fuels in the global **energy mix** in each of the scenarios considered and whether the economy is market-driven (bottom-up) or government-driven (top-down). The energy mix in WEC scenarios relies heavily on fossil fuels. Fossil fuels continue to meet more than two-thirds of primary energy demand across all three scenarios. The absolute volume of oil and coal shrinks in “Unfinished Symphony” and “Modern Jazz”, increasing only in “Hard Rock”.

In the STEPS scenario by IEA the energy mix shifts gradually but remains dominated by fossil fuels. Fossil fuels decrease from 80% of the total energy supply to 73% by 2030, with a modest increase in renewables and low-emissions technologies. Natural gas demand continues to grow until the late 2020s, driven by its role as a bridge fuel, while coal and oil demand peak and begin to decline by 2030. In APS, the energy mix shifts significantly towards renewables and low-emission sources, reducing reliance on fossil fuels driven by strong policy support and falling costs. The reliance on fossil fuels is low in NZE. The orientation towards renewable energy, nuclear energy and clean fuels is high. Where fossil fuels remain in use, carbon capture technologies will be applied.

IRENA’s planned energy scenario maintains a high reliance on fossil fuels with slow declines in coal, oil, and natural gas usage. Nuclear and bioenergy also play important roles, while natural gas demand declines as electrification and efficiency gains progress. Carbon capture and storage (CCS) technologies and hydrogen are deployed in specific sectors to reduce emissions, particularly in hard-to-abate industries. The 1.5°C scenario projects a low reliance on fossil fuels. The share of renewable energy in the global energy mix is projected to increase from 16% in 2020 to 77% by 2050.

SSP1 emphasizes a shift to renewable energy sources, high energy efficiency, and electrification of energy systems. Fossil fuels are phased out rapidly, and bioenergy, wind, and solar dominate the energy supply by mid-century. Carbon capture and storage (CCS) is utilized to manage remaining emissions. A moderate energy transition is anticipated in SSP2, where the energy mix continues to rely on fossil fuels but gradually shifts to include more renewables and natural gas. The SSP3 scenario faces limited international cooperation and technology diffusion, leading to a continued reliance on fossil fuels with low adoption of clean energy technologies. In SSP4, high-income regions adopt low-carbon technologies, including renewables and nuclear energy, while low-income regions rely heavily on traditional biomass and coal due to limited access to modern energy infrastructure. SSP5 relies heavily on fossil fuels, driven by high economic growth and energy demand. Coal, oil, and natural gas dominate the energy mix, with minimal adoption of renewables. CCS technologies are adopted late in the century to manage emissions from fossil fuel use in scenarios targeting mitigation.

A declining but persistent role for fossil fuels is projected under the EU Reference Scenario. Natural gas remains important for power generation throughout the period, primarily to provide flexibility and stability as variable renewables expand. Its use is expected to decrease modestly until 2030 and then remain relatively stable, with gas-fired plants supporting the integration of renewables. Coal use declines rapidly due to EU climate policies and market dynamics, with an almost complete phase-out by 2030. Oil use is largely eliminated except in isolated cases, such as non-interconnected islands. Nuclear capacity decreases over time due to retirements and acceptance issues, while biomass maintains a steady but modest contribution of around 5-6% in the energy mix.

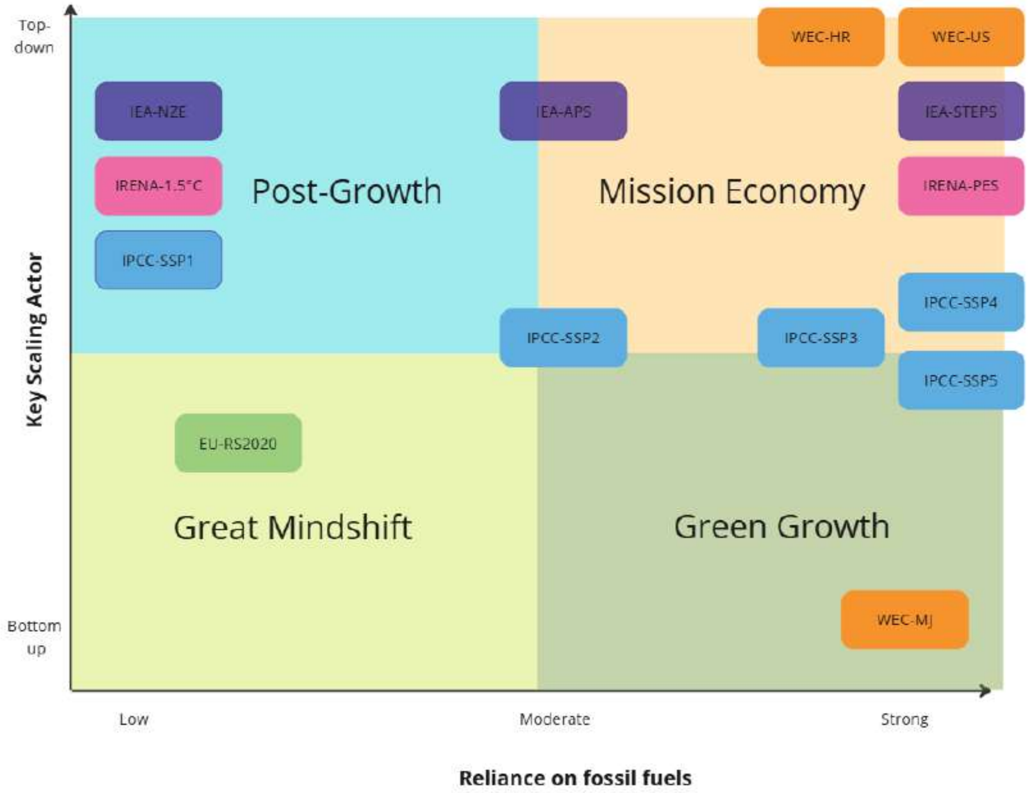

Figure 4: Exemplary clustering of key assumptions of the representative transition scenarios in the dimensions "Reliance on fossil fuels" and "Key Scaling Actor". Source: Own illustration

Different **carbon pricing** systems are considered in different scenarios: carbon taxes, Emissions Trading Systems (ETS) and redistribution measures (Figure 5). Carbon pricing plays a subordinate role in the "Modern Jazz" scenario. No quantified assumptions are made but it may be included in some services with market forces left to decide about feasibility. It would be expected that any carbon pricing implemented within the "Modern Jazz" scenario would be set at a relatively low level to minimize its impact on market competitiveness. In "Unfinished Symphony", a carbon price or tax becomes a pervasive feature of energy policy, building on existing approaches. The prices in existing initiatives range from USD 1 – 127/t CO_{2eq}. There is no information about carbon pricing in "Hard Rock".

In IEA-STEPS, existing and scheduled carbon pricing initiatives are incorporated based on current regional policies such as EU ETS, China's national ETS, Indonesia's ETS for power sector, India's national carbon market and Brazil's national ETS.

Similar to IEA-STEPS, APS and NZE also incorporate existing and scheduled carbon pricing initiatives. In APS, carbon prices are higher than in the STEPS scenario, reflecting additional measures to meet net-zero emissions pledges. There is no explicit pricing in sub-Saharan Africa (excluding South Africa) and other Asia regions, instead, these regions rely on direct policy interventions to drive decarbonization. In NZE, carbon prices are quickly established in all regions and rise rapidly across all advanced economies as well as in prominent emerging market economies with net zero emissions pledges, including China, India, Indonesia, Brazil and South Africa. CO_2 prices are lower but nevertheless rising in other emerging market and developing economies such as North Africa, Middle East, Russia and Southeast Asia (excluding Indonesia).

CO_2 prices are lower in the remaining developing economies, as it is assumed they pursue more direct policies to adapt and transform their energy systems.

The IRENA Planned Energy Scenario (PES) acknowledges existing and planned policies based on governments' plans in place at the time of the analysis. In the 1.5°C Scenario, carbon pricing is part of a range of measures to support a just and inclusive transition. Carbon pricing evolves over time and differentiates prices by each country's income level and accords special treatment to sectors having high direct impacts on people. This also involves assigning the revenue from carbon pricing to public investment. Revenues are assumed to be recycled and redistributed through social-directed payments that target lower-income households progressively, assuming the adoption of distributional policies to mitigate any regressive effects of the energy transition – not only carbon pricing but also climate change itself. The social-directed payments assume 60% of the payments going to the lowest-income quintile, 30% to the second quintile and 10% to the third quintile.

IPCC scenarios quantify carbon prices in relation to different radiative forcing levels (Kriegler et al., 2017; Riahi et al., 2017).

The EU Reference Scenario discusses carbon pricing primarily through the EU Emissions Trading System (ETS), which is projected to be a significant tool for reducing emissions, especially after 2030. Under this system, carbon prices are expected to gradually increase to drive decarbonization efforts, with the ETS price assumed to reach approximately 30€ per ton of CO_2 by 2030. This price is expected to continue rising post-2030 to encourage emission reductions in line with the decreasing cap on allowances. The ETS also covers sectors like energy production and certain industrial processes, aiming to make higher carbon prices an incentive for industries to adopt cleaner technologies and reduce emissions.

	Carbon Pricing Systems		
	Carbon tax	ETS	Redistribution
EU-RS2020		●	
IEA-STEPS	●	●	
IEA-APS	●	●	
IEA-NZE	●	●	
IRENA-PES	●	●	
IRENA-1.5°C	●	●	●
IPCC-SSP1	●		
IPCC-SSP2	●		
IPCC-SSP3	●		
IPCC-SSP4	●		
IPCC-SSP5	●		
WEC-MJ	●		
WEC-US	●		
WEC-HR		no information provided	

Figure 5: Carbon pricing systems considered in the scenarios. Source: Own illustration

International cooperation in the "Modern Jazz" scenario by WEC is driven by market forces and technological innovation. In most countries, there is no concerted effort to contain GHG emissions or fulfill Paris agreements except where consumers express their values by making eco-friendly choices. Unfinished Symphony pursues an increasing international cooperation, that enables development such as electricity grids and synthetic fuel markets. A series of reforms enables improved collaboration on climate issues between the USA, China, Europe and India with an emphasis on providing support for technology innovation and technology transfer to developing nations. “Hard Rock” assumes a lack of international cooperation. Vulnerability to regional value chain disruption increases, which forces collaboration, but on a sub-regional rather than global basis, to create technological and economic solutions for accelerating climate change adaptation.

International cooperation is highlighted as essential in IEA-STEPS for clean energy technology supply chains. The report notes that countries cannot be fully self-sufficient in clean energy resources and technologies, underscoring the ongoing need for international trade and collaboration. Additionally, international finance plays a significant role in supporting the clean energy transition, especially in emerging markets where development finance and international institutions help mobilize investments. In the APS scenario, international cooperation is seen as critical for advancing clean energy and addressing global climate goals. Cooperation focuses on the scaling-up of grid investments and integration to support renewable energy deployment in regions like Southeast Asia. The NZE scenario sees international cooperation as fundamental to achieving global climate objectives. The scenario emphasizes that all countries must contribute to reaching net zero CO_2 emissions by 2050, with advanced economies leading the way and achieving net zero earlier than emerging markets and developing economies.

IRENA PES does not provide specific information on the position towards international cooperation. However, the scenario reflects current international collaboration. The 1.5°C scenario sees greater international collaboration crucial to achieving global climate goals and to address the three pillars that form the foundations for a way forward. First, building the necessary infrastructure and investing at scale in grids, and both land and sea routes, to accommodate new production locations, trade patterns and demand centers; second, advancing an evolved policy and regulatory architecture that can facilitate targeted investments; and finally, strategically realigning institutional capacities to help ensure that skills and capabilities match the energy system we aspire to create.

The IPCC-SSP1 scenario pursues strong and effective international cooperation. In SSP2, a moderate level of international collaboration is anticipated. Global and national institutions work toward - but make slow progress in - achieving sustainable development goals (O'Neill et al., 2017). SSP3 expects weak international cooperation, as it constitutes a "fragmented world in terms of climate policy" (Fujimori et al., 2017). SSP4 is a highly unequal world with polarized levels of international collaboration. High-income countries form coalitions to advance their interests, while low-income countries are often excluded or marginalized (Calvin et al., 2017). SSP5 is characterized by strong international cooperation focused on economic growth and market integration, but environmental and sustainability issues are given secondary importance (Kriegler et al., 2017).

In the EU Reference Scenario, international collaboration is characterized primarily by aligning EU policies with global climate efforts, such as the commitments under the UNFCCC and the Paris Agreement. It also includes interactions with non-EU regions and major economies through global models like POLES-JRC, which allows the EU to consider international fossil fuel prices and assess the impact of its policies within a global energy market context. Additionally, policies at the international level, including maritime and aviation emission standards set by the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO), are part of the scenario to ensure consistency with broader international climate goals.

Wealth redistribution is not directly mentioned in most of the scenarios. However, the IRENA PES acknowledges substantial distributional challenges, especially regarding income and wealth inequalities both between and within countries. Under the 1.5°C Scenario, a wealth tax sensitivity analysis was conducted, where revenues from wealth taxation are created and the impact on GDP, employment and welfare was analyzed.

IPCC scenarios address wealth distribution and income inequality. Under SSP1 "inequality is reduced both across and within countries" (Riahi et al., 2016). In SSP2, income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain (Riahi et al., 2016). In SSP3, inequalities persist or worsen over time (Riahi et al., 2016). SSP4 mentions that highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries (Riahi et al., 2016). SSP5 foresees economic participation of disadvantaged population groups (O'Neill et al., 2017).

Key scaling actors describe the primary driver of change in a transition scenario. In WEC "Modern Jazz", shaping the energy landscape is determined by technology and innovation is driven by businesses and entrepreneurial markets. In "Unfinished Symphony", governments play a central role in driving decarbonization and addressing interconnected challenges like climate change, inequitable energy access, and affordability. This scenario also sees significant public-private investments in clean energy technologies and infrastructure, supported by policies that ensure sustainable development. The primary driver of change in "Hard Rock" are governments with a focus on national security.

In IEA STEPS, APS, and NZE governmental policies are the key scaling actors, either building on currently existing measures or introducing new ambitious initiatives.

The key drivers in IRENA PES and 1.5°C are governmental policies. However, market dynamics also play an important role as well as end-users, especially in the 1.5°C Scenario.

IPCC-SSP1 assumes a top-down process with a strong collaboration between governments, private actors, and civil society (O'Neill et al., 2017). In SSP2, scaling efforts align with historical trends, where governments and private entities work within existing frameworks (Fricko et al., 2017). SSP3 is characterized by fragmented governance, where scaling actors operate independently and prioritize regional goals. "Policies shift over time to become increasingly oriented toward national and regional security issues, including barriers to trade, particularly in the energy resource and agricultural markets [...] several regions move toward more authoritarian forms of government with highly regulated economies." (Fujimori et al., 2017). In SSP4, political and business elites control most global resources (O'Neill et al., 2017). SSP5 can be seen as both market- and government-driven, emphasizing fossil fuel-led economic growth and increasing globalization, alongside government intervention to enhance human capital, social development, and public participation (O'Neill et al., 2017).

The primary driver of change in the EU Reference Scenario is governmental policy. The scenario is designed around existing EU and national policies as of 2019, focusing on achieving energy efficiency, expanding renewable energy, and meeting GHG reduction targets. Policies such as the EU-ETS set carbon prices to guide investment, while the Renewable Energy Directive and Energy Efficiency Directive support sustainable energy development. Although technology and market trends contribute, they act within the framework set by these policies, which are fundamental in shaping the transition until 2030 and beyond.

Finally, Figure 6 below shows whether a transition scenario requires a change in current societal norms and values and individual behaviors, and whether this is primarily driven by society and/or the market (bottom-up) or by governments (top-down). In the WEC "Modern Jazz" scenario, individual behavior changes are primarily market-driven, with consumers choosing sustainable products and services based on efficiency and cost-effectiveness rather than policy incentives. "Unfinished Symphony" calls for significant changes in societal and individual behaviors, driven by policy actions. Consumers adopt socially responsible energy practices to reduce energy demand. In "Hard Rock", current norms and values are not influenced by policies and individual behaviors remain mostly unchanged, resulting in minimal adoption of sustainable practices.

In the IEA STEPS scenario, limited shifts in societal norms and values are driven by the current policy landscape, leading to gradual changes, but at a more limited pace compared to more ambitious scenarios like NZE. The behavioral changes in APS reflect those incorporated into net zero emissions pledges. These are mainly concerned with road transport, for example including traffic reduction measures in cities. The behavioral changes in the NZE scenario are wider ranging and systemic in nature, and include boosting shared mobility, reducing speed limits, discouraging sport utility vehicle ownership and use, adjusting heating and cooling temperatures in buildings, and switching from planes to trains or videoconferencing where possible.

The IRENA PES scenario reflects the current policy landscape and therefore leads to primarily keeping current norms and values with only gradual shifts towards behavior change. The 1.5°C Scenario promotes behavioral changes and modal shift towards public transport. Changes in behavior and consumption patterns play a crucial role in reducing energy consumption and complement the energy transition along with a range of energy efficiency technologies.

In the IPCC-SSP1 scenario, a significant shift in societal norms, values, and behaviors is required, emphasizing low material consumption and a reduced-meat diet. In SSP2, societal inertia persists, leading to material-intensive consumption and medium meat consumption (O'Neill et al., 2017). SSP3 differs from SSP1 and SSP2, with a strong preference for high livestock-oriented food consumption, reflecting limited progress toward sustainable dietary patterns (Fujimori et al., 2017). Similarly, SSP4 scenario reflects a preference for high livestock-oriented food consumption along with a strong household demand for manufactured goods, contributing to resource-intensive lifestyles (Fujimori et al., 2017). SSP5 features meat-rich diets, a culture of materialism, status-driven consumption, and high levels of personal mobility (O'Neill et al., 2017) with little progress in transforming societal norms and values.

The EU Reference Scenario does not specifically call for a fundamental change in societal norms and values, nor does it anticipate significant changes in individual behaviors, such as diet or travel habits, as part of its projections. Instead, it projects energy and transport sector trends based on existing EU policies and market dynamics, assuming stability in societal behaviors. For instance, while energy efficiency and renewable energy integration continue to progress, these changes rely more on policy-driven infrastructure and technological advancements rather than shifts in individual consumption patterns (European Commission. Directorate General for Energy. et al., 2021).

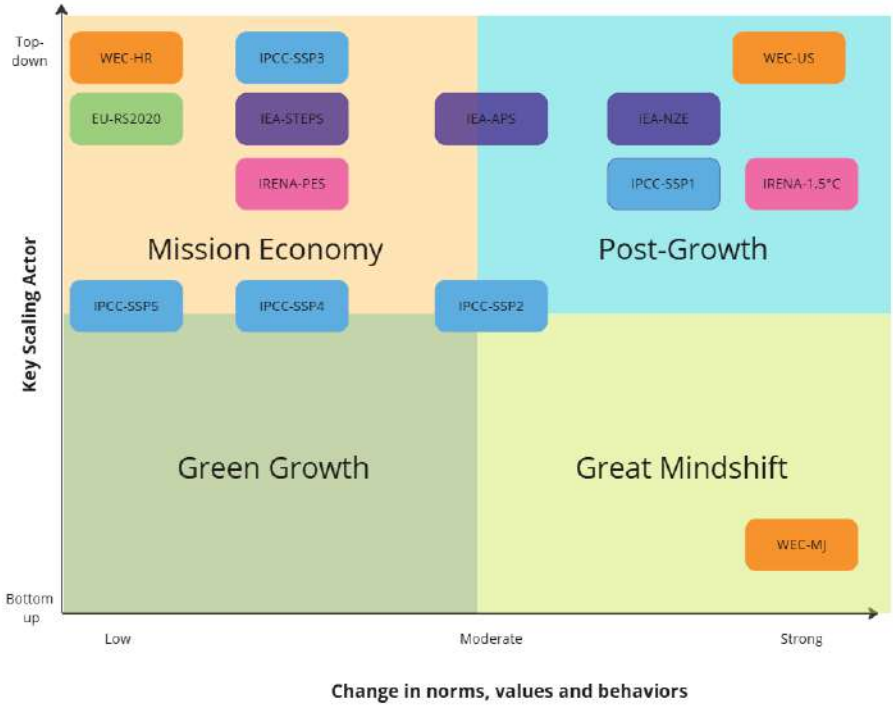

Figure 6: Exemplary clustering of key assumptions of the representative transition scenarios in the dimensions "Change in norms, values and behaviors" and "Key Scaling Actor". Source: Own illustration

4 Positioning Paradigms: A Qualitative Assessment for Transition Scenarios

Sustainability transitions require fundamentally different pathways, depending on how economies, governance structures and social systems are organized. This chapter aims to identify the defining characteristics of the four paradigm clusters - Green Growth, Post-Growth, Mission Economy, and the Great Mindshift - and to assess their alignment with existing transition scenarios (see Section 3). The goal is to assess how well current transition scenarios capture the key dimensions of these paradigms and to show gaps that need to be filled when developing new transition scenarios.

For this, we employ

- A qualitative review of how each paradigm approaches governance, economics, technology, and social structures.
- A comparative analysis of existing transition scenarios to identify missing paradigm elements.
- An expert Delphi study and OECD well-being indicators to quantify social and environmental priorities across paradigms.

The assessment of the four paradigm clusters was done by analyzing their positions on key narrative features (see Table 12 in the Appendix), including GDP growth, technological innovation, governance structures, and scaling actors. These features were derived from the framework proposed by Slingerland et al. (2024), which categorizes paradigms based on their emphasis on these dimensions.

While existing transition scenarios address some aspects of societal development, many key paradigm elements remain underrepresented or absent. To strengthen the gap analysis and provide a more comprehensive comparison, the OECD's Well-Being Indicators were selected to broaden the assessment beyond conventional economic growth metrics and provide a more nuanced picture of societal progress by measuring measure well-being using over 80 indicators covering three main categories: current well-being, inequalities, and resources for future well-being (OECD, 2020). The OECD framework is further divided into 15 dimensions of well-being: income and wealth, work and job quality, housing, health, knowledge and skills, environmental quality, subjective well-being, security, work-life balance, social connections, and civic engagement, and four types of capital (economic, natural, human, and social) to assess future well-being. We use these indicators because they form the foundation for our Beyond GDP indicators that are going to be developed in future research in MultiFutures. In addition, they are well-established, with reliable data sources available across different countries, which ensures consistency and comparability.

To assess how well existing transition scenarios align with the priorities of each paradigm using the OECD Well-Being Indicators, an expert survey was conducted in which we employed a structured Delphi study approach. This method allows for a systematic, iterative assessment of key features and facilitated expert-driven refinement and consensus building (Dalkey & Helmer, 1963; Niederberger & Renn, 2019). The results provide a robust basis for identifying paradigm-scenario discrepancies and refining the scenario development framework.

The survey has followed a multistage Delphi process designed to achieve expert consensus through iterative feedback and refinement (Brown et al., 2020; Cuhls, 2019). It consists of four main steps:

- **Survey design and testing:** A steering group was established among core team members to develop the survey, ensuring that Slingerland et al.'s (2024) definitions and the OECD well-being metrics were clearly integrated. The survey was pre-tested among all team members of the lead writing institution (EI-JKU) to refine clarity and usability.
- **Initial expert assessment:** The survey was distributed to experts from the MultiFutures consortium who assessed and prioritized the relevance of the well-being indicators across the four paradigms. This initial phase established a baseline understanding of expert perspectives and identified areas for further discussion.
- **Aggregation and statistical analysis:** Responses were aggregated and analyzed using descriptive statistics. In the next stages of development, these results will be returned to the MultiFutures team to allow participants to reflect on their initial responses within the broader group perspective and to encourage more informed responses in subsequent rounds.
- **Extend to full consortium:** Aggregated results will be shared with the broader MultiFutures consortium, which includes representatives from all project partners. Additional experts will be invited to complete the survey to enrich the overall results.

