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A Participatory Future Scenario-Building Methodology for Europe's Just Transition by Sectors: The FITTER-EU Case

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Abstract

The twin transition—green and digital—is a European Commission priority, but it raises concerns of misalignment and unequal impacts. While foresight approaches are increasingly used to inform policymaking, there is still limited methodological guidance on how to systematically integrate vulnerability into participatory scenario-building processes. Policies may unintentionally generate disadvantaged groups, making a just transition essential. The Fair and Inclusive Twin Transitions for a Stronger Social Europe (FITTER-EU) project develops a scenario-building methodology to anticipate socio-technical transformations across four sectors (housing and built environment, transport and mobility, energy, and agriculture) in six countries (Spain, Germany, Hungary, Italy, Ireland, and Portugal). The methodology employed combines a multi-level perspective (MLP), distinguishing between niches (emerging innovations), regimes (established systems), and landscapes (macro-level contexts), with the PESTLE analysis (Political, Economic, Social, Technological, Legal, Environmental). This MLP-PESTLE framework is operationalised as both a conceptual and analytical structure, supporting the design of exploratory scenarios grounded in expert evidence, collected through semi-structured interviews and a Delphi survey of policymakers, civil society representatives, researchers, and private sector experts. Findings highlight the methodology's value for addressing unwanted impacts on societal groups, structuring the plurality of perspectives, and supporting its translation into three exploratory scenario configurations per sector (optimistic, neutral, pessimistic) by 2050. These scenarios represent alternative narratives of governance capacity, policy coherence, and social inclusion, reflecting different levels of achievement toward socio-technical transition objectives. This study contributes to the literature by providing a participatory methodological approach that integrates just transition considerations into foresight practices and tools for policymakers to foster anticipatory policymaking.

Keywords
Delphi method; foresight; interviews; just transition; policy impact; scenario building; socio-technical transformations; vulnerability assessment

1. Introduction

1.1. The Twin Transition Policies and Social Vulnerability

This article aims to develop and test a participatory scenario-building methodology that integrates vulnerability analysis into foresight processes to support anticipatory governance of the twin transition with social justice at its centre. The twin transition (combining green and digital transitions) has emerged as a central strategic priority of the European Commission (EC), shaping policy agendas across climate action, industrial strategy, innovation, and public administration (Muench et al., 2022; Terzi et al., 2023).

However, growing evidence suggests that the twin transition is neither socially neutral nor automatically inclusive (Crespy & Munta, 2023; Galgóczi, 2020). While each transition generates its own inclusion challenges—such as energy poverty in the green transition or digital exclusion in the digital transition—their interaction may amplify these risks, producing compounded forms of disadvantage (Aloisi, 2025). Moreover, inequalities are not only individual but also territorial. Regional disparities in infrastructure, institutional capacity, and access to funding shape the speed and direction of the twin transition, potentially reinforcing uneven development across the EU (Barbero et al., 2025; Fazio et al., 2025). Current implementations fail justice standards in most contexts due to narrow policy design focused on reactive compensation rather than holistic integration; insufficient stakeholder participation that amounts to tokenism (Crespy & Munta, 2023); inadequate funding that fails to provide necessary guarantees for workers (Pollin, 2023); and a lack of coordination between digital, green, and social dimensions (Crespy & Munta, 2023; Peretto et al., 2025). Moreover, current trends such as rising energy prices, digital-by-default service provision, uneven access to green technologies, and sectoral restructuring all pose risks for specific population groups (EC, 2022). For the purposes of this study, vulnerability is understood as a structural condition characterised by the combination of high exposure to stressors generated by socio-technical change and limited adaptive capacity arising from financial constraints, skills gaps, or employment precarity. Following Adger (2006) and Kehler and Birchall (2021), vulnerability is not an individual deficit but an outcome of policy design, institutional arrangements, and the differential distribution of transition costs and benefits across social groups and territories. Building on this, social inclusion is understood in this study as a multidimensional and institutionally-mediated condition, referring to equitable access to the opportunities, infrastructure, and decision-making processes generated by socio-technical change (Atkinson, 1998; Levitas, 2005). Inclusion is treated as a structural design criterion whose realisation depends on the alignment between governance arrangements, niche innovations, and regime reform (Geels & Schot, 2007; Wang & Lo, 2021).

In this line, the concept of a "just transition" has gained prominence as a response to these concerns, emphasising the need for fairness, inclusion, and the protection of vulnerable groups during structural transformations (EC, 2022). This concept claims the "need for transformative change ensuring that no individual, community or sector is left behind in the transition towards a sustainable future, both globally and locally" (Monaco, 2023, p. 1). Yet, just transition debates often focus on ex post compensation mechanisms, rather than on anticipatory governance that is capable of identifying risks before they materialise. This reactive orientation limits policymakers' ability to prevent the emergence of new disadvantaged groups (Mandelli, 2022). These are understood in this study as those population segments whose combination of structural vulnerability and exposure to transition-induced stressors places them at heightened risk of bearing the costs of the twin transition without proportionate access to its benefits. The European Institute for Gender Equality (2016) and the European Centre for the Development of Vocational Training (2014) establish that disadvantage is not inherent to groups but is produced by structural conditions. In the context of the twin transition, Adger (2006) and Crespy and Munta (2023) extend this logic: Vulnerability and disadvantage are outcomes of how socio-technical change, governance design, and institutional arrangements distribute costs and opportunities unevenly across the population.

In this matter, anticipatory governance is key to addressing the harms that the twin transition has on societal groups by integrating foresight, participation, and reflexivity into policymaking processes (OECD, 2025). From this perspective, scenario-building is not merely a technical exercise but a governance tool that enables policymakers to explore alternative futures, assess distributional consequences, and adapt policy designs accordingly. In recent years, there has been a growing role for anticipation to guide future sustainability transformations (Muiderman et al., 2022), as it has emerged as an interdisciplinary agenda aiming to govern uncertain futures in the present (Muiderman et al., 2023).

The foresight literature also highlights the increasing methodological diversity of scenario-building approaches. Sossa et al. (2021), in a review of 66 foresight studies, found that scenarios are increasingly constructed through hybrid combinations of methods such as stakeholder analysis, roadmapping, PESTLE analysis (Political, Economic, Social, Technological, Legal, Environmental), backcasting, and participatory techniques, particularly in sustainability-related contexts. This reflects a broader shift from predictive exercises towards more participatory and exploratory approaches to managing uncertainty and supporting strategic decision-making (EC, 2023).

However, there is still limited methodological guidance on how to design scenario-building processes within the field of policy, despite their great potential. The OECD (2025) created the Strategic Foresight Toolkit for Resilient Public Policy, strengthening the need for evidence-informed anticipatory policy making in a changing world. The European Trade Union Institute also published a field manual on scenario building (Meinert, 2014). Both organisations acknowledge the need to support future-ready public policy, despite long-term uncertainty.

1.2. The Multi-Level Perspective and Its Application to Foresight

The multi-level perspective (MLP) has become one of the most influential frameworks for analysing socio-technical transitions (Geels, 2002, 2005; Rip & Kemp, 1997). It encompasses three key elements: first, the landscape, referring to environmental, social, and economic global trends that influence and pressure the regime; second, the regime, which refers to the mainstream society supported by social norms and already integrated systems (preserving the status quo); and finally, the niches, which consist of new ideas and innovations that can challenge the preexisting regime (El Bilali, 2019; see Figure 1). Transitions, under this framework, are conceptualised as the outcome of interactions across these levels.