Figure 7 outlines the steps taken in the initial stages of this assessment. *Note: This report only includes results up to the second step of the Delphi methodology used. Further results will be provided in an updated version of this report in late 2025.*

Building on this assessment framework, we examine how the paradigms align with key variables commonly addressed in transition scenarios and present comparative findings from the expert survey and OECD well-being indicators, providing an in-depth assessment of how each paradigm prioritizes economic, social and environmental dimensions.

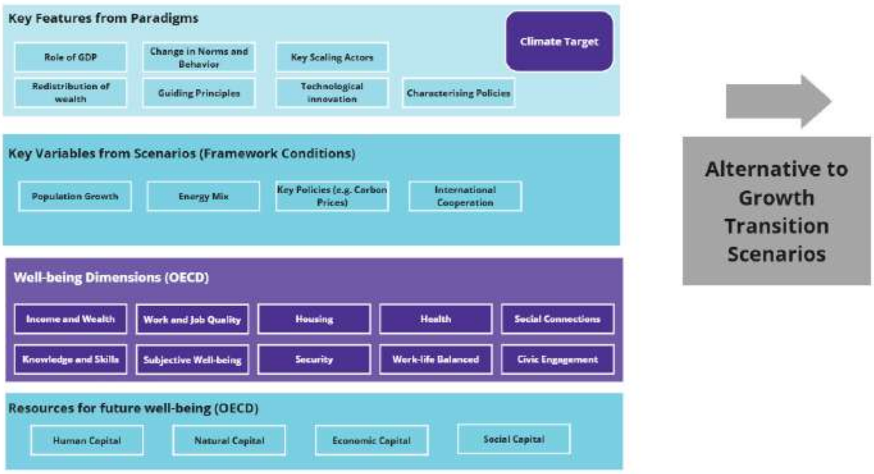

Figure 7: Methodology for developing alternative to growth transition scenarios. Source: Own illustration (Indicators are from OECD, 2020).

4.1 Insights from Expert Assessments

The results of the Delphi survey provide a structured assessment of how well the four sustainability paradigms align with key economic, social and environmental dimensions (based on the OECD better life indicators). A total of 11 experts participated in the first survey, with the exception of Green Growth, which was assessed by 12 experts. Indicators were ranked on a scale of 0 to 5, with experts rating paradigm characteristics using a standardized system.

Numerical values in parentheses (e.g., m = xxx) presented in the following represent mean scores derived from the experts' responses. These scores indicate the relative emphasis each paradigm places on specific dimensions, with higher values reflecting greater alignment with a given indicator. For example, a higher score for "Environmental Quality" suggests that a paradigm places a strong emphasis on environmental sustainability, while a lower score for "Income and Wealth" may indicate a reduced focus on traditional economic prosperity from the experts' perspectives.

4.2 Comparative Assessment of Paradigm Characteristics

In the following, we assess the qualitative position of each paradigm with respect to key paradigm features and scenario variables, as well as current and future dimensions of well-being based on the OECD indicators.

Policies in **Green Growth** focus primarily on economic prosperity and knowledge development, aligning with its market-driven approach. Economic security is emphasized through "Income and Wealth" (m=3.83) and investment in human capital via "Knowledge and Skills" (m=3.92) (see Figure 8). However, social well-being and participation are less prioritized, as reflected in lower rankings for Civic Engagement (m=2.42) and Work-Life Balance (m=2.33). The overall approach favors economic growth as a driver of well-being rather than direct social interventions. Similarly, **Mission Economy** prioritizes government-led environmental and technological policies, with "Environmental Quality" (m=4.00) and "Knowledge and Skills" (m=3.45) ranking highest. While market mechanisms still play a role, state planning directs key sectors. Social participation remains moderate, as seen in Civic Engagement (m=2.91), indicating a top-down governance structure. Work-life balance is the lowest among all paradigms (m=1.82), suggesting a strong focus on productivity rather than leisure or flexible labor markets. In **Post Growth**, policies emphasize social protection, well-being, and sustainability over economic growth. The highest-scoring dimensions reflect this shift: "Environmental Quality" (m=4.55), "Work and Job Quality" (m=4.09), and "Work-Life Balance" (4.27). Unlike Green Growth and Mission Economy, where economic prosperity is central, Post Growth integrates well-being as a core policy objective, as highlighted by "Subjective Well-being" (m=4.18). The approach acknowledges economic considerations ("Income and Wealth" ranks relatively high at m=3.91), but these are secondary to ensuring equitable and sustainable living conditions. **Great Mindshift** represents the most community-oriented and participatory policy framework. It scores highest on "Civic Engagement" (m=4.36) and "Social Connections" (m=4.36), emphasizing bottom-up governance and strong social cohesion. Environmental sustainability is also a key policy pillar, with "Environmental Quality" (m=4.18) and "Housing" (m=4.09) ranking high. The economic dimension ("Income and Wealth" at m=3.18) plays a less dominant role, reflecting a shift from financial security to community-driven well-being and participatory decision-making.

Figure 8: Expert survey results. Comparison of the mean values of different paradigms across OECD well-being indicators. Source: Own illustration

Regarding capital for future well-being, **Green Growth** prioritizes economic (m=4.58) and human capital (m=4.00), focusing on financial security and skills development. Natural (m=3.67) and social capital (m=2.67) are secondary, reflecting a market-driven approach to sustainability with limited civic engagement. **Mission Economy** balances economic (m=3.91), human (m=3.73), and natural capital (m=3.64) through state-led planning, while social capital (m=3.09) remains moderate, reflecting a top-down governance model. **Post Growth** shifts the focus to natural (m=3.91) and social capital (m=3.91), prioritizing sustainability and community well-being over economic capital (m=2.36), with human capital (m=3.27) supporting lifelong learning. **Great Mindshift** maximizes social (m=4.45) and natural capital (m=4.18), fostering community-driven governance and strict environmental limits, while economic capital (m=2.64) plays a minimal role. Fossil fuels remain moderately present in both **Green Growth and Mission Economy**, though with different transition strategies. The main indicators and key resources for each paradigm are summarized in Figure 9 below.

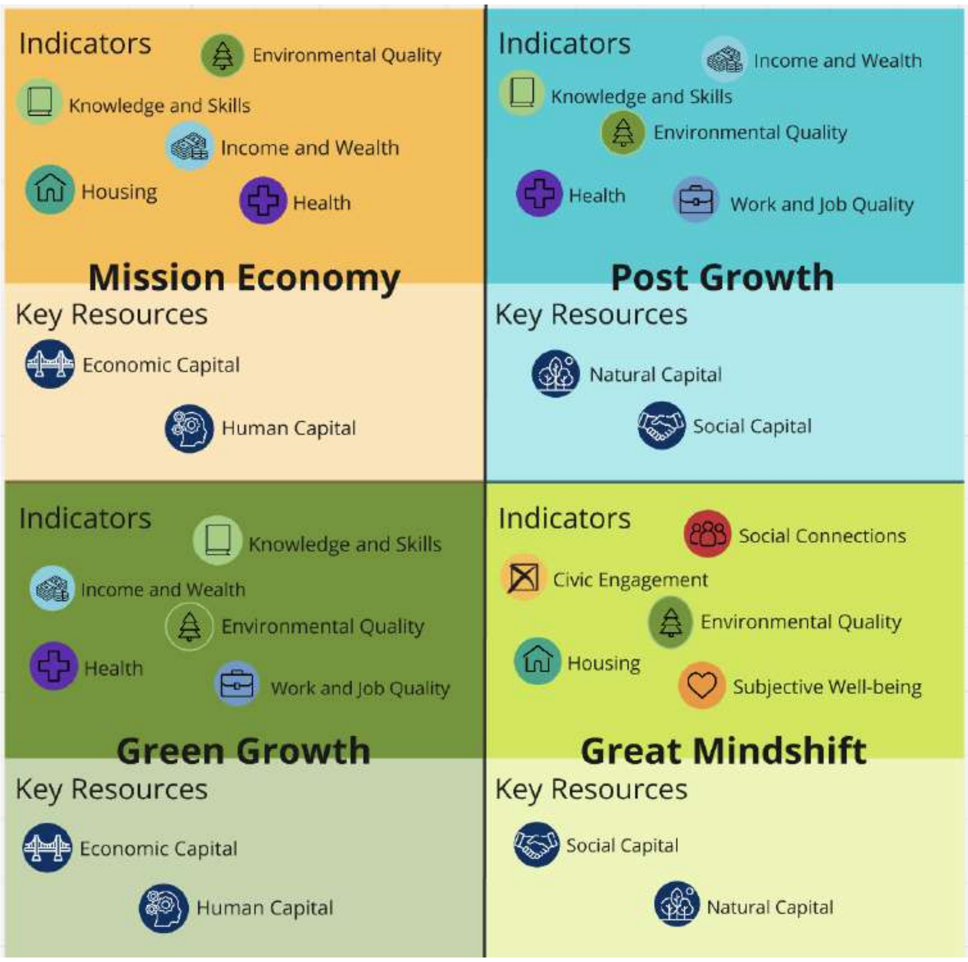

Figure 9: Expert survey results. The most relevant OECD well-being indicators and key resources in each of the paradigms. Source: Own illustration.

In Figure 10 below, the key assumptions are ranked in terms of their relevance to the paradigms, from weak to strong. **Green Growth** relies on market mechanisms and **technological innovation** to drive decarbonization rather than strict fossil fuel phase-outs: "Market-based instruments are also seen as the key way to realize these targets, in particular trading systems like the current EU Emissions Trading Scheme."[1] The focus is on gradual shifts through carbon pricing rather than direct restrictions. Similarly, **Mission Economy** maintains a moderate **reliance on fossil fuels** but incorporates stronger state intervention to accelerate the transition. The government sets ambitious decarbonization goals but does not necessarily eliminate fossil fuels outright: "The government formulates societal 'moonshot' mission. One such goal could be 'solving climate change.'"

While targeted technological shifts may phase out fossil energy, the transition remains structured around state-led planning rather than outright prohibition. In **Post Growth**, reliance on fossil fuels is lower, as the economy is restructured to prioritize planetary boundaries over GDP growth. The narrative explicitly mentions de-fossilization as part of broader industrial shifts: "This might include de-fossilizing, leading to a quick phase-out of fossil industry." However, this shift is gradual, with economic and social transformations shaping energy demand. **Great Mindshift** represents the

[1] *Note: this and all the following direct citations are taken from Slingerland et al. (2024).*

strongest shift away from fossil fuels, integrating strict energy limitations and decentralized, low-carbon alternatives. The focus is on zero fossil reliance, resource caps, and local self-sufficiency: “Planetary boundaries are likely to be set, with zero fossil, reduced extraction, and resource caps as likely policies.” This approach envisions a complete restructuring of energy systems around sustainability principles rather than economic efficiency. Therefore, we classify fossil fuel reliance as moderate in Green Growth and Mission Economy, lower in Post Growth, and minimal in Great Mindshift.

Market-based instruments, such as **carbon taxes and emissions trading schemes (ETS),** play a central role in Green Growth and a significant but mixed role in Mission Economy. In Green Growth, pricing environmental externalities is the primary policy mechanism for sustainability: “Internalizing environmental externalities in market prices is the key mechanism for setting the borders to market actions.” The EU Emissions Trading Scheme (ETS) is highlighted as a core tool, with potential expansion to other planetary boundaries: “These would be developed also for the other (non-climate) planetary boundaries.”

Mission Economy also employs carbon pricing but alongside strong regulatory measures. While market mechanisms remain important, government planning and industrial policy play a dominant role: “The government uses a mix of direct regulation and market-based instruments to achieve its goals.” Unlike Green Growth, where markets lead, Mission Economy combines them with state intervention and enforcement. Post Growth and Great Mindshift de-emphasize market-based solutions in favor of direct regulatory measures and systemic economic transformation. Post Growth relies on structural shifts, such as progressive consumption taxes: “A progressive ‘consumption tax,’ taxing the consumption of goods and services based on their environmental performance, is an important instrument here.” However, the focus is less on carbon pricing and more on broader taxation reforms. Great Mindshift moves even further away from market-based instruments, focusing instead on strict resource caps, decentralization, and local governance: “Planetary boundaries are likely to be set, with zero fossil, reduced extraction, and resource caps as likely policies.” The emphasis is on limiting resource use rather than pricing emissions. Therefore, we classify emissions trading schemes (ETS) as the key instrument in Green Growth, a mix of regulation and market-based instruments in Mission Economy, progressive consumption taxes in Post Growth, and strict resource caps in Great Mindshift.

GDP reliance is central in both the Green Growth and Mission Economy paradigms. In Green Growth, GDP is viewed as a primary driver for financing sustainability goals and measuring the success of policies. The narrative emphasizes, “GDP growth is seen as necessary to finance the realization of sustainability and other societal targets and is a key indicator for the success of governmental policies.” Similarly, Mission Economy positions GDP growth as essential for achieving ambitious societal missions, stating, “GDP growth is considered necessary for achieving the missions’ goals.” In contrast, both Post Growth and Great Mindshift de-emphasize GDP. Post Growth treats economic growth as a subordinate outcome, noting, “Economic growth, or not, is seen as a subordinate outcome of striving for these environmental and social goals.” Great Mindshift goes further, making GDP secondary to policies targeting environmental and social objectives: “GDP becomes subordinate to policies targeting environmental and social objectives.” Therefore, we classify GDP growth as strong in both Green Growth and Mission Economy, while it is weak in Post Growth and Great Mindshift.

Technological innovation plays a key role in both Green Growth and Mission Economy but in different ways. Green Growth heavily relies on market-driven innovation, emphasizing, “Generic support for technological innovation, stimulating such innovation in general without making choices between technologies.” The focus is on incentivizing advancements without state intervention in technological selection. Mission Economy also depends on technological innovation, but with stronger state involvement. The government actively directs innovation through industrial policy, stating, “The government would also develop very detailed plans to realize the goal. This also includes governmental choices regarding the kind of technological innovation to be pursued, i.e., industrial policy involving a-priori selection of the specific technologies to be stimulated.” While technology remains important, the reliance is more strategic and guided rather than purely market-driven. Post Growth and Great Mindshift take a different approach, deprioritizing technological innovation as a primary driver of sustainability. In Post Growth, technology is seen as important but should remain open-access, emphasizing, “Technological innovation is seen as important, but should be pursued on an open-access basis.” Great Mindshift similarly focuses on decentralized, local solutions rather than large-scale technological interventions. Therefore, we classify reliance on technological innovation as strong in Green Growth, moderate in Mission Economy, and low in both Post Growth and Great Mindshift.

Governance structures vary significantly across the four paradigms. Green Growth relies on market mechanisms with minimal government intervention, suggesting a low to moderate bottom-up governance approach: “The government sees the market as the main vehicle for transition towards a sustainable world.” While policies such as emissions trading schemes exist, governance remains largely indirect. Mission Economy, in contrast, follows a strong top-down approach, where the state formulates and enforces detailed plans to achieve predefined societal missions: “The government would also develop very detailed plans to realize the goal.” Policies include a mix of direct regulation and market-based instruments, with strong governmental oversight. Post Growth also leans towards moderate top-down governance, as it involves substantial government intervention in setting environmental and social goals: “A ‘wellbeing’ dashboard of indicators and accompanying budgets are developed for this purpose.” However, governance is less rigid than in Mission Economy, as it incorporates participatory elements. Great Mindshift represents strong bottom-up governance, shifting power to decentralized authorities and local communities: “National governments reform themselves to give more executive power to decentral authorities, e.g., municipalities.” Local participation, citizen-led decision-making, and community-driven initiatives are central governance mechanisms. Therefore, we classify governance as low/moderate bottom-up (2) in Green Growth, strong top-down (5) in Mission Economy, moderate top-down (4) in Post Growth, and strong bottom-up (1) in Great Mindshift.

Inequality reduction plays a minimal role in both Green Growth and Mission Economy. In Green Growth, redistribution is seen as secondary and sometimes even counterproductive, as noted: “Redistribution of wealth within countries might be pursued but is overall seen as less important and sometimes even as detrimental to efficient innovation.” Similarly, Mission Economy does not prioritize redistribution, stating, “Substantial redistribution of wealth within or between countries does not seem likely as goals in a Mission Economy.” Post Growth and Great Mindshift, on the other hand, place a strong emphasis on inequality reduction. In Post Growth, redistribution is framed as a core societal goal: “What is considered to be a ‘just’ redistribution of wealth within and between countries is an essential part of the social goals.” Great Mindshift extends this principle to local and global levels, emphasizing, “Redistribution of wealth on a local level, as well as global redistribution between poorer and richer communities, are important.” Therefore, we classify reducing inequalities as low in Green Growth and Mission Economy, and strong in Post Growth and Great Mindshift.

The role of **norms, values** and **behaviors** varies across paradigms. In Green Growth and Mission Economy, societal norms are expected to remain largely unchanged. Green Growth maintains that “The Green Growth storyline imagines a future society as largely based on current behaviors, norms and values.” Likewise, Mission Economy does not emphasize societal transformation: “A future society is seen as largely based on current behaviors, norms and values, without many limitations to individual freedoms.” Conversely, both Post Growth and Great Mindshift highlight norms and value changes as critical to achieving sustainability goals. In Post Growth, government-driven behavioral change is a key strategy: “Nudging change of current norms, values, and behaviors by the government is seen as an essential precondition for successful sustainability policies.” Great Mindshift takes this further, promoting bottom-up change through local initiatives: “Norms and values change are strongly stimulated, however, with a focus on nudging rather than on enforcement.” Therefore, we classify norms and value changes as moderate in Green Growth and Mission Economy, and strong in Post Growth and Great Mindshift.

Lastly, **planetary boundaries** play a minor role in Green Growth and a moderate role in Mission Economy. In Green Growth, sustainability is addressed through market mechanisms, with planetary boundaries treated as optional: “Most probable sustainability goals to be set are the current climate change goals... however, more ambitious sustainability goals could be imagined.” The focus remains on carbon pricing rather than systemic ecological limits. Mission Economy acknowledges planetary boundaries but does not make them a core constraint. The government may integrate them into specific missions, but economic growth and industrial policy remain dominant: “One such goal could be ‘solving climate change,’ but a formulation in terms of ‘staying within planetary boundaries’ would also be possible.” Post Growth and Great Mindshift strongly emphasize planetary boundaries. Post Growth treats them as fundamental constraints: “Environmental goals are likely to be based on intensified efforts towards staying within all planetary boundaries rather than to reach climate change targets only.” Great Mindshift takes this further, making planetary limits a structural foundation: “Planetary boundaries are likely to be set, with zero fossil, reduced extraction, and resource caps as likely policies.” Therefore, we classify the importance of planetary boundaries as low in Green Growth, moderate in Mission Economy, moderate-strong in Post Growth, and strong in Great Mindshift.

	Inventory of Key Assumptions								
Strong Medium Weak	GDP Growth	Key scaling actor	Technological Innovation	Change in Norms, Values and Behaviors	Redistribution of wealth	Reliance on fossil fuels	Importance of planetary boundaries	Carbon pricing	International cooperation
Post-Growth	Weak	Top-down	Weak	Strong	Strong	Weak	Strong	Strong (progressive consumption taxes)	Moderate/ Strong
Green Growth	Strong	Bottom-up	Strong	Weak	Weak	Moderate	Weak	Moderate (Market-Based (ETS))	Strong
Mission Economy	Strong	Top-down	Strong	Weak	Weak	Moderate	Moderate	Moderate (mix of regulation and market-based instruments)	Strong
Great Mindshift	Weak	Bottom-up	Weak	Strong	Strong	Weak	Strong	Strong (Resource caps)	Strong

Figure 10: Classification of Key Assumptions. Source: Own illustration

5 Matching of Scenarios and Paradigm Narratives

The goal of this matching exercise is to compare the characteristics of the representative transition scenarios presented in Section 3 with the defining characteristics of the four paradigm clusters - Green Growth, Mission Economy, Post-Growth, and Great Mindshift. By aligning scenario assumptions with paradigm narratives, we identify which scenarios align closely with specific paradigms and where significant gaps exist. Section 6 will then close the gaps by developing new transition scenarios that are better able to capture the main assumptions of alternative to growth transition scenarios.

Our mapping approach, which aims to systematically assess alignment, used the following approach:

- **Selection of key characteristics:** The mapping is based on key dimensions derived from the clustering results (Section 2.1) and the qualitative assessment of the paradigms (Section 3).
- **Categorization of scenarios:** Each transition scenario was evaluated based on its quantified and qualitative assumptions about these key characteristics. Where quantitative data were lacking, qualitative descriptions from the scenario reports were used.
- **Comparison to Paradigm Narratives:** Scenarios were systematically evaluated against the defining characteristics of the paradigms. The comparison focused on aligning key assumptions, identifying overlaps, and highlighting inconsistencies. A structured matrix (Figure 10) was created to visualize scenario-paradigm alignment based on the presence and strength of defining characteristics.
- **Identification of Gaps:** Finally, scenarios that partially or inadequately reflected the defining characteristics of a given paradigm were identified. Particular attention was paid to areas underrepresented in existing transition scenarios, such as non-GDP-centric economic models (Post Growth), decentralized governance (Great Mindshift), or mission-oriented government intervention (Mission Economy).

Table 3 presents a comparison of the key features of each scenario with those of the four transition paradigms which draws on the results presented in Figure 10 and the inventory described in Section 3.

Alignment is determined by counting how many features of a scenario correspond to those of a specific paradigm. For example, the IEA NZE scenario aligns most closely with the Mission Economy paradigm, sharing four out of seven defining features.

It is important to note that a “match” does not imply full alignment with a paradigm. Rather, it indicates that—across all scenarios and paradigm features considered—a given scenario shares the closest overall alignment with that paradigm. For instance, the WEC “Hard Rock” scenario is matched with the Post Growth paradigm on the feature of GDP growth, as it projects one of the lowest growth rates among all scenarios assessed.

Empty cells in the table indicate that no strong or direct connection was identified between the scenario and the respective paradigm feature.

Table 3: Scenario-Paradigm Alignment Matrix for identification of gaps among current transition scenarios.

Scenario	GDP Growth	Key Scaling Actor	Techno-logical Innovation	Norms, values & behaviors	Re-distribution of Wealth	Reliance on fossil fuels	Inter-national Co-operation
IEA NZE	**Mission Economy** Green Growth	**Mission Economy** Post-Growth	**Mission Economy** Green Growth	Post-Growth Great Mindshift	-	Post-Growth Great Mindshift	**Mission Economy** Green Growth Great Mindshift
IEA APS	**Mission Economy** Green Growth	**Mission Economy** Post-Growth	**Mission Economy** Green Growth	-	-	**Mission Economy** Green Growth	**Mission Economy** Green Growth Great Mindshift
IEA STEPS	**Mission Economy** Green Growth	**Mission Economy** Post Growth	-	**Mission Economy** Green Growth	-	-	**Mission Economy** Green Growth Great Mindshift
IRENA 1.5°C Pathway	**Mission Economy** Green Growth	**Post-Growth** Mission Economy	**Mission Economy** Green Growth	**Post-Growth** Great Mindshift	**Post-Growth** Great Mindshift	**Post-Growth** Great Mindshift	**Mission Economy** Green Growth Great Mindshift
IRENA PES	-	**Mission Economy** Post-Growth	**Mission Economy** Green Growth	**Mission Economy** Green Growth	-	-	Post-Growth
EU Reference Scenario 2020	Post-Growth Great Mindshift	**Mission Economy** Post Growth	**Mission Economy** Green Growth	**Mission Economy** Green Growth	-	Post-Growth Great Mindshift	**Mission Economy** Green Growth Great Mindshift
WEC Modern Jazz	**Green Growth** Mission Economy	**Green Growth** Great Mindshift	**Green Growth** Mission Economy	**Green Growth** Mission Economy	-	-	Post-Growth
WEC Unfinished Symphony	-	**Mission Economy** Post-Growth	**Mission Economy** Green Growth	Post-Growth Great Mindshift	-	**Mission Economy** Green Growth	**Mission Economy** Green Growth Great Mindshift
WEC Hard Rock	**Post-Growth** Great Mindshift	**Post-Growth** Mission Economy	**Post-Growth** Great Mindshift	Green Growth Mission Economy	-	-	-
IPCC SSP1	Green Growth **Mission** Economy	**Mission Economy** **Post-Growth**	**Mission Economy** Green Growth	**Post-Growth** Great Mindshift	**Post-Growth** Great Mindshift	**Post-Growth** Great Mindshift	**Mission Economy** Green Growth Great Mindshift

IPCC SSP2	-	**Post-Growth** Mission Economy	-	-	**Post-Growth** Great Mindshift	**Post-Growth** Mission Economy	**Post-Growth**
IPCC SSP3	**Post-Growth** Great Mindshift	**Mission Economy** **Post-Growth**	**Post-Growth** Great Mindshift	**Mission Economy** Green Growth	**Mission Economy** Green Growth	-	-
IPCC SSP4	-	**Mission Economy** Post-Growth	**Mission Economy** Green Growth	Green Growth **Mission Economy**	**Mission Economy** Green Growth	-	**Mission Economy** Green Growth Great Mindshift
IPCC SSP5	**Mission Economy** Green Growth	**Mission Economy** Post-Growth	**Mission Economy** Green Growth	**Mission Economy** Green Growth	Post-Growth Great Mindshift	-	**Mission Economy** Green Growth Great Mindshift

5.1 Analyzing Scenario-Paradigm Alignment

Having a closer look at alternative paradigms is necessary to start reflecting on the variety of aspects that remain disregarded when developing visions of a climate neutral future in the way done by the currently well recognized transition scenarios. Comparing existing transition scenarios with the four alternative paradigm clusters reveals that existing transition scenarios are primarily aligned with Mission Economy and, to a lesser extent, with Post Growth. Scenarios that emphasize government-driven decarbonization, GDP growth and technological innovation tend to align with Mission Economy assumptions.

In contrast, Great Mindshift is significantly underrepresented in current transition scenario frameworks. Most scenarios do not consider limited GDP growth, alternative well-being indicators, decentralized governance, or radical shifts in societal norms and values. While some elements, like circular economy principles or social equity considerations, are discussed in selected scenarios, they do not comprehensively reflect the systemic changes required under Great Mindshift. Most current transition scenarios are strongly characterized by governmental (top-down) solutions. Therefore, more scenarios are better aligned with Mission Economy than with other paradigms.

Green Growth

Regarding the Green Growth paradigm cluster, WEC Modern Jazz is closely aligned with Green Growth key characteristics. This scenario is characterized by following features: (i.) **emphasis on GDP growth** as a key driver of the sustainability transition; (ii.) **market-based solutions**, including carbon pricing and emissions trading systems; (iii.) **reliance on technological innovation** to drive decarbonization (e.g. renewables, hydrogen, Carbon Capture Utilization and Storage / CCUS); and (iv.) **limited focus on societal transformation** beyond changes in the energy sector.

Mission Economy

Scenarios that include strong government intervention and industrial policy are to some extent consistent with the Mission Economy paradigm. Examples include the EU Reference Scenario 2020, IEA (NZE, APS, STEPS), and WEC Unfinished Symphony. These scenarios share assumptions regarding the following aspects: (i.) a **state-led approach to energy transitions**, with governments actively having a strong influence on investments; (ii.) dominance of mandatory **climate targets and regulatory frameworks,** which include targeting the achievement of the Paris Agreement and even making provision for safeguarding predefined planetary boundaries; (iii.) **public-private collaboration on technological innovation,** which include funding policies that allow government to lead outcomes related to technical innovation; and (iv.) **limited consideration of wealth redistribution** or broader social equity measures within and across counties.

Post-Growth

Few scenarios reflect post-growth principles that emphasize degrowth, sufficiency, and well-being indicators over GDP expansion. An overlap occurs e.g. in IPCC scenarios (SSP1, SSP2, and SSP3), and IRENA (1.5°C pathway) which include: (i.) greater **attention to social welfare and equity-based policies**, where a primacy of human well-being over economic growth is explored for certain transition period and overall reduction of inequalities within and across countries takes place; (ii.) some consideration of **alternative economic models** (e.g. circular economy) are present, concerning mainly the valorization of planetary boundaries. However, no scenario completely abandons GDP as a key metric or imposes absolute environmental limits.

Great Mindshift

No existing scenario fully represents the Great Mindshift paradigm, which envisions a bottom-up, decentralized transformation driven by societal value shifts rather than market or government intervention. Partial overlap exists in selected IPCC SSP narratives (SSP1) that recognize: (i.) a **shift towards participatory governance and decentralized decision making**; and (ii.) emphasis on social cohesion and behavioral change. However, technological and economic structures remain largely unchanged, meaning that these scenarios do not capture the full scope of societal transformation that characterizes Great Mindshift.

5.2 Critical gaps emerging from the analysis

Our preliminary findings highlight two critical gaps in existing transition scenarios:

Absence of explicit post-growth strategies

Independently from the specific focus of each transition scenario, matching the achievement of environmental sustainability with certain level of economic growth appears to be a common point of departure among all reviewed scenarios. Keeping GDP at a growing pace is one underlying assumption that sustainability goals try to deliver. Conversely, an economic model that favors a reduced utilization of resources where GDP growth plays no central role is not a focus in current transition scenarios. Consequently, no transition scenario explicitly models degrowth pathways or economies consciously operating within planetary boundaries. Furthermore, sufficiency-based consumption patterns and working-time reduction policies are absent.

Underrepresentation of scenarios focused on broader societal missions

Few scenarios explicitly explore broader societal missions beyond decarbonization (e.g., social equity, resilience). Strong redistributive policies are mostly absent. This underscores the need to integrate a more profound characterization of implications of political regimes and their transitions, size and power of state institutions, parallel political agendas being pursued by governments, etc.

Also, decentralized, community-driven transitions are not in the focus of current transition scenarios. Alternative growth paradigms emphasize society and social transformations alongside environmental sustainability goals. Giving a prominent representation of societal aspects, novel metrics could allow for exploring norm shifts, cultural values, and participatory governance models. Thereby, a comprehensive picture of future transition pathways could be drawn, since societal transformation pathways are dynamic and interlinked with the chances to accomplish a climate neutral future on a global scale.

Chapter 5 revealed how existing scenario frameworks tend to underrepresent key paradigm elements—such as shifts in norms and behaviors, redistribution of wealth, and changes in the role of GDP. These gaps highlight the limitations of current scenario models, which often prioritize economic or technological drivers while neglecting deeper structural and societal transformations. To move beyond this, MultiFutures develops a new set of preliminary transition scenarios that reflect the diverse assumptions, normative priorities, and systemic logics embedded in four paradigm clusters.

These scenarios are systematically derived from key features of each paradigm—such as the role of government in collecting and redistributing resources, the weight placed on environmental limits (e.g. GHG emissions vs. planetary boundaries), and the relevance of social preferences, norms, and cohesion. In other words, each paradigm assigns different importance to various effects, side-effects, and feedback mechanisms. For instance, a Green Growth scenario might ignore distributional side-effects of a carbon tax, even if it is regressive, whereas a Post-Growth or Great Mindshift paradigm would give higher weight to equity and integrate compensatory mechanisms.

To trace these complex interlinkages, we model the impact of proposed policies and drivers—like carbon pricing, innovation, education, or social investment—on key economic, societal, and environmental dimensions. This is done through **causal diagrams**, which describe how interventions in one part of the system can trigger ripple effects, unintended consequences, or reinforcing feedbacks elsewhere. The visual framework demonstrates how paradigm-specific assumptions (e.g. change in norms, role of GDP, technological directionality) are mapped onto systems of **macroeconomic drivers**, **social innovation and norms**, **technological innovation**, **human capital and demographics**, and **energy**, ultimately influencing the **OECD well-being dimension**.

The following chapter introduces the resulting scenarios. Each reflects a distinct logic of transformation and offers a coherent vision of how climate targets can be achieved—while also engaging with broader questions of equity, well-being, and long-term sustainability.

6 Preliminary List of Transition Scenarios

Building on the conceptual framework, empirical findings, and normative discussions in Sections 2 to 5 - and drawing directly from the narrative foundations established in Slingerland et al. (2024) – the preliminary alternative transition scenarios presented in the following derive their structure and rationale from a well-established set of storylines. As discussed above, Slingerland et al. (2024) identified the four alternative futures - Green Growth, Mission Economy, Post Growth, and Great Mindshift - which lay out distinct pathways for sustainable welfare and prosperity in Europe. These same narratives serve as the backbone for the scenario development process.

The interconnection between the narratives is both thematic and methodological. Slingerland et al. (2024) present divergent perspectives on how societies can steer away from GDP-centric models by addressing environmental limits, distributional equity, and behavioural change. For example, in the Green Growth storyline, market mechanisms are championed as the vehicle for internalizing environmental externalities and achieving decoupling through technological innovation. By contrast, the Mission Economy narrative emphasizes robust governmental intervention and the implementation of 'societal missions' to direct technological choice, while the Post Growth and Great Mindshift narratives focus on reconfiguring economic and social priorities through redistributive policies and localized, bottom-up innovation respectively.

Section 6 operationalizes these narrative threads by first detailing the underlying system dynamics - including key drivers and feedback mechanisms via causal diagrams - in Sections 6.1 to 6.3 and then elaborating on specific scenario narratives in Sections 6.4 - 6.8. The baseline scenario, which echoes the conventional, policy-driven path, is expanded with alternative scenarios that integrate the distinct principles outlined in Slingerland et al. (2024).

6.1 Description of the macroeconomic system

The transition scenarios we develop are grounded in a macroeconomic perspective (Blanchard & Sheen, 2013; Dafermos et al., 2017; Haldane & Turrell, 2018; Herbert et al., 2023; Hertel, 1997).

In the economy, we consider household behavior, firm dynamics, fiscal policy, international trade, energy systems, and environmental outcomes (Hertel, 1997; Dafermos et al., 2017; Naumann-Woleske, 2023) as illustrated in Figure 11.

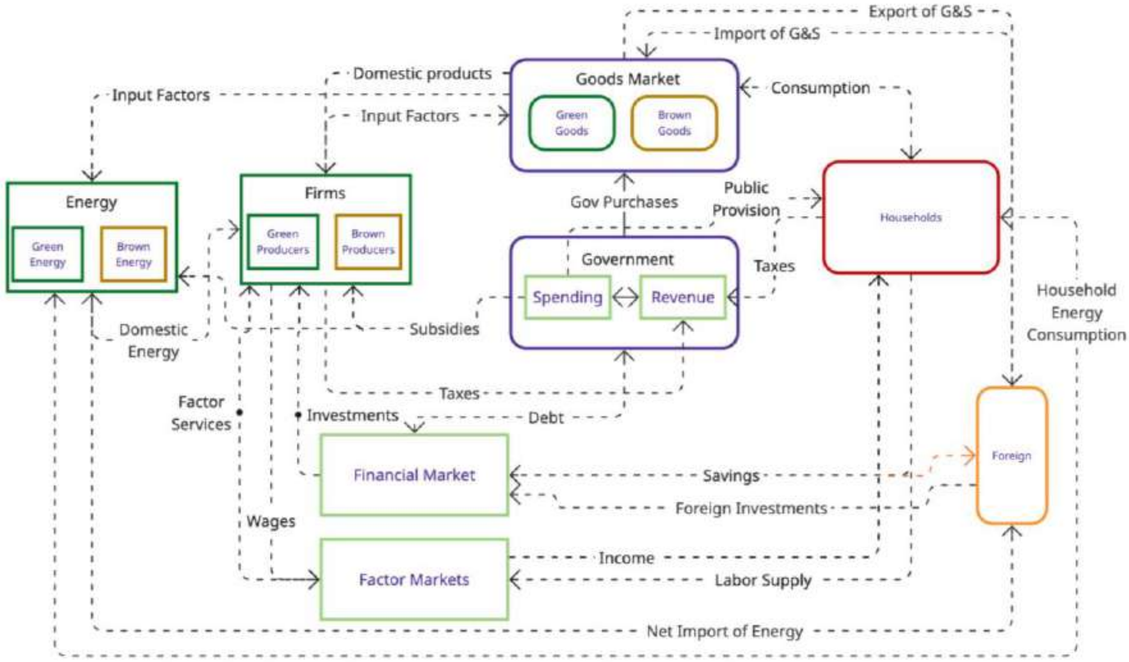

Figure 11: Overview of the macroeconomic system.

Households supply labor to the factor markets and earn income in return. Their wages are largely determined by labor productivity, which in turn depends on technology, education, and institutional settings (Ashenfelter & Card, 2010; Mincer, 1974). This income is allocated across consumption, savings, and taxes. Household consumption is a key driver of aggregate demand (AD) and has an environmental impact (Deaton & Muellbauer, 1980). In our system, households can consume goods and services, including both green and brown products and energy. Energy use - divided into renewable (green) and fossil-based (brown) sources - is directly influenced by prices, income levels, and behavioral preferences (Allcott, 2011).

Firms combine inputs - labor, capital, and energy - to produce outputs sold to households, governments, and international markets (Blanchard & Sheen, 2013). Producers are influenced by technological capabilities, market prices, and policy signals such as carbon taxes or emissions trading systems (Acemoglu et al., 2012). A distinction is made between brown producers (fossil-intensive) and green producers (low-carbon, circular, or regenerative). Investment flows, driven by expected returns and supported by public subsidies or taxes, determine the pace of capital reallocation between these sectors (Bowen & Fankhauser, 2011).

The **government** collects **revenue** (primarily through carbon, corporate, income, and VAT taxes) and redistributes revenue through **public spending** (Gruber, 2005). A main source of government spending are **subsidies** (supporting either green or brown investments) and **public provision**, which includes education, healthcare, mobility, housing, basic income, and military expenditures (Blanchard & Sheen, 2013; OECD, 2011).

Following approaches like Acemoglu et al. (2012) and Gillingham & Stock (2018)**,** we distinguish between green (renewable) and brown (fossil-based) sources. Energy flows to firms and household decisions are shaped by efficiency, international trade, and price signals. Prices are set via a **merit-order system**, where the marginal unit needed to meet demand determines the market price. This mechanism links energy use to environmental outcomes and policy (Cludius et al., 2014; Sensfuß et al., 2008). As the share of renewable energy sources in total energy generation increases, the *merit-order effect* lowers wholesale energy prices, but also introduces price volatility and revenue uncertainty (Aladejare & Salihu, 2023; Pashardes et al., 2014). Carbon pricing further reshapes dispatch order and investment signals (Shimomura et al., 2024).

The **financial market** directs household savings and international capital into productive investment (Feldstein & Horioka, 1980; Obstfeld & Rogoff, 2000). It also enables government borrowing when public revenues fall short (Miller & Russek, 1989). Factor markets - especially the labor market - determine employment levels and wage distribution, linking household income directly to productivity and macroeconomic dynamics (Blanchard & Sheen, 2013). Meanwhile, the external sector integrates the domestic economy into global trade and capital flows. Imports and exports of goods, services and energy, as well as cross-border investments, shape the net trade balance and influence GDP growth and volatility (Feenstra & Taylor, 2021; Fleming, 1962; Melitz & Obstfeld, 2018; Mundell, 1963). In the context of climate policy, trade openness can also expose countries to carbon leakage as firms shift emissions-intensive production to regions with laxer environmental regulations (Aichele & Felbermayr, 2015; Böhringer et al., 2012).

Environmental degradation, driven by fossil fuel combustion, greenhouse gas emissions (GHG), and unsustainable resource use, is modeled as a negative externality within the system (Rees, 2020; Rockström et al., 2009). At the same time, the carbon capacity of the planet, defined as its ability to absorb CO_2, serves as a binding constraint on mitigation efforts (Nordhaus, 2017; Shukla et al., 2022b). This capacity can be increased through reforestation and land-use change (Yu et al., 2022), deployment of carbon capture and storage (CCS) technologies (Bose et al., 2024; Zhang et al., 2024), and conservation of natural carbon sinks such as forests and wetlands (Mo et al., 2023; Pan et al., 2023).

6.2 Drivers of transitions

To understand how transitions unfold across different economic paradigms, we identify key drivers, sub-drivers and policy instruments. These drivers - ranging from taxation and subsidies to regulation and public provision - shape the incentives, capacities, and constraints within the economy. The following table outlines these drivers, their sub-drivers, and provides illustrative examples that highlight how each mechanism can influence environmental outcomes and broader well-being dimensions.

Table 4: The main drivers considered in the scenarios.

Driver	Subdriver	Example
Taxation	Income or wealth tax	Progressive income tax, inheritance tax etc
	Corporate Tax	Tax on company profits or capital gains
	Carbon Tax	Tax on CO_2 emissions per ton
	VAT	Value-Added Tax applied to consumer goods
Subsidies	Green Subsidy	Subsidies for solar panels, heat pumps, or electric vehicles
	Brown Subsidy	Subsidies for carbon or resource intensive goods
	Carbon Capacity	Subsidize CCS

Public Provision	Social Welfare State	Investments in education, public healthcare, affordable housing, mobility
	Carbon Capacity	Government directly invests in and operate state-owned CCS facilities
	Basic Income	Universal basic income or minimum income guarantee
Regulation	Production Standards	Emissions standards for production, energy efficiency labels, performance
	Prices	Minimum or Maximum prices
	Cap and Trade	EU Emissions Trading System (EU ETS), California Cap-and-Trade Program
	Carbon Capacity	Mandating carbon capture and storage (CCS)

6.3 Causal Diagrams

Following this system description, we now explore the interactions between selected drivers, such as carbon taxes, public provision of education, or subsidies for green technologies and the environment. **Figure 12 below gives an overview of the main drivers and how they affect the system.**

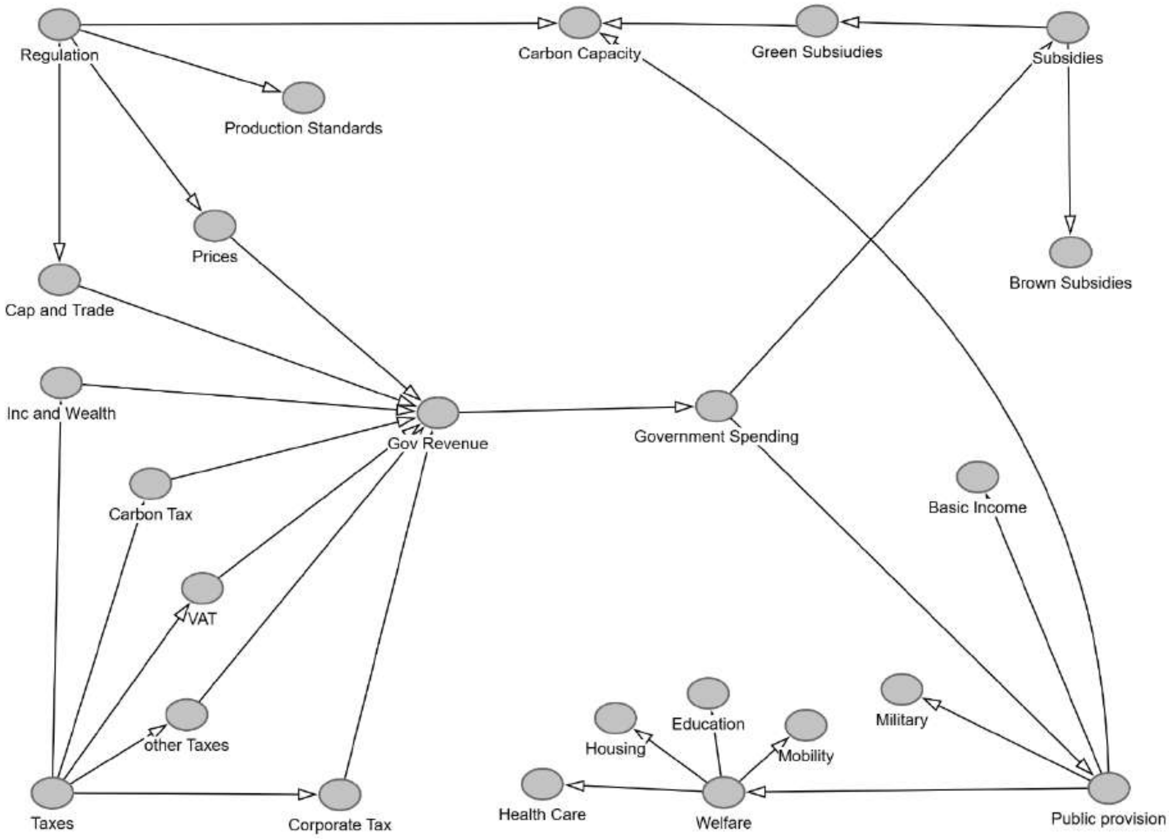

Figure 12: Overview of the main drivers in the system

This causal diagram (see also Box 2 below) illustrates how i) **taxation**, ii) **subsidies**, iii) **regulation**, and iv) **public provision** influence both environmental outcomes and social well-being. At the center we find **government revenue**, that includes **carbon taxes**, **income and wealth taxes**, **corporate taxes**, **VAT**, and **other taxes**. In addition, **cap-and-trade schemes** and regulatory interventions contribute to revenues and influence market behavior (Blanchard & Sheen, 2013; Haldane & Turrell, 2018).

Regulation plays a central role by setting conditions for production standards and influencing prices. It also directly shapes carbon capacity, either by setting emission limits, establishing efficiency standards, or through mechanisms like cap-and-trade. These regulations can affect relative prices (e.g., by internalizing environmental costs), which in turn impact consumption patterns and, ultimately, government revenue through taxation.

Government spending is divided into two main categories: **subsidies** and **public provision**. **Subsidies** include support for both green and brown activities. Green subsidies directly enhance **carbon capacity** by supporting renewable energy, carbon sinks, or technological innovation. Brown subsidies, on the other hand, maintain unsustainable economic structures. Moreover, we include the possibility of **abolishing harmful subsidies** to reduce environmental degradation and free up fiscal space for more effective spending.

Public provision refers to public goods and services such as **education**, **healthcare**, **housing**, **mobility**, **military**, and **basic income,** where markets might fail and be unable to provide these goods even though they increase welfare (Gruber, 2005). We summarize these activities as the **social welfare state (SWS)** (Castles, 2010).

6.3.1 Example for a Causal Diagram - Carbon Tax

A carbon tax works as a fiscal policy to reduce GHG emissions and aligns economic activity with planetary boundaries. The tax directly raises the price of brown goods - carbon-intensive products - and shifts consumption patterns by making them less attractive relative to green goods (Andersson, 2019). This change in relative prices affects the quantity of brown and green goods consumed, and thus the total emissions generated (Metcalf, 2021; Rausch & Reilly, 2012).

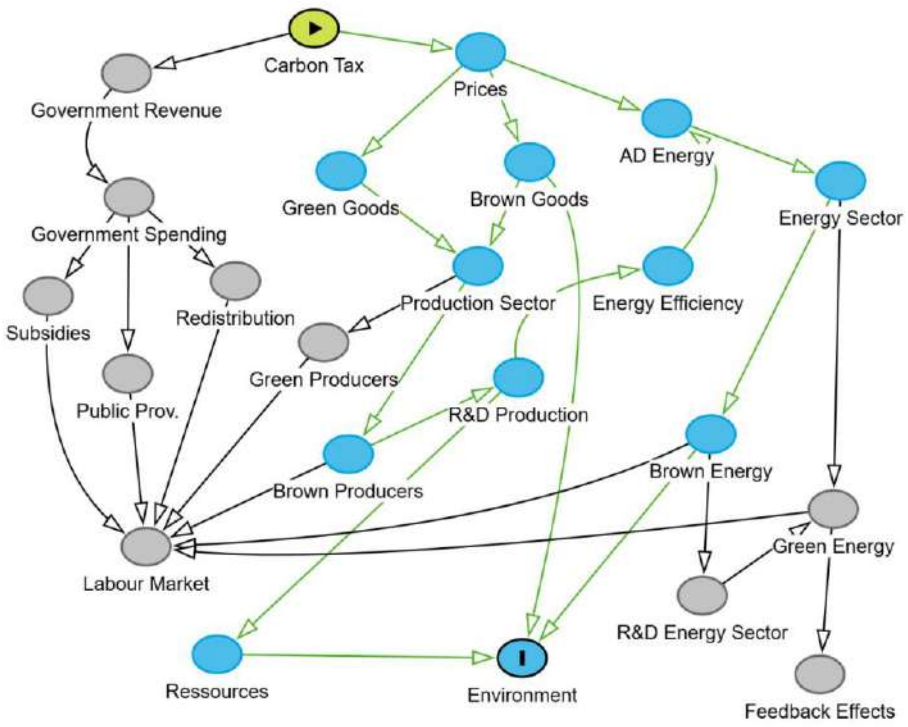

Figure 13: The impact of a carbon tax on the environment

The carbon tax raises the price of brown goods and affects aggregate energy demand (AD energy). This leads to behavioral and structural changes in the production sector, where both brown and green producers adjust their output in response to changing price signals and consumer preferences (Goulder & Hafstead, 2017; Metcalf & Stock, 2020). As prices rise, consumption of brown goods and demand for brown energy are reduced, thereby reducing their negative environmental impact. Green goods and green energy become relatively more attractive which supports a reallocation of resources within the labor market, benefiting green sectors and discouraging brown production (European Commission, 2020; Morgenstern et al., 2002; OECD, 2021; Vona et al., 2018). Through the production sector, the system dynamically reallocates labor and capital between green and brown producers (Jenkins, 2014; Klenert et al., 2018).

The carbon tax also increases government revenue, which can be used to finance public provision, redistribution, or targeted green subsidies. Recycling tax revenues into social programs helps mitigate the regressive effects of carbon pricing and supports public acceptance (Carattini et al., 2019; Sterner, 2012). In parallel, green subsidies can stimulate research and development (R&D), particularly in energy and manufacturing, fostering innovation and lowering abatement costs (Acemoglu et al., 2012). As R&D improves energy efficiency, energy intensity declines, reducing pressure on the energy sector. This transition is reinforced by innovation in the R&D energy sector, which increases the share of green energy in the overall mix. Over time, these shifts reduce the environmental footprint of both production and consumption. Feedback effects from green energy can increase policy ambition or the social acceptance of transition strategies (Andersson, 2019; Baranzini et al., 2000; Brännlund & Nordström, 2004; Fremstad & Paul, 2019; Pressman & Scott III, 2017).

Box 2. Using Causal Diagrams in MultiFutures
A Directed Acyclic Graph (DAG) is a visual tool for representing causal assumptions, where nodes are variables and arrows indicate causal direction. "Acyclic" means there are no loops - causes precede effects. While DAGs can't include feedback loops directly, most such relationships are actually bidirectional effects over time. These can be modeled by representing each variable at different time points. We refer to DAGs as “causal diagrams” throughout this report. In the context of our transition scenario development work, causal diagrams are essential because they highlight how policy interventions (e.g. carbon taxes, public education or subsidies) interact with economic, social and environmental variables (see Figure 11). For this stage of the development of transition scenarios in the MultiFutures project, we developed specific **causal diagrams for key public policy areas**, including education, housing, mobility, health care, and basic income, as well as for critical economic instruments, such as carbon taxes, VAT, corporate and income taxes, and subsidies. Each of them shows how a policy driver triggers a cascade of effects - some direct, some mediated through changes in preferences or behavior - that feed back into the system. These diagrams inform our understanding of how different paradigms (e.g. mission economy, post-growth) might steer transitions in different ways. Above, we present an exemplary causal loop diagram for the case of carbon taxes, all other diagrams are discussed in this report’s online appendix accessible via the MultiFutures website (multifutures.eu)

6.4 Baseline Scenario

The Baseline Scenario outlines the projected evolution of the European Union's energy, economic, and environmental systems up to 2050, assuming the continuation of existing policies without additional climate or energy interventions. It serves as a benchmark to assess the potential impacts of future policy measures.

6.4.1 Motivating Forces

The Baseline Scenario is driven by economic growth, internal market dynamics, carbon pricing through the EU ETS, and regulatory efficiency standards. Governments act primarily to correct market failures and facilitate low-carbon investment, but not to reshape norms, redistribute wealth, or promote sufficiency (see also Section 3). There is no fundamental normative shift: GDP growth, competitiveness, and cost efficiency remain guiding objectives. While climate targets are pursued, the approach relies on incrementalism, investment incentives, and carbon pricing - not redistribution or structural reforms.

Table 5: Overview of the drivers considered in the baseline scenario.

Driver	Description	Change
Regulation	Cap and Trade (ETS)	Carbon price rises from €30 (2030) to €150/tCO_2 (2050) Declining ETS cap; full auctioning assumed
Regulation	Standards	Vehicle emission limits for light and heavy-duty vehicles Cars: –37.5%, Trucks: –30% CO_2 by 2030
Regulation	Waste regulation	65% MSW recycling (2030), ≤10% landfill (2035)
Regulation	Energy efficiency standards	Status-quo of legislation
Regulation	Deregulation of markets	Market Coupling with EU-wide electricity market integration and flow-based capacity allocation
Subsidies	Financial support for renewables, EVs, energy efficiency, and R&D	Status-quo of legislation
Subsidies	Discount Rate Reductions	Households: 14.75% → 12% (renovation), 13.5% → 9.5% (appliances)
Subsidies	RES Shadow Price (RES-Value)	Status-quo of legislation
Taxes	Excise Duties	Fuel taxes modeled by country and fuel type
Public Provision	Expansion of transport, energy, and digital networks, especially TEN-T and smart grids	Core TEN-T by 2030, full by 2050; grid expansion modeled
Other	Output Gap	Output gap closes by 2024; labor converges to potential
Other	Carbon Capacity	LULUCF Carbon Sink -300 MtCO_2/year assumed through 2050

6.4.2 Policies, institutions, economic and social conditions

The Baseline Scenario is structured around a market-oriented governance model, where climate and energy transitions are driven by carbon pricing, regulatory standards, infrastructure expansion, and green investment incentives, rather than redistribution or structural reforms. Policy instruments are designed to enhance efficiency, reduce emissions, and stimulate technological innovation - without challenging existing patterns of ownership, consumption, or inequality.

At the core of this policy framework lies the EU Emissions Trading System (EU ETS). It operates as a cap-and-trade mechanism with a progressively declining emissions cap for the power, industry, and aviation sectors. Emission allowances are auctioned, generating significant public revenues. These revenues are not redistributed for social equity, but are instead reinvested in infrastructure and innovation, particularly in smart grids, clean mobility, and industrial decarbonization.

This creates a fiscal feedback loop:

ETS auction revenues → state coffers → green R&D, smart grids, EV infrastructure → technological cost reductions → enhanced decarbonization. Moreover, the carbon price - rising from €30/tCO_2 in 2030 to €150/tCO_2 in 2050 - drives reallocation of private investment from carbon-intensive to low-carbon sectors (European Commission, 2021, p. 42), reinforcing a production reallocation loop in which firms respond to cost pressures by adopting cleaner technologies.

Two further feedback loops support this process:

1. The R&D loop, in which public and private investment in low-carbon innovation reduces the marginal cost of abatement over time through learning-by-doing (European Commission, 2021, p. 45).
2. The energy efficiency loop, where reduced discount rates for households (e.g. 14.75% → 12% for renovations, 13.5% → 9.5% for appliances) make efficiency investments more attractive, increasing adoption without changing behaviors directly (European Commission, 2021, p. 52–53, Tables 6 & 7).

Green subsidies, including feed-in tariffs, feed-in premiums, and support for electric vehicles and building renovations, play a central role (European Commission, 2021, p. 45). By 2050:

- Solar PV capacity increases from 88 GW (2015) to 513 GW (European Commission, 2021, p. 45).
- Wind energy provides over 30% of electricity by 2030 (European Commission, 2021, p. 45).
- Electric vehicles comprise 50% of the light-duty vehicle fleet by 2050, including 32% battery electric and 18% plug-in hybrid (European Commission, 2021, p. 47).

However, these subsidies target supply-side innovation, not ownership models or sufficiency. Consumer behavior is expected to shift passively, through price signals and efficiency improvements, not active engagement or cultural change (European Commission, 2021, p. 44). At the same time, brown subsidies persist. Fossil fuel support continues in heating, transport, and agriculture, and legacy exemptions remain for energy-intensive industries (European Commission, 2021, p. 45, p. 47). These policies undermine price signals and reinforce carbon lock-in, reducing the net effect of green investments.

Beyond pricing and subsidies, a critical structural driver in the Baseline Scenario is infrastructure expansion and EU market integration. The model assumes:

- Completion of the core TEN-T transport network by 2030 and comprehensive TEN-T by 2050 (European Commission, 2021, p. 50).
- Implementation of ENTSO-E and ENTSOG Ten-Year Network Development Plans for electricity and gas (European Commission, 2021, p. 50–51).
- Full flow-based market coupling and coordinated cross-border balancing (European Commission, 2021, p. 50)

These infrastructure and governance reforms enable deep RES integration, improve market liquidity, reduce balancing costs, and avoid excess investment in peak capacity. However, they serve technical optimization and market efficiency, not local empowerment, equity, or democratic participation. The Baseline Scenario includes no reforms to: Income, corporate or wealth taxation. Public investment remains sectoral and growth-supportive, not equity-oriented. Inequality, affordability, and energy poverty are not systematically addressed.

6.4.3 Human development

In the baseline scenario, human development is a means to economic and technological progress rather than an end in itself. **Education**, health and employment are treated as enablers of innovation, labor productivity and energy transition, rather than as universal rights or vehicles for social justice. The scenario lacks any substantial redistribution, guarantees of basic services or sufficiency-oriented policies. As such, improvements are driven by indirect benefits from green investments, while distributional and affordability issues remain unaddressed.

Education plays a supporting role in the energy transition probably through the promotion of **STEM disciplines** and **digital skills** needed for infrastructure rollout and innovation plans. The scenario does not include reforms of education systems, an explicit focus on educational attainment, PISA results or equity in skills. There are also no measures to reduce NEET rates (young people not in employment, education or training). The modelling assumes that labor market needs will be met by existing structures, with no targeted investment in equity or access to education. **Health** improvements are primarily environmental co-benefits of decarbonization.

Reduced air pollution from electrification and renewable energy deployment contributes to increased life expectancy and reduced premature mortality (European Commission, 2021, p. 47). In addition, exposure to extreme temperatures will be reduced through reduced GHG emissions and increased resilience of energy systems. However, the health system itself is not expanded or reformed.

The scenario assumes moderate employment growth in sectors related to the green transition - such as renewable energy, building renovation and transport infrastructure - thanks to investment incentives and subsidy schemes (European Commission, 2021, p. 45, p. 50). However, job quality and labor justice are not explicitly modelled. There are no social protection reforms, no wage support policies and no active labor market interventions.

6.4.4 Population and Urbanization

In the baseline scenario, demographic trends such as ageing, fertility and migration are treated as exogenous variables, taken from external sources - notably Eurostat and the European Commission's Ageing Report (2021). These projections are incorporated into the macroeconomic modelling but are not influenced by policy interventions within the scenario. The modelling assumes a continuation of current demographic trends without proactive reforms to influence the structure, density or geographical distribution of the population.

According to the projections of the Ageing Report used in the scenario, the EU population remains stable until around 2030, after which it starts to decline gradually. Meanwhile, the proportion of elderly people increases steadily, putting pressure on pension systems and health care services. These assumptions are implemented in the GEM-E3 macroeconomic model, which assumes that the output gap closes by 2024, i.e. actual and potential GDP converge and the economy operates at full capacity in the long run. Labor markets are assumed to converge to their natural rate of unemployment and idle resources are phased out over time. However, there are no targeted policies to address fertility, family support or intergenerational imbalances, and no redistributive mechanisms to manage demographic risks.

Urbanisation in the baseline scenario is not framed as a spatial or sustainability challenge, but rather as a functional input to infrastructure planning. The scenario indirectly reflects urban growth through investments in transport, energy and digital infrastructure. Completion of the TEN-T core network by 2030 and the comprehensive network by 2050, deployment of electric vehicle charging infrastructure and electrification of transport, and deployment of intelligent transport systems and smart grid technology.

6.4.5 Environment and Resources

Environmental progress is focused on emissions reduction and energy efficiency, not ecological integrity. The scenario achieves reductions in GHG emissions per capita, air pollution, and exposure to extreme temperatures, supported by the EU ETS, electrification, and renewable deployment.

The Circular Economy Package is included, with targets of 65% recycling by 2030 and ≤10% landfilling by 2035. However, material throughput is not capped, and sufficiency measures are absent. The LULUCF sector (Land Use, Land Use-Change and Forestry) remains a stable carbon sink (~300 MtCO_2/year), but is not expanded through rewilding or land stewardship (European Commission, 2021, p. 119). There are no policies targeting biodiversity, protected areas, or soil health.

6.4.6 Technology

In the baseline scenario, technological change is the central driver of decarbonization, energy efficiency and economic modernization. The scenario assumes that emissions reductions, system flexibility and productivity gains are achieved primarily through supply-side innovation, enabled by a combination of market incentives, public and private investment and sector-specific regulation. Technology development follows a growth-compatible, efficiency-oriented path, focusing on cost reduction, market integration and infrastructure development. Broader societal considerations such as sufficiency, openness or digital inclusion are not part of the scenario's governance logic. The scenario emphasizes technological learning-by-doing, with declining costs for renewable energy technologies, energy storage and electric mobility. Public investment is channeled through subsidies (e.g. feed-in tariffs, EV support) and the reinvestment of ETS auction revenues in low-carbon technologies (European Commission, 2021, p. 45). These policy instruments activate a reinforcing R&D loop in which innovation lowers the marginal cost of abatement and increases uptake.

Investment in intellectual property, digitalization of the energy system and automated infrastructure is expected to increase over time. However, innovation is driven by market demand and capital returns, not by broader societal goals such as repairability, technological sovereignty or open-source access.

6.5 Green Growth

Green growth is an economic paradigm that seeks to reconcile the pursuit of economic expansion with environmental sustainability. Its central goal is to decouple GDP growth from environmental degradation by improving resource efficiency, investing in clean technologies, and promoting the sustainable use of natural capital (Bowen & Fankhauser, 2011; OECD, 2011). The framework is based on the neoclassical assumption that markets are efficient but prone to environmental externalities, especially those related to pollution and carbon emissions, that need to be internalized through appropriate pricing mechanisms (Andersson, 2019; Stern & Stiglitz, 2017).

6.5.1 Motivating Forces

The Green Growth storyline imagines a future society that broadly maintains current behaviors, norms, and values. The role of government is limited but strategic: correcting market failures, setting price signals that reflect actual social costs, and investing in enabling infrastructure and research where there are public goods or positive spillovers. Economic growth remains the dominant measure of success, and the transition narrative assumes that technological innovation, driven by market forces and aligned incentives, can deliver both decarbonization and economic expansion (Acemoglu et al., 2012).

Table 6: Overview of the main drivers in Green Growth.

Driver	Description
Tax	Carbon Tax
Regulation	Cap and Trade
Public Provision	Social Welfare State

6.5.2 Policies, institutions, economic and social conditions

The core institutional mechanism for achieving net-zero emissions by 2050 is a cap-and-trade system (ETS). This system sets a binding, gradually declining emissions cap to ensure that total emissions fall in line with climate targets. Allowances are auctioned, generating significant government revenue that activates a fiscal feedback loop. Rather than being used for redistribution, these revenues are reinvested in areas that improve economic productivity without distorting market outcomes. As shown in the cap-and-trade diagram (see Box 2 above), these include public education (to increase human capital), transportation infrastructure (to support efficient urbanization and mobility), and military and digital infrastructure (to maintain global competitiveness). Public housing and basic income are excluded, as redistribution is not considered pro-growth in this paradigm.

The price signal from carbon permits shifts household demand away from brown goods and energy and reallocates capital to greener sectors. Firms in carbon-intensive sectors face rising costs and are incentivized to reduce emissions or purchase allowances, while green firms gain a competitive advantage, thus activating a production-side reallocation loop. In parallel, a steadily increasing carbon tax reinforces this dynamic. As described in the carbon tax diagram (see Section 6.3.1), rising prices for brown goods and energy reduce household demand and push firms toward cleaner technologies and energy sources. Both instruments (ETS and carbon tax) generate market-driven decarbonization, supported by targeted green R&D subsidies, which increase productivity and reduce abatement costs over time. Importantly, the regressive distributional effects of these instruments are acknowledged but not systematically addressed, as redistribution is not a policy priority. Thus, social cohesion and democratic trust may be eroded at the margins, but are not considered primary constraints.

6.5.3 Human development

Education is the most important social investment, justified by its role in improving productivity and enabling green innovation. As captured in the education diagram (see Box 2 above), public spending boosts human capital, which feeds back into economic performance and technological capacity (OECD, 2023; Romer, 2015). Health care, digital access, and infrastructure are supported only when they serve labor productivity, reduce climate risk, or facilitate energy efficiency. Broader welfare provision is minimal and targeted, with no universal basic income or large-scale redistribution. As a result, while human development indicators improve overall, inequality may increase, especially in lower-income groups and regions stabilizing growth (Burke et al., 2015). Community cohesion and social innovation are not central.

6.5.4 Population and urbanization

Urbanization is occurring rapidly, especially in emerging markets, but is being managed efficiently. Investments in urban infrastructure, electrified transportation, and energy-efficient buildings reduce per capita emissions without constraining population growth or rural-urban migration. There is no active population policy. Fertility rates passively stabilize with rising income and education, and migration continues to support labor market flexibility in urban regions. Cities are used as hubs for technological and environmental innovation, not for social experimentation (UN-Habitat, 2020).

6.5.5 Environment and resources

The environmental transition is driven by price mechanisms, not by ecosystem restoration or deep ecological restructuring. Carbon capacity increases modestly through offset markets, afforestation subsidies, and soil carbon programs (see Box 2 above for the carbon capacity diagram), but ecosystem protection is instrumental, not intrinsic (Griscom et al., 2017). Resource efficiency improves through R&D and energy efficiency standards, but absolute material throughput remains high. Biodiversity pressures persist unless explicitly priced through permit systems or sectoral regulations. Energy use declines relative to GDP, but total energy demand continues to grow, with a gradual shift to renewables. The energy efficiency loop plays a critical role, as both firms and households respond to price signals by adopting efficient technologies (Haberl et al., 2020).

6.5.6 Technology

Technology is the primary driver for transformation (Romer, 1990). The R&D production and energy loops drive private and public investment in clean energy, electrification, and digital efficiency systems. These shifts reduce abatement costs and increase the returns to green capital. Technology diffusion is rapid in developed economies, with emerging economies benefiting indirectly through trade and foreign investment. Smart infrastructure, grid optimization, and data-driven decarbonization tools are accelerating efficiency. Importantly, the direction of innovation is market-driven, not shaped by mission-driven policy or industrial planning. This enables efficiency, but may miss broader systemic shifts or co-benefits (e.g., equity, biodiversity).

6.6 Mission Economy

In a mission economy, public policy is strategically directed towards achieving ambitious, measurable, and time-bound "missions." This approach draws inspiration from historical "moonshot" programs that successfully mobilized resources and coordinated the public and private sectors to achieve transformative goals (Mazzucato, 2021). The government has an active role in achieving a specific time-bound mission. Imagine a EU where the government, acting with near-dictatorial authority, mobilizes all levers of state power to drive transformational change. The European government sets out to achieve objectives that go far beyond incremental reform, instituting a mission economy where clear, measurable targets—like net-zero emissions and the eradication of housing and energy poverty—shape every policy.

6.6.1 Motivating Forces

The state is seen as a proactive force in creating and shaping markets to achieve missions designed with the purpose of achieving a bigger goal. The mission economy can be aligned with or opposed to Green Growth, Post Growth, and Great Mindshift, depending on how it is designed and implemented. Depending on the missions, different metrics are used to measure success and development. Economic growth, decarbonization, education, population demography, income and/or wealth inequality, as well as housing affordability are all plausible missions that a government might pursue. As a result, different drivers and instruments are considered. We begin by setting goals, within which specific missions are defined.

Table 7: Main drivers in the Mission Economy

Driver	Instruments
Taxes	Carbon tax, income tax, wealth tax, corporate tax, VAT
Regulation	Cap and trade, production standards, price limits, household budgets (missing in graph), legislation
Public Provision	Social welfare state, security and defense
Subsidies	Subsidies for activities related to the mission

6.6.1.1 Policies, institutions, economic and social conditions

Institutional mechanisms for achieving specific goals are mission-specific. The mission economy provides the framework within which economic and human activity takes place: a regulatory framework that reaches every member of society. Legislation and regulation, penalties, audit and monitoring institutions together with taxes, public provision, and subsidies represent the policy and institutional framework of the mission economy. In the context of our analysis, missions are designed to achieve targeted goals set by governments to address specific societal challenges. We distinguish between three broader mission categories:

1. **Environmental Missions:** These include increasing carbon sequestration capacity, reducing biodiversity loss and extinction rates, limiting the introduction of novel entities into ecosystems, and managing key planetary boundaries such as atmospheric aerosol loading, freshwater use, and land-use change.
2. **Economic Missions:** These typically focus on metrics such as GDP growth, per capita income, employment rates, and gross national income (GNI).
3. **Social Missions:** These include goals such as improving housing affordability, raising living standards, reducing income and wealth inequality, and expanding access to quality healthcare and education.

Some missions may be consistent and mutually reinforcing, while others involve trade-offs. For example, policies that promote rapid economic growth may conflict with policies that protect biodiversity or reduce emissions. In our scenario framework, we assume that governments define missions in pursuit of the broader public interest—and evaluate outcomes along several dimensions against a baseline (e.g., the EU Reference Scenario). Consistent with the top-down logic of a mission-driven approach, the government remains agnostic about unintended side effects, prioritizing progress toward fulfilling specific goals even if they negatively impact other areas.

According to Eurostat, in 2020, 61% of household consumption expenditure in the EU was allocated to housing, food, and transportation. Housing expenditures include rent, water, electricity, gas, and other fossil fuel costs. Except for Malta, housing costs accounted for at least 35% of total expenditures in every EU country. Expenditures on food and non-alcoholic beverages ranged from 9.4% in Luxembourg to 27.6% in Romania, averaging 16.9% across the EU. Mobility-related expenses accounted for 11% of household budgets, with significant national variation.

For these reasons, we propose the following goal: **Net-zero combined with energy and housing affordability.** In the following, we focus on one specific mission within the net-zero goal in order to give an understanding about the procedure that we follow.

Table 8: Description of a potential mission towards net-zero

Mission 1: Carbon capture and storage (CCS) combined with building overhaul to reach net-zero
CCS is a way of reducing carbon dioxide emissions involving three steps: • **Capturing** the CO_2 produced by power generation or industrial activity (e.g., during hydrogen production, steel or cement making) • **Transporting** the captured CO_2, and • **Storing** it deep underground. The 6th IPCC report highlights the need to deploy technologies for removing CO_2 in tandem with reducing emissions to limit future temperature increases. Although the IPCC notes a theoretical maximum of 30 gigatons of CO_2 could be trapped annually by 2050, recent studies (Zhang et al., 2024) suggest a realistic best-case scenario of 5-6 gigatons globally. In the EU, with current emissions at 3 gigatons of GHG per year and technical limitations (with a very modest potential of around 0.3 gigatons under strict government-imposed limits), reaching net-zero using CCS alone appears improbable. Besides technological limitations, there are few incentives to adopt CCS if carbon dioxide should just be stored (for environmental reasons) instead of using it in enhanced oil recovery (EOR), considering that fossil fuel companies already receive a lot of subsidies for CCS. Instead of relying on inefficient subsidies, in a mission economy, governments might simply enforce the storage of captured carbon. Furthermore, emissions in energy-intensive industries tend to be hard to abate. Recent research finds that the majority of fossil CO_2 emissions in the future will not be widely dispersed but will instead be concentrated at specific points in industry (Wolf-Zoellner et al., 2025). Therefore, we regard CCS as a mission aiming at substantially supporting the net-zero goal. Since energy supply is responsible for 27.4% of GHG emissions, residential and commercial buildings are responsible for 11.9% of GHG emissions - without including the emissions for producing the electricity consumed in this sector, - and over one third of energy related emissions come from buildings, we consider reducing the emissions in private housing and commercial buildings as a mission that coupled with CCS might allow to reach net-zero.

In this scenario, the government commands a dramatic overhaul of the building stock as part of its net-zero strategy. Under strict mandates, every residential and commercial property—whether owner-occupied or rented—is required to upgrade its energy performance. Legislation forces homeowners and landlords to invest in energy efficiency upgrades. The government not only mandates the improvements but also provides direct public financing and technical support. Besides imposing increased energy efficiency, the government imposes per capita budgets on energy consumption for private, institutional and commercial buildings. To reduce hard to abate emissions industrial plants must install state-of-the-art CCS systems. To ensure compliance, audits and monitoring mechanisms are implemented at regular intervals. A government-run body oversees all upgrades to ensure that renovation standards meet energy efficiency benchmarks and that CCS installations capture the maximum possible emissions. This top-down approach, while heavy-handed, is designed to rapidly cut fossil fuel dependency and mitigate climate change by imposing uniform, non-negotiable standards across all sectors.

6.6.2 Human development

Energy-efficient retrofitting of buildings reduces household energy consumption, leading to lower utility bills, which in turn free up household resources for other investments, including education and healthcare. Enhanced indoor air quality, resulting from better insulation, ventilation, and heating systems, supports physical and mental health, with expected long-term gains in life expectancy and reductions in respiratory illness. At the same time, the mission generates substantial employment in construction, clean technology, and retrofitting industries. These jobs are often local and non-automatable, contributing to labor market resilience and offering opportunities for upskilling and vocational training, especially for younger and low-income workers. However, these benefits may be unevenly distributed. The rising cost of sustainable building materials and regulatory standards can lead to higher construction costs and increased rents, particularly in urban areas. In the absence of accompanying rent controls or housing subsidies, this could disproportionately burden low-income households and crowd out private investment in education or health, especially among younger families. Thus, while the mission contributes positively to human development overall, equity-enhancing policy design, such as targeted subsidies, affordable housing mandates, and redistributive taxation, is essential to ensure inclusive outcomes.

6.6.3 Population and urbanization

The large-scale retrofitting of the existing urban housing stock is expected to revitalize aging neighborhoods, improve housing quality, and increase the overall attractiveness of urban living. These upgrades, combined with improved energy performance and healthier indoor conditions, can drive a reconcentration of population in urban cores, reversing trends of suburban sprawl and supporting more compact, resource-efficient urban forms. As population density increases in retrofitted zones, this facilitates economies of scale in public transport, energy distribution, and the provision of education, health, and childcare services.

However, these benefits are contingent on inclusive implementation strategies. Without safeguards, the rising attractiveness of renovated districts may trigger gentrification and displacement, pricing out long-standing lower-income residents. In alignment with the mission-oriented approach, such risks are addressed ex-ante through affordable renovation programs, rent stabilization policies, and targeted social protection. These policies aim to preserve demographic diversity and prevent the erosion of social cohesion, while ensuring that the urban energy transition delivers equitable spatial outcomes.

6.6.4 Technology

Technological development is mission-oriented: it is goal-specific, time-bound, and cross-sectoral, targeting hard-to-abate emissions and the inefficient building stock. The mission stimulates **technological innovation in two priority areas**: 1) Public funding and regulation accelerate the deployment of next-generation CCS technologies. This includes research in capture efficiency, modular capture units for smaller emitters, low-energy transport systems, and the development of safe, long-term underground storage; 2) the building overhaul drives investment in pre-fabricated insulation materials, triple-glazing, passive house standards, and electrified HVAC systems. Retrofitting is digitally integrated through **smart energy management** platforms that optimize energy flows at the building and neighborhood level. Automation, Internet-of-Things (IoT) solutions, and AI-based predictive maintenance become standard in residential and commercial buildings. Through **mission-aligned procurement**, public R&D investment, and regulation, the state fosters **technological spillovers** across construction, clean tech, energy systems, and digital infrastructure. This accelerates **supply chain innovation**, increases the return on green capital, and anchors industrial capacity within the EU. Importantly, **directionality matters**: technologies are selected not only for their efficiency but also for their **contribution to broader societal goals**, including equity, resilience, and environmental integrity. However, the speed and scale of technological rollout under a mission-driven regime also raise **risks of disruption**. Short-term mismatches between labor supply and demand for high-skill technical jobs may increase structural unemployment. Technologies introduced without adequate consultation or interoperability standards may lead to inefficiencies, security vulnerabilities, or citizen backlash. Moreover, centralized technology governance may concentrate power in large firms or state institutions, reducing technological pluralism or democratic oversight.

6.7 Great Mindshift

The "Great Mindshift" refers to a fundamental and transformative shift in societal values, beliefs, and worldviews that is considered essential for achieving genuine sustainability. Addressing complex challenges like the pressure on environmental boundaries and social inequalities requires moving away from measuring progress in terms of economic performance via metrics like GDP. It is essential to embrace a more holistic and interconnected understanding of well-being, economic prosperity, and the relationship between human society and the natural environment (Göpel, 2016).

6.7.1 Motivating Forces

Creative ideas and fundamental shifts in thinking, rather than incremental changes within the current economic paradigm, are required to achieve sustainability. Radical shifts in values and norms create new systems and frameworks characterized by new ways of acting and relating to each other and the planet. Human systems are historically the result of views and values in effect at a given period in time, and as such they can be reshaped and reinvented. Here we consider Great Mindshifts related to the planetary boundaries within which human activities are carried out.

Climate mitigation happens in response to changes in values and norms, which reduces possible policy instruments to education and awareness campaigns highlighting the interplay between well-being and the environment. Such a change in values can affect both consumption and production pattern. Promoting sustainable consumption patterns, both via the quantity of goods and services consumed and the environmental impact of these, is key in achieving a net-zero economy.

A demand shift towards environmental-friendly goods and services could foster sustainable economies, force environment-harming goods and services out of the market and shift the focus from unsatisfactory metrics like GDP towards environmental and social aspects of prosperity. The Great Mindshift might also lead to different production decisions, moving away from purely profit-oriented governance. This might lead to an increase in R&D, technological innovation, waste management, the adoption of circular economy schemes, etc. Depending on the production costs, prices might be affected by such a change. These pathways are increasingly supported by social tipping points and public narratives (Otto et al., 2020; Raworth, 2017).

Table 9: Main Drivers in the Great Manshift

Driver	Instruments
Regulation	Production Standards
Regulation	Consumption Standards

6.7.2 Policies, institutions, economic and social conditions

Unlike the Green Growth scenario, where market signals dominate, the Great Mindshift embeds sustainability in cultural norms. Citizens voluntarily reduce their consumption and pressure institutions to do the same. Local governments and cooperatives co-create policies that focus on sufficiency, social justice, and ecological responsibility. Government institutions lead by adopting clean energy, reducing material throughput, and promoting the commons. Community wealth and civic engagement replace GDP growth as the primary performance measure. This activates causal paths related to social preferences, collective behavior, and institutional demonstration effects (Avelino & Wittmayer, 2016; Ostrom, 1990, 2009).

6.7.3 Human development

Human development becomes a core priority but not just for productivity reasons. Education emphasizes ecological literacy, systems thinking and cooperation (Rieckmann, 2017; Wiek et al., 2011). Public health systems are strengthened to reduce inequalities and build resilience. Rather than serving labor markets, social policies promote flourishing within planetary boundaries. Inequalities are reduced through shared norms of sufficiency and redistribution.

6.7.4 Population and urbanization

Fertility stabilizes as prosperity and gender equity increase. Migration is balanced by resilient local economies that provide meaningful livelihoods. Cities are reoriented toward low-impact living: walkability, community gardens, and shared infrastructure. Urban design promotes social inclusion and ecological regeneration (Bai et al., 2016; Seto et al., 2012). This activates the loops of urban sufficiency and population stabilization.

6.7.5 Environment and resources

Environmental improvements are systemic. Carbon capacity expands through rewilding, soil regeneration, and coastal wetland protection (Meadows et al., 2018; Steffen et al., 2015; Watson et al., 2019). Resource use declines as society shifts to shared, reused, and repaired goods. Biodiversity stabilizes through habitat restoration, reduced land-use change, and agroecological farming. Pollution, emissions, and waste all decrease. This draws on carbon capacity, material use reduction, land restoration, and ecological behavior loops.

6.7.6 Technology

Technology plays a supporting rather than a leading role. It is evaluated based on societal relevance, environmental impact, and democratic governance. Technology development focuses on sufficiency (not efficiency), open-source design, local repairability, and decentralization. High-tech solutions are used selectively to increase resilience and reduce systemic risk (Vetter, 2020; Smith et al., 2016). This activates loops around local innovation, repair economies, and tech sufficiency.

6.8 Post Growth

The postgrowth paradigm shifts the focus from economic growth and GDP as the standard measure of a country's economic performance and prosperity towards more comprehensive metrics that consider social and environmental goals (D'Alisa et al., 2014; Jackson, 2016a; Kallis et al., 2012; Raworth, 2017; Victor & Rosenbluth, 2009). Environmental sustainability, reductions in working time, income inequalities within and between countries, social inclusion, quality of life, intergenerational fairness and behavioral changes all play an important role. Governments embrace a top-down approach in order to achieve their goals, but still they do not impose their goals on society - as would be the case in the mission economy - but are aligned with the change of values and norms favoring a more inclusive and less GDP driven society.

6.8.1 Motivating Forces

Similar to the Great Mindshift, the Post Growth paradigm is based on fundamental shifts in norms and values. From a GDP oriented paradigm towards a more inclusive paradigm that accounts for heterogeneities between individuals, countries, cultures and environments. We therefore construct scenarios within which governments change, determine and directly impact the environment, the labor market, the housing market, health care, education, social and geographical inequalities. Governments can do so by introducing new regulations, imposing taxes, subsidizing specific sectors and/or providing specific goods and services (Jackson, 2009; Kallis et al., 2018).

Table 10: Main drivers in the Post Growth paradigm

Driver	Instruments
Regulation	Cap and trade, production standards, price limits, household budgets (missing in graph)
Taxes	Carbon tax, income tax, wealth tax, corporate tax, VAT
Public Provision	Social welfare state, security and defense
Subsidies	Subsidies for activities related to desired goals

6.8.2 Policies, institutions, economic and social conditions

Post Growth rejects the idea that infinite economic growth is necessary to finance environmental measures. Economic growth can occur as it cannot, but both growth or degrowth are the result of achieving environmental and social goals. Still the policies that can be adopted are similar to the ones in the Green Growth scenario, but they differ in magnitude, redistribution effects and are not designed to foster economic growth in the first place.

The cap-and-trade system might be the most efficient policy to reduce negative environmental impacts from human activities by setting hard caps on resource use or emissions directly, such that environmental goals are reached for sure. Carbon taxes represent another powerful policy instrument, but their effectiveness depends on the magnitude of the tax and is less straight-forward than the cap-and-trade system.

Besides the magnitude of the caps and the carbon taxes, Post Growth policies advocate for a just and equitable society. The redistribution of government revenue plays a crucial role when it comes to the public provision of universal basic income, universal basic services, housing, energy, transport and healthcare, reorienting the economy by encouraging circular economy practices toward sufficiency, care, and resilience, investing in and subsidizing renewable energy, energy efficiency and low-impact infrastructure. Governments play a major role in shaping cultural and behavioral changes, which can be achieved via awareness campaigns, education, prices that work as an information signal, but also via the adoption of prosperity indicators beyond GDP in institutional reports and press-conferences. Advertising bans or restrictions, as we know them for products like cigarettes, for high-impact products, e.g. SUV, private jets and fast fashion, might be considered as well.

6.8.3 Human development

Human development is decoupled from economic growth. Henceforth, education is not a mere means to higher incomes, but it has an intrinsic value. Education should be accessible for everyone and sustainability and environmental stewardship should be embedded in public education, shifting away from material aspiration and competition towards more non-material aspirations and cooperation (Jackson, 2016b; Raworth, 2018). In a Post Growth society universal education and health care are prioritized. Public expenditures and the provision of public goods and services should aim at allowing people to live dignified lives regardless of income. This approach reflects a normative shift toward enhancing human well-being through investments in knowledge, equitable access to resources, and strengthened social infrastructure.

6.8.4 Population and urbanization

In the previous section, we pointed out that in the Post Growth paradigm education holds an intrinsic value rather than being an instrument for higher income. However, higher education and labor market participation play an important role in demographic shifts and population change by affecting fertility rates. Opportunity costs of childbearing increase with higher education (Becker, 1981). Further, with increasing education the likelihood of having at least one child increases, whereas the likelihood of having more than one child decreases (DeCicca & Krashinsky, 2023). This shifts the distribution of fertility toward more universal but smaller families. Higher education is also found to delay childbearing, improve infant health (McCrary & Royer, 2011) and increase the use of contraceptives (Bongaarts, 1982). Besides the effects of education on fertility rates, immigration and worldwide population trends should be considered.

Human populations exceed the long-term carrying capacity of the Earth due to overconsumption, fossil fuel dependency and ecological degradation, which mirrors the ecological overshoot of any species, usually followed by population collapse (Rees, 2020). Mainstream economics views a shrinking population as inherently problematic because it is a threat to economic growth. However, this concern primarily arises in growth-dependent economic models, particularly those relying on intergenerational transfers—such as pay-as-you-go pension systems—where sustained population growth is assumed to maintain fiscal stability. Besides the pension system, a declining and aging population puts pressure on the healthcare system and public finances. This could be seen as an opportunity to reorient public services, labor and production systems to fit a smaller, aging population and set a new framework to rethink economic and environmental goals.

Urban planning shifts toward compact, walkable cities that minimize ecological footprints while maximizing access to public goods. Housing is a major challenge for many economies. The Post Growth paradigm postulates a shift from the private housing market towards community land trusts and social housing models. Cities embrace regenerative design, integrating green infrastructure, urban agriculture, e.g. vertical farming, and circular resource flows. The revitalization of rural areas, which have become depopulated might be considered as well.

6.8.5 Environment and resources

Environmental governance in a Post Growth world is centered on biophysical limits, drawing on the planetary boundaries' framework. Resource use is capped, shared, and reduced, aiming to stay within safe ecological limits. This includes strict limits on fossil fuels, GHG emissions, extraction of critical minerals, deforestation, and biodiversity loss. Land use shifts toward agroecology and rewilding, reducing pressure on land systems. Wealthier nations are required to take historical responsibility for their ecological overshoot and lead the way in absolute reductions in material throughput.

The exceeding of the carrying capacity of the Earth and historical responsibility couple biophysical limits, energy and material flows, ecosystem functions, geographical equity, redistribution, consumption and well-being equity (D. W. O'Neill et al., 2018). In short, planetary boundaries should be respected and social worldwide equity should be guaranteed. Growth-based economies should be abandoned in favor of steady-state or degrowth models if technological improvements cannot guarantee that we stay within planetary boundaries while at the same time guaranteeing a life in dignity for everyone. It is therefore important to combine ecological measures with well-being measures. It was found that by doing so, high-income countries are ecological overshoot leaders, pinning down their historical responsibility (Hickel, 2020).

6.8.6 Technology

Technological change is guided by sufficiency and efficiency rather than by profit seeking behavior. Post Growth societies invest in low-tech, open-source, and socially embedded innovations. Emphasis is placed on repairability, durability, and sharing rather than disposability or speed. High-tech solutions are selectively deployed—for example, in renewable energy, digital platforms for sharing economies, or ecological monitoring—but always within social and environmental constraints. Technologies that increase demand (e.g., AI-driven consumerism) or rebound effects are actively discouraged. There's a shift from innovation for growth to innovation for resilience, care, and conviviality. Intellectual property regimes are reformed to support knowledge commons and technological sovereignty.

6.9 Impact on well-being

This section provides an overview of how current and future OECD well-being indicators are expected to evolve across four paradigms: Green Growth, Mission Economy, Post-Growth, and the Great Mindshift. **Upward-facing arrows (↑) indicate an increase, while downward-facing arrows (↓) indicate a decrease in the metric of a specific indicator. Arrows are colored green where a change is considered an improvement, and red where it is regarded as a deterioration.** For example, a reduction in greenhouse gas emissions (↓) is viewed as a positive development relative to the status quo, and is therefore represented by a downward green arrow.

Table 11: Potential impact on well-being (OECD indicators).

Green Growth	Mission Economy	Post Growth	Great Mindshift		Green Growth	Mission Economy	Post Growth	Great Mindshift		Green Growth	Mission Economy	Post Growth	Great Mindshift	
				Income and Wealth					**Environmental Quality**					**Economic Capital**
▲ (green)	•	▼ (red)	▼ (red)	Household income	▼ (green)	▼ (green)	▼ (green)	▼ (green)	Air pollution (PM2.5)	▲ (green)	▲ (green)	▼ (red)	▼ (red)	Financial net worth of government
▲ (green)	•	▼ (red)	▼ (red)	Household wealth	▲ (red)	▼ (green)	▼ (green)	•	Exposure to extreme temperatures	•	▲ (red)	▼ (green)	▼ (green)	Household debt
▲ (red)	•	▼ (green)	▼ (green)	S80/S20 income share ratio						▲ (green)	•	▼ (red)	▼ (red)	Financial net worth of the total economy
▲ (red)	▲ (red)	▼ (green)	▼ (green)	Household net wealth of the top 10%					**Subjective Well-being**	▲ (green)	•	▼ (red)	▼ (red)	Produced fixed assets
▲ (red)	•	▼ (green)	•	Relative income poverty	▼ (red)	•	▲ (green)	▲ (green)	Life satisfaction	▲ (green)	•	▼ (red)	▼ (red)	Intellectual property assets
▲ (red)	▲ (red)	▼ (green)	•	Difficulty making ends meet	▲ (red)	•	▼ (green)	▼ (green)	Low life satisfaction	▲ (green)	•	▼ (red)	▼ (red)	Gross fixed capital formation
▲ (red)	▲ (red)	▼ (green)	•	Financial insecurity	▲ (red)	•	▼ (green)	▼ (green)	Vertical inequality in life satisfaction	▲ (green)	▲ (green)	▲ (green)	•	Investment in R&D
					▲ (red)	•	▼ (green)	▼ (green)	Negative affect balance	•	•	•	•	Leverage ratio of banking sector
				Housing	▲ (red)	•	▼ (green)	▼ (green)	Worry					
▲ (red)	•	▼ (green)	•	Overcrowding rate	▲ (red)	•	▼ (green)	▼ (green)	Sadness					**Social Capital**
▼ (red)	•	▲ (green)	•	Housing affordability	▼ (red)	•	▲ (green)	▲ (green)	Enjoyment	•	•	▲ (green)	▲ (green)	Gender parity in politics
▲ (red)	•	▼ (green)	•	Housing cost overburden	▼ (red)	•	▲ (green)	▲ (green)	Smile/Laugh	•	•	•	•	Trust in national government
▲ (green)	•	•	•	Households with high-speed internet access	▲ (red)	•	▼ (green)	▼ (green)	Pain	▼ (red)	•	▲ (green)	▲ (green)	Trust in others
▲ (red)	•	▼ (green)	•	Energy poverty						▲ (red)	•	▲ (green)	▼ (green)	Low trust in others
									Safety	•	•	▲ (green)	▲ (green)	Government stakeholder engagement
				Work and Job Quality	•	•	▼ (green)	▼ (green)	Homicides	▲ (red)	•	▼ (green)	▼ (green)	Corruption
▲ (green)	▲ (green)	•	•	Employment rate (ages 25–64)	•	•	▲ (green)	▲ (green)	Feeling safe at night	▼ (red)	•	▲ (green)	▲ (green)	Volunteering
▲ (red)	•	▼ (green)	▼ (green)	Gender wage gap	•	•	•	•	Road deaths					

▼	•	▼	•	Long-term unemployment rate										**Human Capital**
▼	•	▼	•	Youth not in employment, education or training					**Work-Life Balance**	•	•	•	•	Premature mortality
▲	•	▼	•	Labor market insecurity	▼	•	▲	▲	Time off	▼	•	▼	▼	Labor underutilization rate
▲	•	▼	▼	Job strain	▼	•	▲	▲	Satisfaction with time use	▲	•	▲	•	Educational attainment of young adults
▲	•	▼	▼	Long hours in paid work	▲	•	▼	▼	Low satisfaction with time use	•	•	•	•	Smoking prevalence
▲	•	▼	▼	Wages	▲	•	▼	▼	Vertical inequality in satisfaction with time use	▲	•	▼	•	Obesity prevalence
▼	•	▼	▼	Low wages (% of full-time employees earning less than 2/3 of gross median earnings of all full-time employees)										
▲	•	▼	▼	P90/P10 ratio of wages					**Social Connections**					**Natural Capital**
▼	•	▲	▲	Job satisfaction	▼	•	▲	▲	Social support	▼	▼	▼	▼	Greenhouse gas emissions per capita
▲	•	▼	▼	Low job satisfaction	▼	•	▲	▲	Social interactions	▲	▲	▲	▲	Renewable energy supply
▲	•	▼	▼	Vertical inequality in job satisfaction	▼	•	▲	▲	Satisfaction with personal relationships	▼	•	▲	▲	Biodiversity (Red List Index)
				Health	▲	•	▼	▼	Low satisfaction with personal relationships	▼	•	▲	▲	Protected terrestrial areas
▼	•	▲	•	Life expectancy at birth	▲	•	▼	▼	Loneliness	▼	•	▲	▲	Protected marine areas
▲	•	▲	•	Perceived health					**Civic Engagement**	▲	•	▼	▼	Water stress internal
▲	•	▼	▼	Deaths of despair (suicide, overdose, alcohol)	•	•	•	•	Voter turnout	▲	•	▼	▼	Water stress total
▲	•	▼	▼	Depressive symptoms	•	•	•	•	Having a say in what the government does	▲	•	▲	▲	Recycling rate
										▲	•	▼	▼	Land use change (natural/semi-natural land)
				Knowledge and Skills						▼	•	▲	▲	Intact forest landscapes
•	•	•	•	PISA score (maths, reading, science)						▼	▼	▼	▼	Carbon footprint
▼	•	▼	•	Students with low skills						▼	•	▼	▼	Material footprint

7 Conclusion

This report presents the process used in the MultiFutures project to develop transition scenarios that are consistent with the key features and assumptions of alternative sustainability paradigm clusters - Green Growth, Post-Growth, Mission Economy and the Great Mindshift. By systematically mapping these paradigms in relation to existing transition scenarios, such as the IPCC SSPs and the World Energy Scenarios of the WEC, it identifies areas of alignment and key gaps, particularly with respect to well-being, equity, and non-GDP economic models. While many existing scenarios reflect market-led or state-led decarbonization strategies, they largely fail to incorporate alternative economic structures, decentralized governance, and sufficiency-based policies.

To address the gaps identified in current scenario frameworks, this report extends conventional transition analysis by systematically integrating well-being indicators and incorporating alternative governance and economic structures into scenario development. The MultiFutures approach expands the analytical focus beyond emissions reduction and technological innovation to include a broader and more balanced set of economic, social, and environmental objectives. By explicitly linking well-being metrics to the assumptions and priorities of different paradigms, the scenarios offer a more holistic foundation for analyzing sustainability transitions.

The four preliminary transition scenarios provide a structured, qualitative basis for exploring how distinct paradigm logics shape sustainability pathways. Each scenario reflects a different configuration of governance, economic models, and societal priorities. Green Growth emphasizes market-based solutions and technological progress; Post Growth introduces resource constraints and sufficiency as guiding principles; Mission Economy relies on state-led, goal-oriented policy; and Great Mindshift promotes a community-driven, value-based transformation.

These scenarios are grounded in **causal diagrams**. While not dynamic feedback models, these diagrams clarify how main drivers—such as taxation, public provision, regulation, or subsidies—affect outcomes across multiple well-being domains. This enables a structured exploration of **trade-offs, synergies, and paradigm-specific blind spots**—for example, the risk that equity concerns are downplayed in efficiency-driven models like Green Growth, even when implementing regressive policies such as carbon pricing. These trade-offs and policy pathways will be further elaborated and quantified in the next steps of the MultiFutures project. This stepwise approach ensures that the qualitative scenario narratives presented here serve as a robust foundation for subsequent interdisciplinary and stakeholder-informed exploration of transition pathways.

To assess their real-world feasibility and impact, however, these qualitative scenarios must be translated into quantitative models that can simulate economic, social, and environmental outcomes. The next phase of MultiFutures will focus on:

- Defining key model parameters to quantify the assumptions underlying each scenario,
- Incorporating OECD indicators of well-being to assess multidimensional sustainability outcomes,
- Incorporating the results of the next round of the Delphi survey to refine the assumptions based on expert consensus,
- Comparing systemic impacts and trade-offs across scenarios to assess their implications,
- Identifying effective policy levers that can guide the transition to sustainability while mitigating socio-economic risks, and

- Conducting a workshop based on the Anticipatory Systems Method (ASM) to co-develop concrete pathways of how the different futures in each paradigm cluster might unfold, and to develop more concrete transition scenarios that include policy packages.

This process will ensure that the scenarios developed in this report do not remain abstract narratives but become empirically based tools for decision-making on sustainability transitions.

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9 Document Information

Project short name	**MultiFutures**
Project long name	Multidimensional Transition Pathway Analysis for Sustainable Futures: Exploring Alternative Paradigms and Broadening Policy Options through Innovative Scenario Development
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Summary	This report presents transition scenarios aligned with alternative growth paradigms, including Mission Economy, Post-Growth, Green Growth and the Great Mindshift. These paradigms challenge the dominance of GDP as the central measure of progress and promote a more multi-dimensional view of sustainability. The approach combines a systematic evaluation of existing global and European scenarios with a qualitative assessment of how well they reflect key features of alternative paradigms. Fourteen widely recognized scenarios are analyzed in terms of their socio-economic drivers, assumptions and the extent to which they incorporate values such as social equity, ecological limits and long-term resilience. Based on this analysis, a set of preliminary transition scenarios is proposed. These serve as a basis for developing more inclusive, forward-looking models that better reflect the complexity and values of sustainable development.
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10 Appendix

10.1 Brief description of the representative transition scenarios

10.1.1 European Commission, 2021 - EU Reference Scenario 2020

Published by: The European Commission, 2021. Prepared for the European Commission (in particular for the Directorate-General for Energy, Directorate-General for Climate Action, and Directorate-General for Mobility and Transport), the EU Reference Scenario was developed by E3-Modelling, in cooperation with the International Institute for Applied Systems Analysis (IIASA) and EuroCARE.

Aim: The EU Reference Scenario 2020 provides projection trends for the sectors energy, transport, and greenhouse gas (GHG) emissions up to the year 2050. Rather than forecasts for possible futures, the EU Reference Scenario was developed upon simulations projecting the development of specific policy areas based on the latest available data sources, assumptions and expert assessments It serves as a baseline for EU energy and climate policy, helping policymakers understand the long-term impacts of existing measures and supporting the transition toward climate neutrality.

Modeling framework: The PRIMES energy system model, along with GEM-E3, CAPRI, GLOBIOM, and other models, is used to project energy demand, supply, and emissions. The models are interconnected to simulate market dynamics and policy impacts across sectors, including energy, transport, agriculture, and land use.

Main assumptions: The report considers current EU policies, including the "Clean Energy for All Europeans" package and national energy and climate plans (NECPs). It also incorporates macroeconomic trends, technological advancements, and fuel price projections, while factoring in the impact of COVID-19 on short-term economic activity.

Scenario description: The EU Reference Scenario depicts time related projections, assumes steady progress in energy efficiency and renewable energy deployment. Fossil fuels, particularly coal and oil, gradually decline, while natural gas remains significant. By 2050, the energy system shifts towards increased electrification, renewable energy sources, and decarbonized transport. The scenario emphasizes policy consistency and technological progress as critical drivers for meeting the EU’s climate goals.

10.1.2 International Energy Agency, 2023 - World Energy Outlook 2023

Published by: The International Energy Agency (IEA), 2023. The report includes contributions from the World Energy Outlook (WEO) research team and other directorates of the IEA, with support from governments and international organizations.

Aim: The report analyses global energy trends, focusing on energy security, the energy transition, and climate goals. It offers insights for policymakers to manage the transition to a sustainable energy system while ensuring reliability and affordability.

Modeling framework: The IEA uses the Global Energy and Climate Model (GECM), supported by sector-specific models. The GECM is a hybrid model that combines two earlier models focusing on energy markets and technologies perspectives correspondingly. The scenarios project the future global energy landscape based on varying levels of policy ambition and technological adoption.

Main assumptions: The scenarios consider existing energy and climate policies, national pledges, and technological progress, along with economic factors and the impacts of geopolitical tensions, including the ongoing war in Ukraine and energy market disruptions.

Scenario description:

- Stated Policies Scenario (STEPS): Based on current policy settings, fossil fuel demand peaks by 2030, driven by clean energy adoption, though emission reductions remain insufficient to meet global climate goals. Energy security and affordability challenges persist.
- Announced Pledges Scenario (APS): Reflects the fulfillment of all national climate pledges. This scenario accelerates the transition to clean energy, leading to a stronger decline in fossil fuel use, though further action is still required to reach net zero emissions by 2050.
- Net Zero Emissions by 2050 (NZE): Focuses on limiting global warming to 1.5°C, requiring rapid electrification, tripling renewable energy capacity, and deep emission cuts by 2030. This scenario highlights the urgent need for international cooperation and clean energy investments.

10.1.3 International Renewable Energy Agency, 2023 - World Energy Transitions Outlook 2023: 1.5°C Pathway

Published by: The International Renewable Energy Agency (IRENA), 2023. This report outlines the progress and challenges in transitioning the global energy system to align with the 1.5°C climate target.

Aim: The report presents a roadmap for limiting global temperature rise to 1.5°C by mid-century. It aims to inform policymakers and stakeholders about the pathways needed to achieve net-zero emissions by 2050, focusing on renewable energy, electrification, and energy efficiency. Macroeconomic impacts are also projected in terms of economic growth and employment. Projections about the impact on welfare are also presented based on a 5-dimensions' welfare index that is applied to the different world regions.

Modelling framework: The *World Energy Transitions Outlook* is based on IRENA's 1.5°C Scenario, which models a comprehensive energy transition using available renewable technologies, clean hydrogen, and energy efficiency improvements. The scenario is compared to the Planned Energy Scenario, which reflects current national energy policies and commitments. Baseline forecasts are built using the e3me model of Cambridge Econometrics. Main data sources for population are UN's World Population Prospects. Short term GDP data sources come mostly from the International Monetary Fund, while long-term forecasts are based mostly on the European Commission's Annual Ageing Reports and the IEA's World Energy Outlook. In addition, IRENA's World Energy Transitions Outlook analysis the socio-economic impact of their transition projections using a welfare index that covers five critical dimensions and then corresponding indicators.

Main assumptions: The 1.5°C Scenario assumes rapid deployment of renewable energy technologies, significant improvements in energy efficiency, and global investment increases. It incorporates international pledges and Nationally Determined Contributions (NDCs) under the Paris Agreement but highlights the need for more aggressive policy actions to close the emissions gap by 2050.

Scenario description:

- The Planned Energy Scenario (PES) is the baseline, projecting trends based on existing policies. Under this scenario, fossil fuel investments continue, and emission reductions fall short of the 1.5°C goal.
- The 1.5°C Scenario outlines a rapid, global-scale transformation of energy systems, with renewable energy accounting for 77% of the total energy mix by 2050. The scenario emphasizes electrification, especially in transport and buildings, and renewable-based hydrogen production, reducing energy-related CO2 emissions by 37 gigatons by 2050. It requires an investment of USD 150 trillion and a sharp increase in renewable energy capacity.

10.1.4 World Energy Council, 2019 - World Energy Scenarios 2019: Exploring Innovation Pathways to 2040

Published by: The World Energy Council in 2019. The WEC is a global forum promoting sustainable energy systems and addressing energy challenges worldwide.

Aim: WEC's *World Energy Scenarios* present three global storylines that describe potential futures for energy systems up to 2040. The report aims to help energy leaders, policymakers, and stakeholders navigate the complex, rapidly changing energy landscape, supporting them in making informed decisions and fostering collaboration across sectors in regard of the main sources of disruptions identifies therein.

Modeling framework: The model used in the previous report to quantify the energy transition scenarios is the Global Multi-Regional MARKAL Model (GMM) developed by the Paul Scherrer Institute (PSI). GMM is a technologically detailed, cost-optimization model that focuses on energy supply, conversion, and end-use technologies. It applies an optimization algorithm to determine the least-cost configuration of the global energy system from the perspective of a social planner with perfect foresight. The model accounts for technological and economic factors, optimizing investment and operational decisions to meet energy demand while considering factors like costs, efficiencies, and availability.

Main assumptions: The 2019 World Energy Scenarios report focuses on key drivers such as technological progress, consumer behavior, policy, and economic growth.

Scenario description:

- The "Modern Jazz" scenario envisions a market-driven world with rapid technological advancements and a focus on sustainability. Led by the private sector, energy efficiency improves through digital technologies, while renewables rise, natural gas serves as a transition fuel, and coal declines.
- In the "Unfinished Symphony" scenario, governments lead the drive toward global sustainability through strong regulations, carbon pricing, and green technology subsidies. International cooperation is key, with multilateral agreements and organizations coordinating efforts to advance low-carbon technologies, reduce greenhouse gas emissions, and improve energy efficiency.
- The "Hard Rock" scenario depicts a fragmented world focused on national energy security and self-sufficiency, with limited international cooperation. Geopolitical tensions and regional competition shape the energy landscape, with slower progress in clean energy and a focus on immediate economic and energy security concerns over sustainability.

10.1.5 Intergovernmental Panel on Climate Change, 2021-2021 - Sixth Assessment Report (AR6)

Published by: The Intergovernmental Panel on Climate Change (IPCC), 2021-2022. The Sixth Assessment Report (AR6) is a comprehensive report of the latest scientific knowledge on climate change, its impacts and risks, adaptation, and mitigation, produced by three Working Groups.

Aim: The Sixth Assessment Report (AR6) aims to provide the most up-to-date understanding of climate science, covering the physical science basis, impacts and vulnerabilities, and mitigation options. It serves as a critical input for policymakers to address climate change and to inform international climate negotiations.

Modelling: AR6 employs various Earth system models and Integrated Assessment Models (IAMs) to project future climate outcomes based on different socio-economic pathways. These models simulate interactions between the atmosphere, oceans, land, and ice systems, as well as human activity, to assess climate sensitivity, carbon budgets and mitigation strategies.

Main assumptions: The report considers a range of socio-economic and policy futures, incorporating factors like population growth, economic development, energy use, and technological innovation. It also accounts for varying degrees of international cooperation on climate policy, adaptation measures, and mitigation efforts, particularly around CO2 and non-CO2 greenhouse gas emissions.

Scenario description:

- SSP1-1.9 (Very low GHG emissions scenario): Scenario consistent with limiting global warming to 1.5°C. This pathway assumes significant shifts towards sustainability, with strong international cooperation, rapid adoption of green technologies, and deep emissions cuts.
- SSP1-2.6 (Low GHG emissions scenario): A scenario with strong climate mitigation, aiming to limit warming below 2°C. It assumes robust efforts in energy efficiency, renewable energy, and carbon removal technologies.
- SSP2-4.5 (Intermediate GHG emissions scenario): A moderate scenario where societal and economic trends follow historical patterns, leading to intermediate emissions. Global warming is projected to exceed 2°C by 2100 unless stronger mitigation actions are taken.
- SSP3-7.0 (High GHG emissions scenario): A higher-emissions scenario where countries prioritize energy security and economic growth over climate policies. It results in fragmented international efforts and a significant rise in global temperatures, reaching around 3°C by 2100.
- SSP5-8.5 (Very high GHG emissions scenario): A high-emission pathway assuming rapid economic growth driven by fossil fuels, with minimal climate mitigation, leading to global warming of over 4°C by 2100.

10.2 Narratives used in the expert survey presented in Section 4

The following table shows the descriptions of the paradigm narratives used in the Delphi expert survey. They are shortened versions of those developed in Slingerland et al. (2024) in the MultiFutures project.

Table 12: Overview of the Narratives used in the survey.

Paradigm	Narrative used in expert survey
Green growth	The Green Growth approach envisions the market as the primary driver of a sustainable transition, using market mechanisms to internalize environmental costs and align incentives with environmental goals. Key targets include limiting global warming to 1.5°C and potentially addressing broader planetary boundaries through mechanisms like emissions trading systems, such as the EU Emissions Trading Scheme. Innovation is stimulated broadly without favoring specific technologies, and economic growth (GDP) is viewed as essential to funding sustainability and societal objectives. This model emphasizes minimal government interference in individual behaviors, preserving freedom while focusing on market-based solutions. Redistribution of wealth is considered secondary, with global redistribution largely overlooked. The Green Growth vision relies on current societal norms and values, maintaining continuity while leveraging market tools for environmental progress.
Mission Economy	The Mission Economy approach envisions the government leading societal "moonshot" missions to address urgent issues, such as climate change or staying within planetary boundaries. The government sets ambitious goals and creates detailed plans, including selecting specific technologies to support through industrial policy. A mix of direct regulations and market-based tools drives progress, with close monitoring and enforcement. While GDP growth is considered necessary for achieving these missions, the approach maintains current societal norms, individual freedoms, and behaviors. Wealth redistribution, both within and between countries, is not a primary focus.
Post Growth	The Post Growth paradigm prioritizes environmental and social goals over economic growth, with governments actively steering towards societal welfare using a well-being dashboard of indicators and budgets. Key aims include staying within planetary boundaries, ensuring just wealth redistribution within and across countries, and phasing out polluting industries, such as fossil fuels. Structural changes like a basic income, shorter working weeks, and taxing consumption based on environmental impact are central, alongside reduced labor taxes as compensation. Societal norms and behaviors are shaped through government nudging, while technological innovation is promoted on an open-access basis. Enhanced democratic participation through citizen councils and financial system reforms to curb profit-driven non-material economies are also envisioned. Economic decline in some sectors is seen as acceptable to achieve these overarching goals.
Great Mindshift	The Great Mindshift envisions a decentralized approach, with national governments empowering local authorities to pursue ambitious environmental and social targets. The focus shifts to local self-sufficiency and autonomy, guided by principles like Transition Towns. Policies prioritize

	staying within planetary boundaries, with measures such as zero fossil use, resource caps, and reduced extraction. Norms and values evolve through nudging, led by local entrepreneurs and citizens driving bottom-up change. Citizen participation in policymaking is central, alongside respect for indigenous knowledge, nature's rights, and wealth redistribution at local and global levels. GDP becomes secondary to environmental and social outcomes.

10.3 Full List of Dimensions used in the expert survey presented in Section 4

Dimension	Explanation	Indicators used
Income and Wealth	This dimension reflects the economic well-being of households, capturing aspects such as disposable income, wealth distribution, financial security, and the ability to meet basic needs.	Indicators include household income levels, wealth inequality, relative income poverty, and financial resilience. .
Work and Job Quality	This dimension captures the quality and availability of employment, as well as earnings and job satisfaction. It reflects employment rates, wage equality, labor market security, job quality, and the prevalence of long working hours.	Indicators include employment rates, gender wage gaps, job satisfaction levels, and wage distribution.
Housing	This dimension captures the adequacy, affordability, and accessibility of housing, as well as households' ability to maintain basic living standards.	Indicators include, housing affordability, energy poverty, and access to essential services like broadband Internet.
Health	This dimension captures the physical and mental well-being of individuals, encompassing life expectancy, perceived health status, mental health, and causes of preventable deaths.	Indicators include longevity, self-reported health, and the prevalence of depressive symptoms.
Knowledge and Skills	This dimension captures the knowledge and skills essential for personal development, economic opportunities, and societal participation.	Housing affordability, energy poverty, access to essential services (e.g., broadband).

Environmental Quality	This dimension captures the impact of environmental conditions on human well-being, focusing on air quality and climate-related risks.	Indicators include the percentage of people exposed to air pollution and the percentage of people affected by extreme temperature events.
Subjective Well-being	This dimension captures individuals' overall sense of satisfaction and emotional experiences, reflecting both evaluative and affective aspects of well-being.	Indicators include mean life satisfaction scores, the prevalence of low life satisfaction, vertical inequality in satisfaction, and the frequency of positive (e.g., enjoyment, smiling) and negative (e.g., worry, sadness, pain) emotional experiences.
Security	This dimension captures the state of being free from fear or anxiety, encompassing physical, financial, and emotional safety as well as stability in one's environment.	Indicators include percentage of people declaring that they feel safe when walking alone at night in the city or area where they live.
Work-life Balance	This dimension captures the balance between work and personal life, emphasizing the time available for leisure, personal care, and overall satisfaction with time use.	Indicators include the amount of time off for leisure and personal care, satisfaction with time use, the prevalence of low satisfaction, and inequalities in satisfaction with time use.
Social Connections	This dimension captures the strength and quality of individuals' relationships and social interactions, emphasizing the role of social ties in well-being.	Indicators include the percentage of people with reliable social support, time spent on social interactions, satisfaction and dissatisfaction with personal relationships, and the prevalence of loneliness.
Civic Engagement	This dimension captures the extent to which individuals participate in and influence democratic processes, reflecting their involvement in shaping collective decisions.	Indicators include voter turnout in major national elections and the percentage of people who feel they have a meaningful say in government decisions.
Economic Capital	This dimension captures the government's financial net worth as a percentage of GDP, household dept relative to disposable income, the	

	economy's net financial assets per capita, and the leverage ratio of financial institutions' assets to equity.	
Natural Capital	This dimension captures the sustainability of environmental resources and ecosystems essential for supporting life and economic activity.	Indicators include greenhouse gas emissions per capita, renewable energy supply, biodiversity health (e.g., Red List Index), the extent of protected terrestrial and marine areas, water stress levels, recycling rates, changes in natural land cover, intact forest landscapes, and the ecological footprint (e.g., carbon and material footprints, soil nutrient balance).
Human Capital	This dimension captures the skills, knowledge, experience, and health that individuals possess, which contribute to their productivity and overall societal and economic development.	
Social Capital	This dimension captures the functioning of institutions, representation in decision-making, and the level of trust in society.	Indicators include the percentage of women in national parliaments, trust in national government and others, low levels of interpersonal trust, government stakeholder engagement in policymaking, perceived corruption levels, and rates of volunteering.

10.4 Exemplary overview of the inventory of representative transition scenarios

The following table provides an exemplary overview of the approach used in the inventory of representative transition scenarios. The full inventory is available as an Excel file on multifutures.eu.

Table 13: Exemplary results of data collection exercise.

Scenario	GDP Growth	Reliance on technological innovation	Key Scaling Actors	Norms, values, and behavioral change
WEC-MJ	3.1% CAGR 2015-2060 (strong)	Strong (market driven)	Bottom up	Low
WEC-US	2.7% CAGR 2015-2060 (moderate)	Strong (government and citizen driven)	Top down	Strong
WEC-HR	2.2% CAGR 2015-2060 (low)	Low (government driven)	Top down	Low
IEA-STEPS	3% CAGR until 2030 (strong)	Moderate (government and market driven)	Top down	Low
IEA-APS	3% CAGR until 2030 (strong)	Strong (government driven)	Top down	Moderate
IEA-NZE	3% CAGR until 2030 (strong)	Strong (government driven)	Top down	Strong
IRENA-PES	2.8% CAGR 2023-2050 (strong)	Strong (government driven)	Top down	Low
IRENA-1.5°C	4.3% CAGR 2023-2050 (strong)	Strong (government driven)	Top down	Strong
EU-RS2020	1.3% CAGR 2019-2070 (low)	Strong (government driven)	Top down	Low

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Appendix to D1.5
Preliminary List of Transition Scenarios

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Funded by the European Union

Disclaimer

Draft Report, approval from CINEA pending

Please note

Use of Artificial Intelligence based tools: This report was written independently, with AI tools such as ChatGPT and DEEPL used for editing, proofreading, and extracting information relevant to the cluster analysis (see Section 2 of this report). AI-assisted inputs were critically reviewed and incorporated only where they contributed to clarity and precision. The analyses, interpretations, and conclusions are the authors own.

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1 Appendix

This appendix extends the analysis done in MultiFutures' report on "Developing Pathways for a Sustainable Future: Preliminary List of Transition Scenarios" available on the project's website under https://www.multifutures.eu.

1.1 Causal Diagrams

Following this system description, we now explore the interactions between selected drivers, such as carbon taxes, public provision of education, or subsidies for green technologies and the environment. Figure 1**A below gives an overview of the main drivers and how they affect the system.**

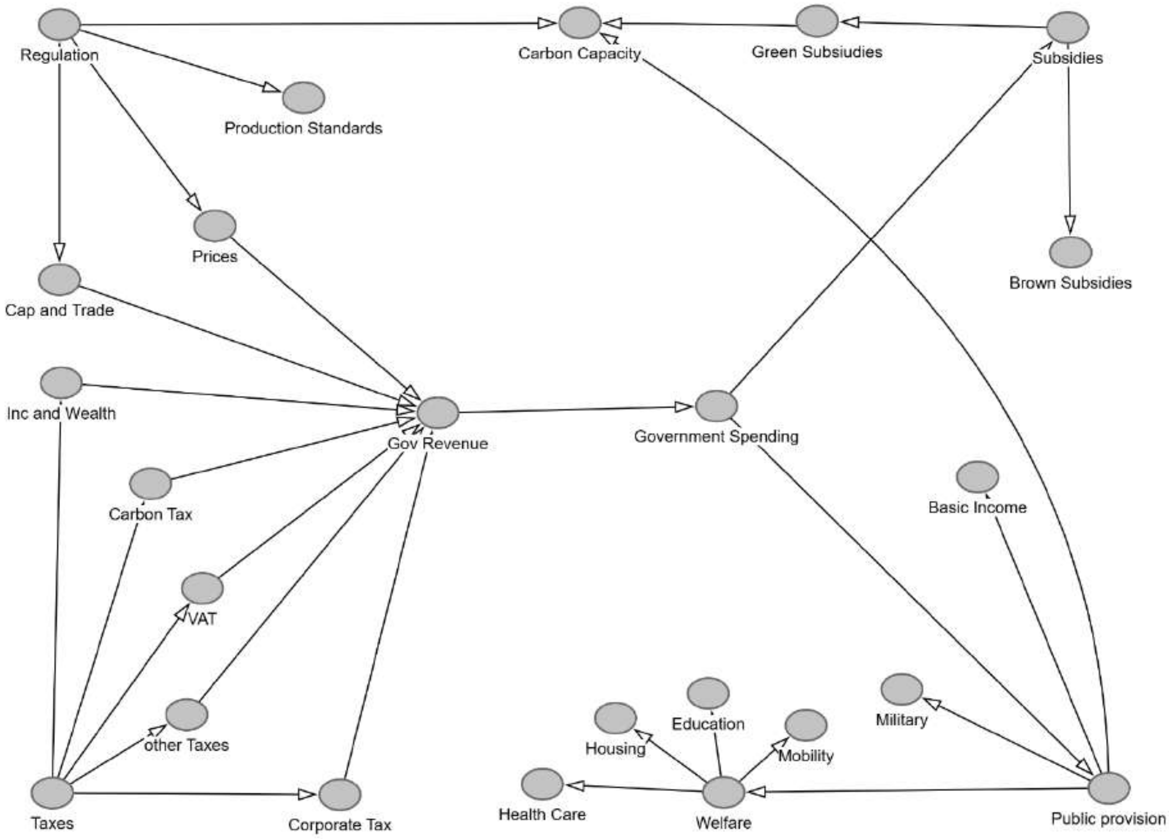

Figure 1A Overview of the system

This causal diagram illustrates how i) taxation, ii) subsidies, iii) regulation, and iv) public provision influence both environmental outcomes and social well-being. At the center, we find government revenue, which includes carbon taxes, income and wealth taxes, corporate taxes, VAT, and other taxes. In addition, cap-and-trade schemes and regulatory interventions contribute to revenues and influence market behavior (Blanchard & Sheen, 2013; Haldane & Turrell, 2018).

Regulation plays a central role by setting conditions for production standards and directly influencing prices by setting price limits. It might also be designed with the goal of increasing the carbon capacity— for instance, by incentivizing carbon capture and storage (CCS), or by strict land use and forestry regulation together with environmental protection laws. Emissions limits might be introduced by new regulation via cap-and-tade and emission budgets for different institutional sectors. Regulations imposing emission limits can affect relative prices (e.g., by internalizing environmental costs), which in turn impact consumption patterns, emissions and, ultimately, government revenue through taxation.

Government spending is divided into two main categories: **subsidies** and **public provision**. The **subsidies** include support for both green and brown activities. Green subsidies directly enhance **carbon capacity** by supporting renewable energy, carbon sinks, or technological innovation. Brown subsidies, on the other hand, maintain unsustainable economic structures. Moreover, we consider the possibility of **abolishing harmful subsidies** to reduce environmental degradation and free up fiscal space for more effective spending.

Public provision refers to public goods and services such as **education**, **healthcare**, **housing**, **mobility**, **military**, and **basic income,** where markets may fail and be unable to provide these goods, even though they increase welfare . We summarize these activities as the **social welfare state (SWS)** .

1.1.1 Public Provision

1.1.1.1 Education:

Education is a cornerstone of the social welfare state and a fundamental investment in human capital (Mincer, 1974; Rieckmann, 2017). Beyond its economic value, education drives long-term socio-environmental change by influencing demographic, behavioral, and institutional dynamics. Figure 2A illustrates how changes in education affect environmental outcomes (green arrows) and broader societal systems (grey arrows).

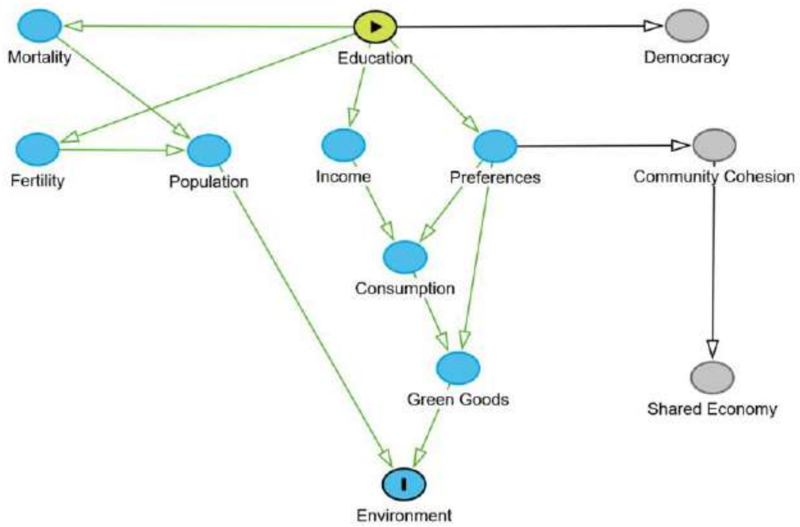

Figure 2A: The impact of education on the environment.

The causal diagram begins with education, which reduces fertility and mortality rates, thereby affecting population growth over time. A smaller or more stable population puts less pressure on natural ecosystems, resulting in lower resource consumption and emissions (Bongaarts, 2010; Cochrane, 1979; Cutler & Lleras-Muney, 2006). At the same time, education increases income and changes preferences, both of which affect consumption patterns (Card, 1999; Mincer, 1974; Pan et al., 2023). While higher income typically leads to increased consumption, education also shifts values toward sustainability, leading to greater demand for green goods (Steg & Vlek, 2009; Zsóka et al., 2013). These changes in preferences also affect community cohesion, fostering trust, cooperation, and a greater sense of collective responsibility (Putnam, 2017; Woolcock, 2001). In turn, this enables the growth of shared economic practices—such as shared mobility, co-housing, or the sharing of tools and resources—that help reduce material consumption and environmental impact (Curtis & Lehner, 2019; Hamari et al., 2016; Heinrichs, 2013). Through these interconnected social and behavioral feedback loops, education plays an indirect but critical role in promoting more sustainable lifestyles. In addition, education has a direct impact on democratic engagement, supporting civic participation and institutional responsiveness, both of which are essential for advancing environmental policy (Barro, 1999; Glaeser et al., 2007). Preferences themselves affect community cohesion, strengthening the capacity for shared initiatives and deepening the societal shift towards low-impact, collaborative consumption.

1.1.1.2 Housing

Another important aspect of the **SWS** is the housing or building sector. The building sector accounts for approximately *34%* of total global energy-related CO_2 emissions (Hamilton et al., 2024). Starting with housing, several immediate pathways unfold, as shown in Figure 3A below.

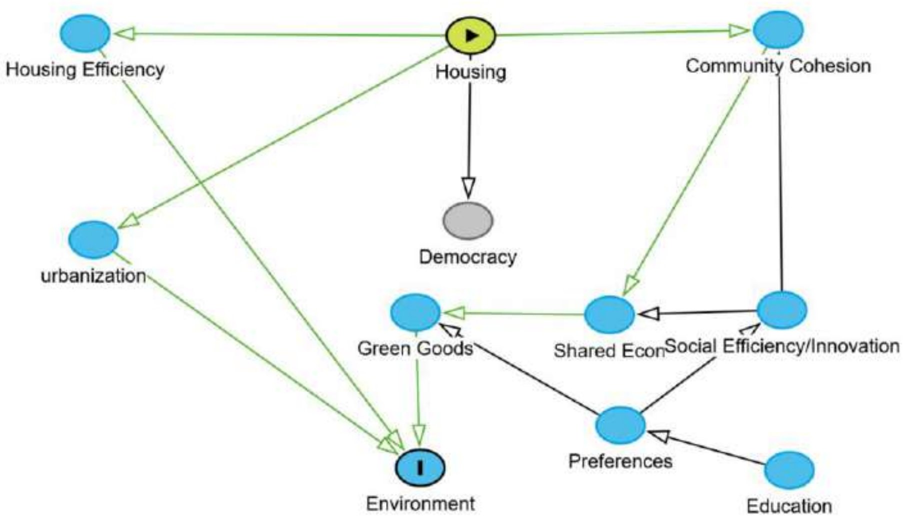

Figure 3A: Causal diagram showing how housing affects the environment (green lines) and democracy (grey line).

First, housing influences urbanization, which, in turn, has a direct impact on the environment through land use, infrastructure demand, and spatial energy use (Creutzig et al., 2016; Seto et al., 2012). Housing also influences housing efficiency—such as insulation, energy standards, or building design—which has a direct positive impact on environmental quality by reducing emissions and energy consumption in the residential sector (Ürge-Vorsatz et al., 2015).

Housing contributes to community cohesion by enabling stable, inclusive, and livable neighborhoods (Forrest & Kearns, 2001). Community cohesion, in turn, supports the growth of the shared economy—practices such as shared mobility, co-living, or tool libraries—that reduce the material intensity of consumption (Frenken & Schor, 2017; Heinrichs, 2013). The shared economy also encourages the uptake of green goods, which directly benefit the environment through lower lifecycle emissions and resource footprints (Martin, 2016).

Education enters as a supporting driver - it shapes preferences that affect both the demand for green goods and the development of social efficiency and innovation (Zsóka et al., 2013). Finally, housing has a political dimension: it affects democracy by influencing political participation, trust, and civic engagement (Norris, 2002). While this is not directly linked to environmental outcomes in the diagram, it represents a potential pathway for institutional responsiveness to sustainability challenges.

1.1.1.3 Mobility

The mobility sector accounts for approximately 15–20% of global greenhouse gas emissions, largely driven by road transport and fossil fuel use (IEA, 2023; IPCC, 2014). Mobility is another key dimension of public provision and influences the types of transport used—such as electric vehicles (EVs)—while shaping broader patterns of inequality and energy consumption, which feed back into the environment (Creutzig et al., 2016; Shaheen & Cohen, 2013).

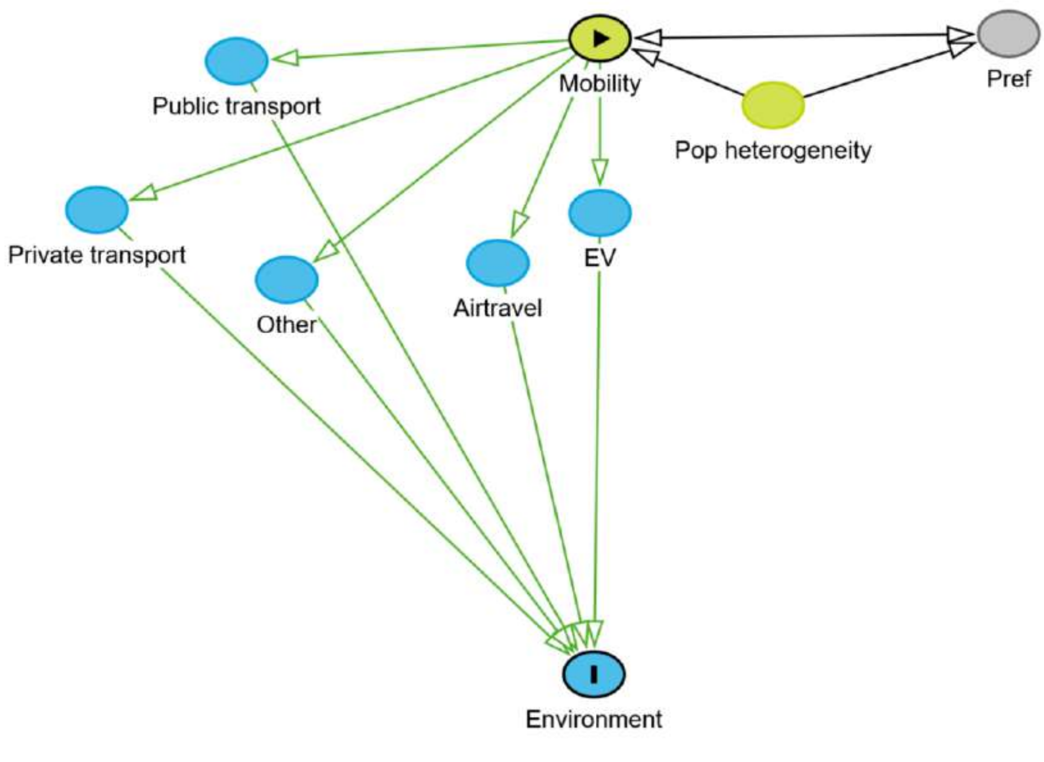

Figure 4A: The causal impact of mobility on the environment.

Figure 4A shows that when mobility systems become more inclusive, affordable, or sustainable, they can stimulate the adoption of EVs, which contribute to reducing emissions and improving environmental outcomes—**assuming the electricity mix is decarbonized** (IEA, 2023; Sovacool, 2014)

The graph also captures how population heterogeneity influences both mobility and underlying preferences, shaping demand for various goods and behaviors, including participation in shared economy models. These preferences feed into the use of green goods, support for social innovation, and engagement with shared mobility solutions—each of which has environmental implications (Frenken & Schor, 2017).

Moreover, preferences and mobility influence one another dynamically: people's mobility options shape their values and expectations, while changing preferences (e.g., toward sustainability or convenience) can drive the uptake of greener transport choices or reduce travel demand altogether.

1.1.1.4 Healthcare

This diagram below illustrates how health care, as a component of public provision, influences environmental outcomes through both demographic and consumption pathways. Positioned at the top of the system, health care affects mortality and fertility rates. Improvements in health care generally lead to lower mortality, but may initially reduce fertility through better reproductive health services and long-term socioeconomic effects. Together, these two factors determine population growth, which, in turn, drives aggregate consumption.

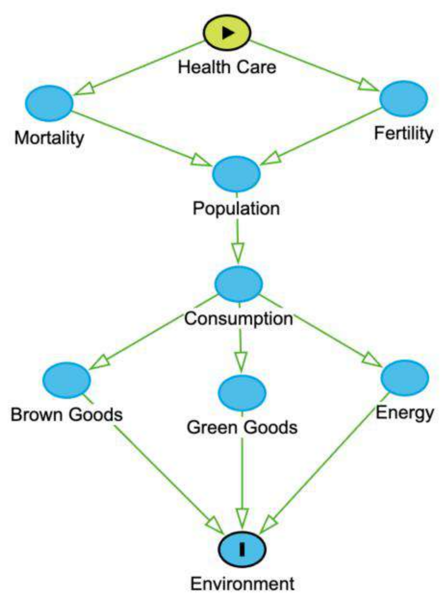

Figure 5A: The relationship between healthcare and the environment.

As the population increases, total consumption increases—leading to greater demand for brown goods, green goods, and energy. These three categories of consumption directly impact the environment. Brown goods (e.g., resource-intensive or polluting products) contribute negatively to environmental health. Green goods (e.g., sustainably produced or low-impact products) offer a more favorable footprint, although they still have some impact. Energy consumption, depending on its source, can either contribute to emissions or support low-carbon transitions. In this diagram, energy is treated generically, but its environmental impact would vary depending on the share of renewables versus fossil fuels.

The model captures how health policy, often viewed through a purely social or health lens, also plays a critical role in shaping environmental dynamics over time. By influencing demographic trends and consumption levels, investments in health care affect the scale and structure of demand for goods and energy, thereby altering pressures on ecosystems. This systems perspective highlights the importance of integrating social policy into environmental transition strategies, particularly within paradigms such as the mission economy, where public services are aligned with broader sustainability goals.

1.1.1.5 Basic Income

This causal diagram (see Figure 6A) illustrates the multiple pathways through which **basic income** affects environmental outcomes and social well-being. As a form of **public provision**, basic income directly increases **household income**, which then feeds into higher **consumption**. This increased purchasing power can reduce **material deprivation** and support **child education**, while potentially also contributing to **income inequality**, depending on how the basic income scheme is designed and financed

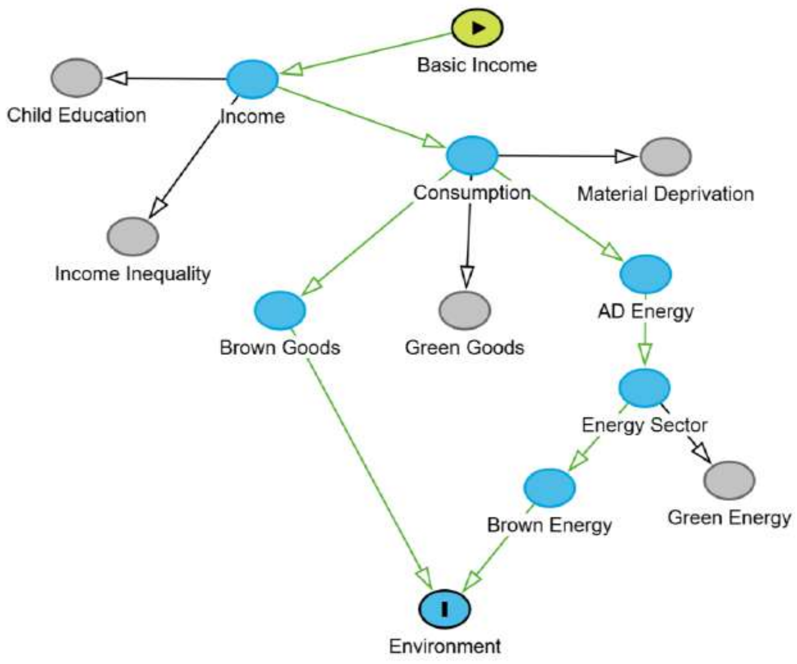

Figure 6A: A: The causal impact of the public provision of a basic income on the environment.

However, increased income leads to a rise in the consumption of both **green** and **brown goods**, which, in turn, negatively affects the environment (York et al., 2003)**. Brown goods** contribute directly to environmental degradation through their embedded emissions and resource intensity. In contrast, **green goods** may have a neutral or weaker effect on the environment, depending on their energy source, production efficiency, and lifecycle impacts (Hertwich & Peters, 2009). A key feedback loop runs through **energy demand (AD Energy)**. As overall consumption increases, so does the demand for energy. This demand is met by the **energy sector**, which relies on a mix of **brown** and **green energy**. If energy supply leans toward brown sources, this reinforces environmental degradation (IPCC, 2022; IEA, 2023). However, if green energy dominates, the environmental impact of rising energy demand can be mitigated. The interaction between social equity (e.g., reduced deprivation, enhanced education) and sustainability (e.g., energy mix, brown goods consumption) underscores the potential for co-benefits and trade-offs in policy design (Bidadanure, 2019; Ghatak & Maniquet, 2019; Hall et al., 2019; Sager, 2019).

1.1.2 Taxes

1.1.2.1 Carbon Tax

A carbon tax works as a fiscal policy to reduce greenhouse gas (GHG) emissions and align economic activity with planetary boundaries. The tax directly raises the price of brown goods—carbon-intensive products—and shifts consumption patterns by making them less attractive relative to green goods (Andersson, 2019). This change in relative prices affects the quantity of brown and green goods consumed, and thus the total emissions generated (Metcalf, 2021; Rausch & Reilly, 2012).

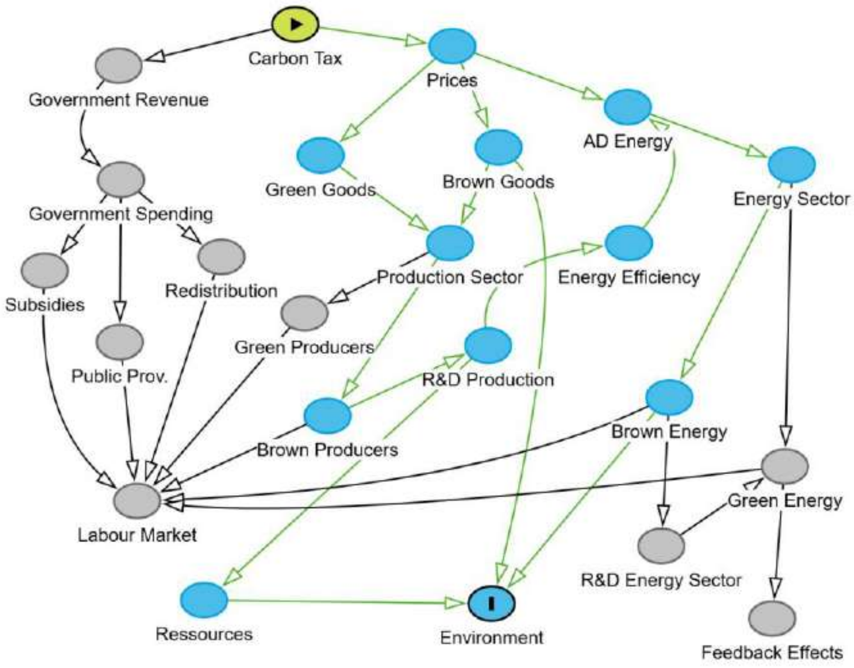

Figure 7A: The impact of a carbon tax on the environment.

The carbon tax raises the price of brown goods and affects aggregate energy demand (AD energy). This leads to behavioral and structural changes in the production sector, where both brown and green producers adjust their output in response to changing price signals and consumer preferences (L. Goulder & Hafstead, 2017; Metcalf & Stock, 2020). As prices rise, consumption of brown goods and demand for brown energy are reduced, thereby reducing their respective contributions to environmental impact. Green goods and green energy become relatively more attractive, which supports a reallocation of resources within the labor market, benefiting green sectors and discouraging brown production (European Commission, 2020; Morgenstern et al., 2002; OECD, 2021; Vona et al., 2018). Through the production sector, the system dynamically reallocates labor and capital between green and brown producers (Jenkins, 2014; Klenert et al., 2018).

The **carbon tax** also increases government revenue, which can be used to finance public provision, redistribution, or targeted green subsidies. Recycling tax revenues into social programs helps mitigate the regressive effects of carbon pricing and supports public acceptance (Carattini et al., 2019; Sterner, 2012). In parallel, green subsidies can stimulate research and development (R&D), particularly in energy and manufacturing, fostering innovation and lowering abatement costs (Acemoglu et al., 2012). As R&D production improves energy efficiency, energy intensity declines, reducing pressure on the energy sector. This transition is reinforced by innovation in the R&D energy sector, which increases the share of green energy in the overall mix. Over time, these shifts reduce the environmental footprint of both production and consumption. Feedback effects from green energy can feed back to increase policy ambition or social acceptance of transition strategies (Andersson, 2019; Baranzini et al., 2000; Brännlund & Nordström, 2004; Fremstad & Paul, 2019; Pressman & Scott III, 2017)

1.1.2.2 Taxation (VAT, income or wealth taxes & corporate taxes)

Next, we discuss how VAT, income or wealth taxes and corporate taxes affect household consumption and environmental outcomes (Benzarti & Carloni, 2019). Unlike targeted taxes such as carbon taxes, VAT is a general consumption tax, and its environmental effectiveness depends largely on its design (Gruber, 2005; Stiglitz & Rosengard, 2015).

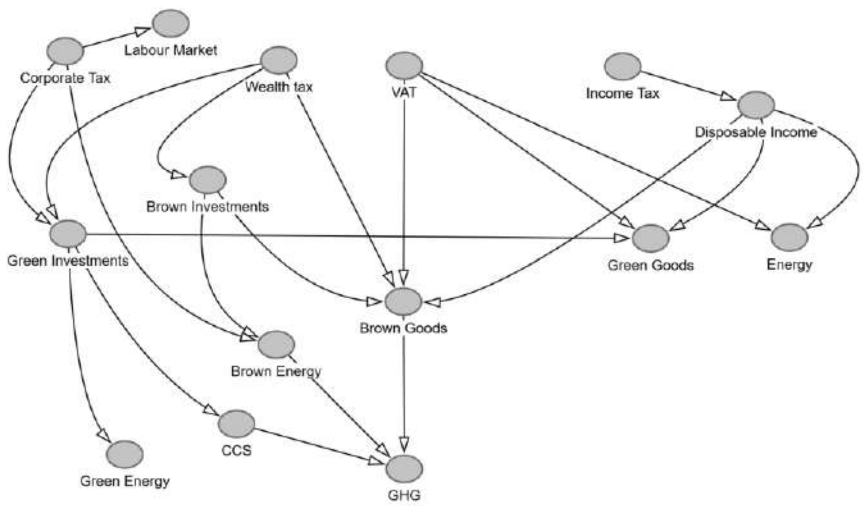

Figure 8A: The impact of VAT on the environment.

In this system, **VAT** directly increases the price of brown goods, green goods and energy, thereby reducing disposable income and influencing consumption choices. This can lead to a modest reduction in greenhouse gas emissions, but without favoring greener alternatives, its climate impact remains limited (Andersson, 2019; Gruber, 2005). However, when VAT is designed with exemptions or reduced rates for low-carbon products—such as green goods, green energy or energy-efficient technologies—it encourages a shift in consumption patterns. Lower VAT on green alternatives can encourage households to spend more of their income on green goods and services, thereby reducing their dependence on brown goods and fossil fuels (Fullerton & Metcalf, 2001). VAT also interacts indirectly with the wider tax system. It affects disposable income, which determines how households allocate their expenditure between energy, consumer goods and investment. These choices affect the production and use of green and brown technologies, which in turn feed back into the system through emissions from brown energy, brown goods and even energy use more generally (Jakob et al., 2014; Taxation, 2011).

Corporate Tax influences firms' investment decisions and employment. Higher corporate taxes can reduce investments in brown energy and brown goods, thereby limiting the growth of carbon-intensive industries (Jorgenson & Yun, 1991). At the same time, a well-designed tax system can incentivize firms to redirect capital toward green investments, such as renewable energy and carbon capture technologies (CCS). Corporate taxes also impact the labor market, as they affect business costs and potentially employment, which loops back into household income.

Income Tax directly reduces disposable income, shaping household consumption behavior (Diamond, 1998; Kaplow, 2024; Saez, 2001) Lower disposable income typically reduces overall consumption, including energy use and the purchase of both brown and green goods (Auten & Carroll, 1999; Piketty & Saez, 2013; Stiglitz & Rosengard, 2015). However, the environmental effect depends on the structure of consumption: if the income tax reduces carbon-intensive spending more than green alternatives, it may help lower emissions.

Wealth Tax has a dual function. It influences the flow of funds into brown vs. green investments, and it can shift consumption patterns by reducing high-carbon luxury consumption. By discouraging capital accumulation in polluting sectors and incentivizing low-carbon alternatives, wealth taxes can help reorient the economy toward sustainability. Wealth taxes also affect household demand, particularly for brown goods, which are often more carbon-intensive (Jakobsen et al., 2020; Kapeller et al., 2023; Piketty et al., 2023; Saez & Zucman, 2019; Zucman, 2015).

1.1.3 Regulation

1.1.3.1 Cap and Trade

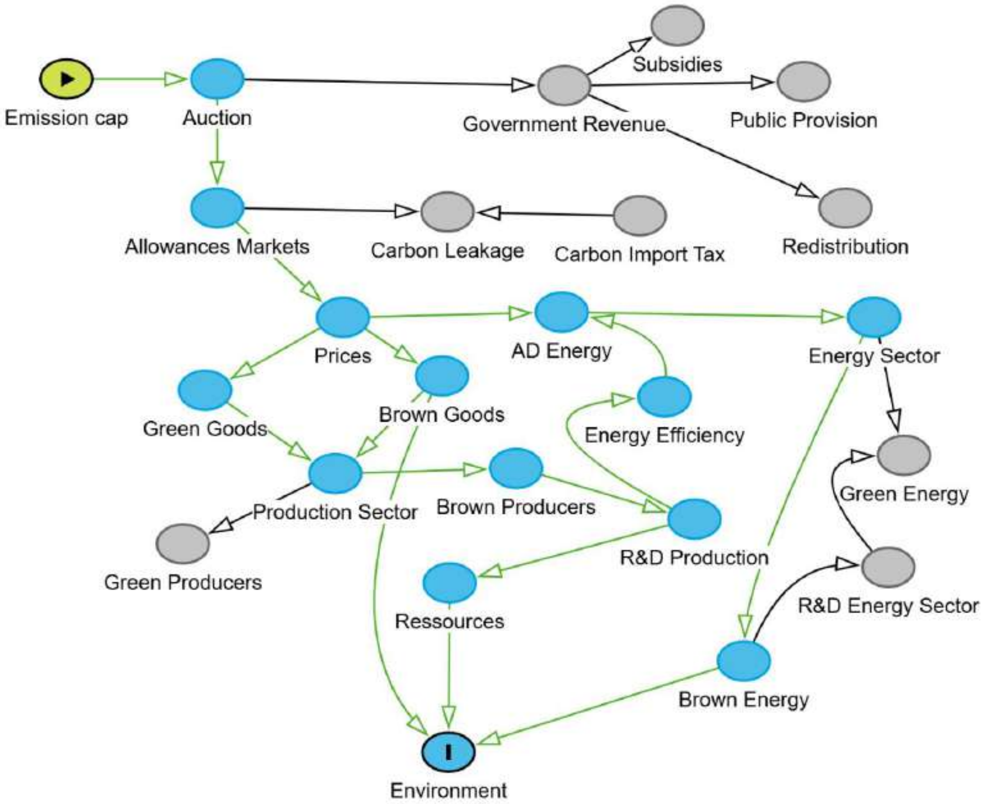

Figure 9A: Causal impact of the regulation ‘Cap and Trade’ on environmental

Figure 9A illustrates how a cap-and-trade system with auctioned permits regulates greenhouse gas (GHG) emissions. The emissions cap, which determines the total amount of emissions allowed in the economy, limits environmental damage and triggers a cascade of market and institutional responses (Abrell et al., 2019; Abrell & Rausch, 2017). First, the emissions cap leads to the introduction of an auction system through which permits are allocated. The revenues from these auctions contribute directly to government revenues, which can be redistributed through subsidies, public provision (e.g., welfare, green infrastructure), or income redistribution policies that reinforce either environmental or social objectives (Sato et al., 2022). The ETS internalizes the cost of emissions and adjusts relative prices. These carbon-inclusive prices feed into consumer and producer decisions: they increase the price of brown goods and reduce the relative cost advantage of emission-intensive products. This dampens aggregate demand for energy (AD energy) and shifts the balance of consumption towards green goods (Burtch et al., 2014; L. H. Goulder & Schein, 2013). Price signals affect both the structure of production and investment. Producers are incentivized to adopt low-emission technologies and restructure away from brown production (Aichele & Felbermayr, 2015; Newell et al., 2013). At the same time, increased investment flows into R&D for energy and resource efficiency, reducing demand-side pressures and increasing system resilience. In the energy sector, carbon pricing shifts energy production from brown to green energy, supported by parallel developments in energy R&D. The loop captures multiple feedbacks: (1) price effects reduce energy demand and shift production; (2) fiscal flows enable targeted spending and redistribution; and (3) innovation investments build long-term system capacity and reduce future emissions. Together, these dynamics support the transition to a low-carbon economy while maintaining economic functionality and mitigating unintended social consequences such as carbon leakage or regressive effects.

1.1.3.2 Prices

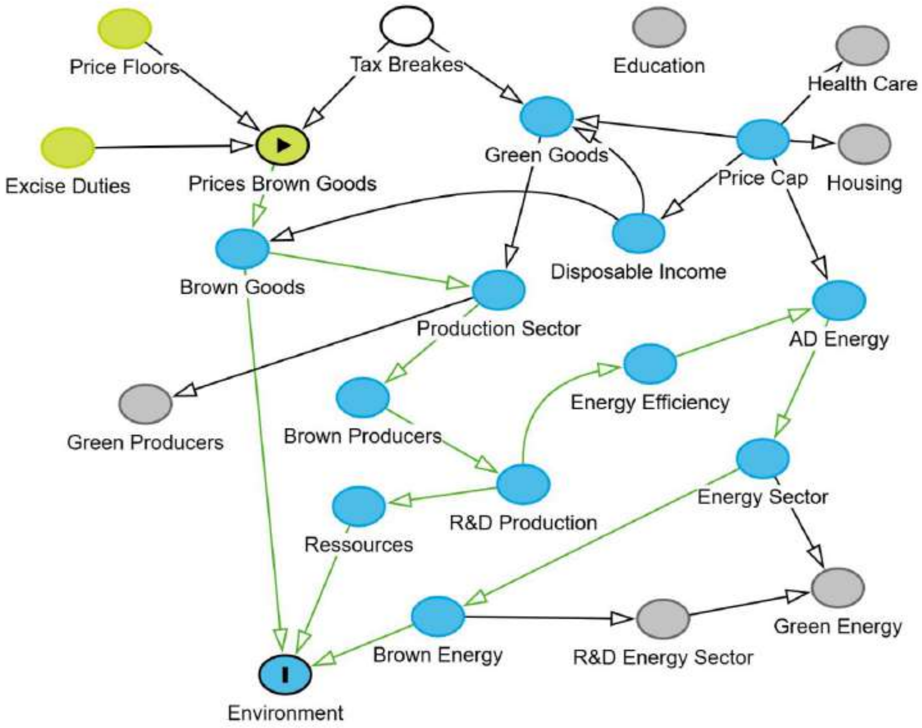

Figure 10A: How regulating prices affects the environment

Figure 10A shows indirect price instruments such as excise taxes, price floors, price caps, and tax rebates affect environmental outcomes by influencing consumption and production decisions. It focuses on the price of brown goods, which directly affects the consumption of carbon-intensive goods and thus their environmental impact. Excise taxes and price floors raise the price of brown goods, reducing their consumption and shifting demand to alternative products. At the same time, tax rebates and price caps can reduce the price of green goods or limit the upward pressure on brown goods to maintain affordability and mitigate regressive distributional effects. Changes in the consumption of brown and green goods affect the production sector, determining the relative success of brown and green producers. This allocation of demand and investment drives production patterns and employment, and further feeds into R&D production, which contributes to improvements in energy efficiency and natural resource use.

Energy efficiency reduces overall energy demand, which changes the composition of the energy sector, potentially reducing reliance on brown energy and increasing the share of green energy, especially when combined with innovations from energy R&D.

Ultimately, the loop affects the environment through three channels: the level of brown goods and brown energy consumption, the intensity of resource use, and the effectiveness of green alternatives. By steering relative prices, this regulatory loop provides a powerful lever to reduce environmental degradation while maintaining attention to distributional equity.

1.1.4 Subsidies

Figure 11A illustrates how government subsidies influence environmental and economic outcomes through their effects on investment behavior, energy production and labor allocation.

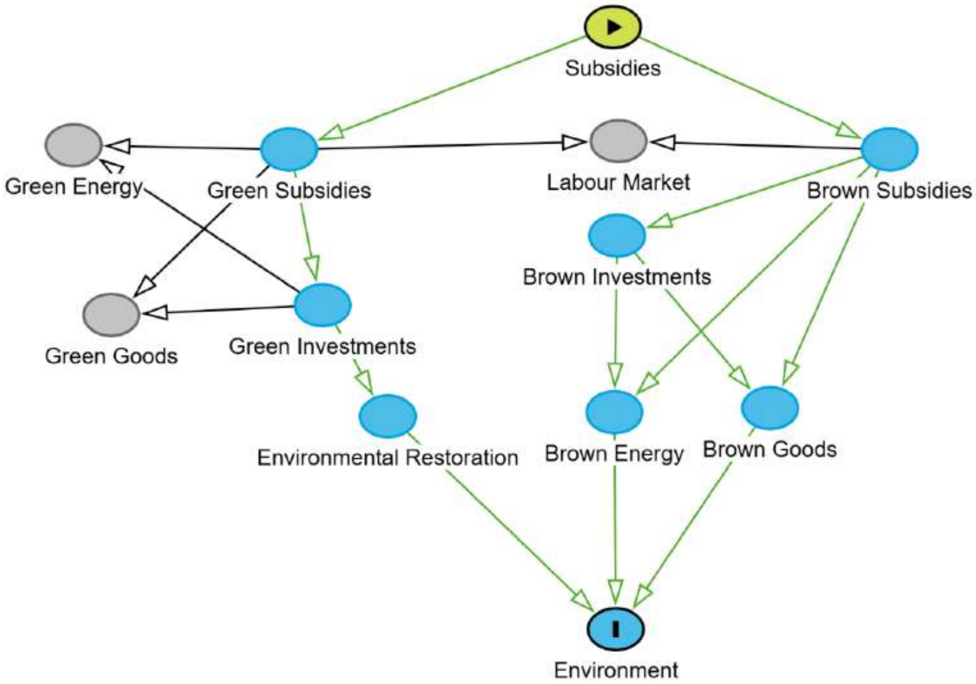

Figure 11A: The impact of subsidies (green and brown) on the environment

Green subsidies support **green investments**, which in turn stimulate the production of **green energy** and **green goods** (Benkhodja et al., 2023; OECD & IEA, 2021). These investments can also contribute directly to **environmental restoration**, reinforcing positive ecological outcomes. In addition, green subsidies influence the **labor market** by increasing demand for workers in sustainable sectors, thereby shifting employment and skills toward green industries (Acemoglu et al., 2012; Dechezleprêtre & Sato, 2017; Gruber, 2005). In contrast, **brown subsidies** reinforce the status quo by directing resources toward **brown investments** (Coady et al., 2019). These investments fuel further production of **brown goods** and **brown energy**, both of which contribute significantly to environmental degradation. The feedback loop becomes self-reinforcing: subsidies lead to investment, which increases emissions and resource extraction, locking the system into a carbon-intensive trajectory. Brown subsidies also influence the **labor market** by sustaining employment in high-emission industries, potentially slowing the green transition (Bowen et al., 2018).

1.1.4.1 Production Standards

Figure 12A shows how different production standards—including emission performance standards (EPS), power plant emission limits, energy efficiency standards, clean technology mandates, industrial heat decarbonization and production bans—serve as regulatory tools to influence industrial practices and reduce greenhouse gas (GHG) emissions.

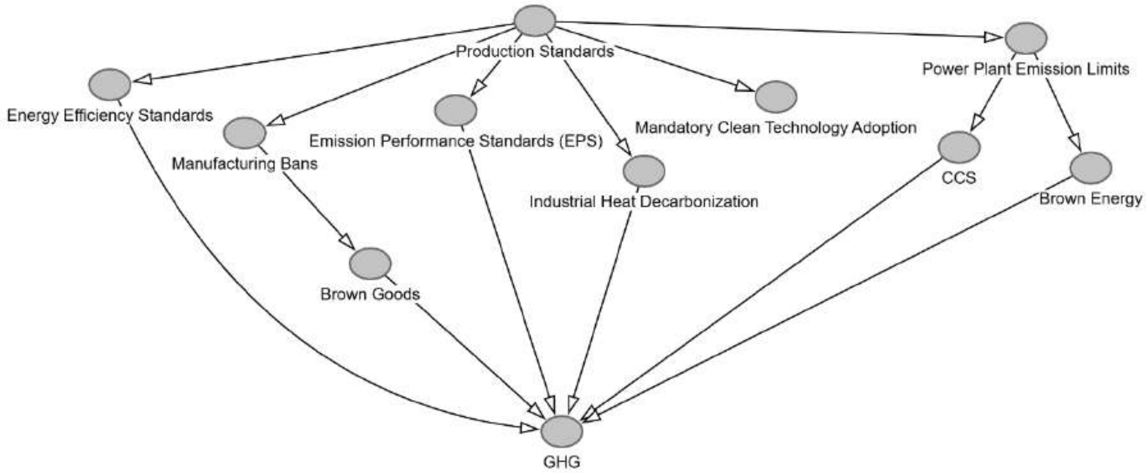

Figure 12A: How regulating production standards affects the environment.

The implementation of production standards directly affects both brown goods (carbon-intensive products) and brown energy (fossil fuel-based energy sources). Emission Performance Standards (EPS) set legal limits on emissions per unit of output, encouraging companies to invest in carbon capture technologies or switch to less carbon-intensive production methods. Similarly, energy efficiency standards set minimum efficiency requirements for factories and machinery, encouraging the adoption of energy-saving technologies and reducing overall energy consumption (Angel et al., 2007).

Mandatory Clean Technology Adoption requires industries to integrate low-carbon technologies into their operations, fostering innovation and accelerating the shift towards sustainable practices. Manufacturing Bans prohibit the production of certain high-emitting products, such as fossil fuel vehicles, directly reducing the production of brown goods. Industrial Heat Decarbonization Policies mandate the replacement of fossil fuel-based heating systems with cleaner alternatives, reducing the carbon footprint of industrial processes (IEA, 2023). Power plant emission budgets limit the CO_2 intensity of power plants, leading to a reduction in the production of brown energy and encouraging the adoption of renewable energy sources. Another important element in this framework is CCS, which is influenced by power plant emission limits (Baranzini et al., 2017). The adoption of CCS technologies allows for the capture and storage of CO_2 emissions from power plants, further reducing GHG emissions. Taken together, these production standards create a regulatory framework that forces industry to reduce emissions through technological innovation and cleaner production methods. By directly addressing the sources of GHG emissions, these standards play a critical role in steering the economy towards sustainability and achieving environmental goals.

1.1.4.2 Carbon Capacity

The figure below illustrates how carbon capacity—the Earth's ability to absorb and store carbon without triggering environmental harm—can be strengthened through a mix of public provision, regulation, and subsidies. Carbon capacity encompasses natural sinks such as forests, soils and oceans, as well as technological solutions like carbon capture and storage (CCS)(Minx et al., 2018; Shukla et al., 2022). Increasing this capacity is essential for stabilizing atmospheric CO_2 concentrations and achieving climate mitigation targets (Pierre et al., 2022).

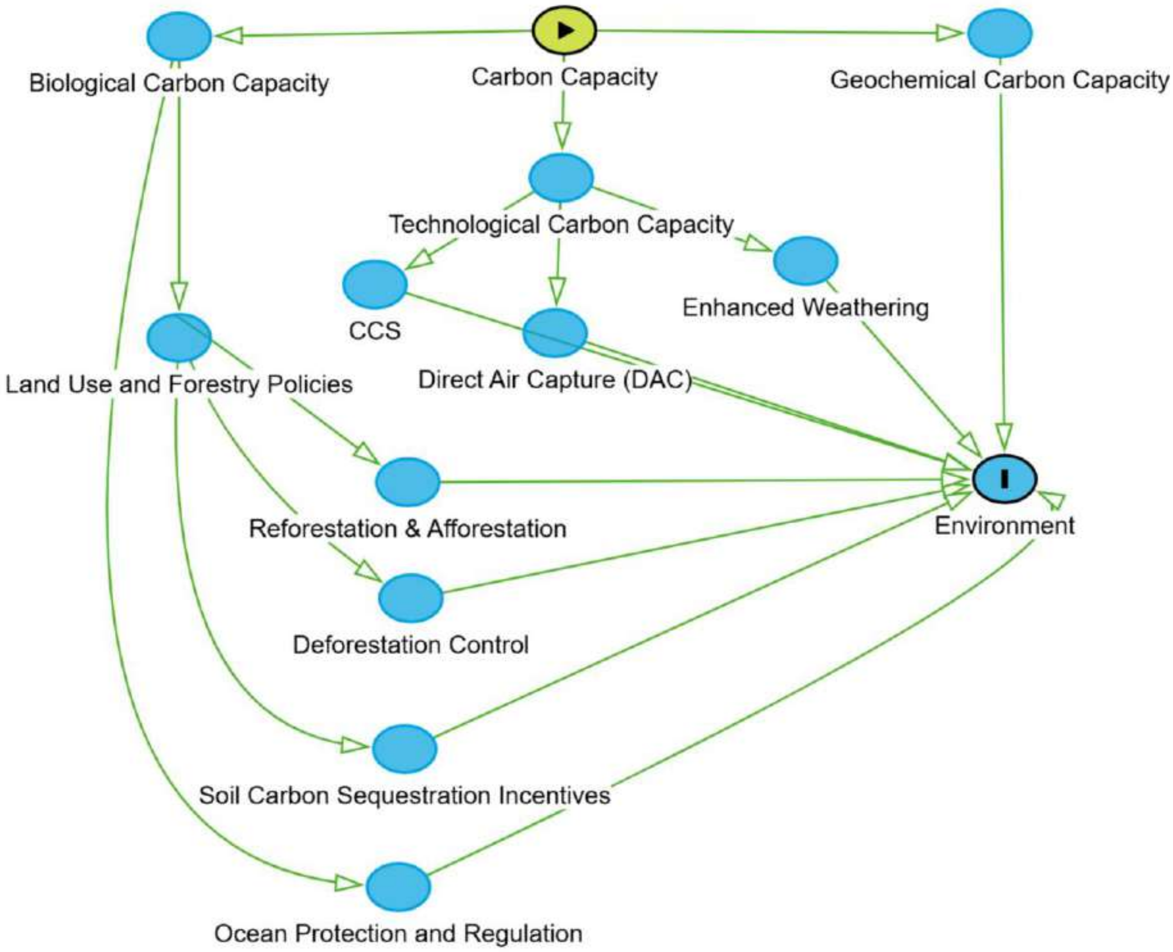

Figure 13A: The causal impact of Carbon Capacity.

At the top of the system, carbon capacity is divided into three interconnected domains: Biological, Geochemical, and Technological Carbon Capacity (Bose et al., 2024; Griscom et al., 2017). These domains inform targeted policy areas. For instance, land-use and forestry policies—linked to biological capacity—activate a chain of interventions: reforestation and afforestation (public provision), deforestation control (regulation), and subsidies for soil carbon sequestration (Smith et al., 2008). These actions enhance carbon sinks and reduce land-use emissions.

Technological Carbon Capacity supports engineered carbon removal approaches, including Direct Air Capture (DAC), CCS, and Enhanced Weathering. These methods are critical complements to nature-based solutions, especially for decarbonizing hard-to-abate sectors like cement and steel (Fuss et al., 2018). In parallel, ocean-based measures such as marine ecosystem protection and ocean alkalinity enhancement align with biological capacity and reinforce the importance of marine carbon sinks in maintaining planetary equilibrium (Gattuso et al., 2018).

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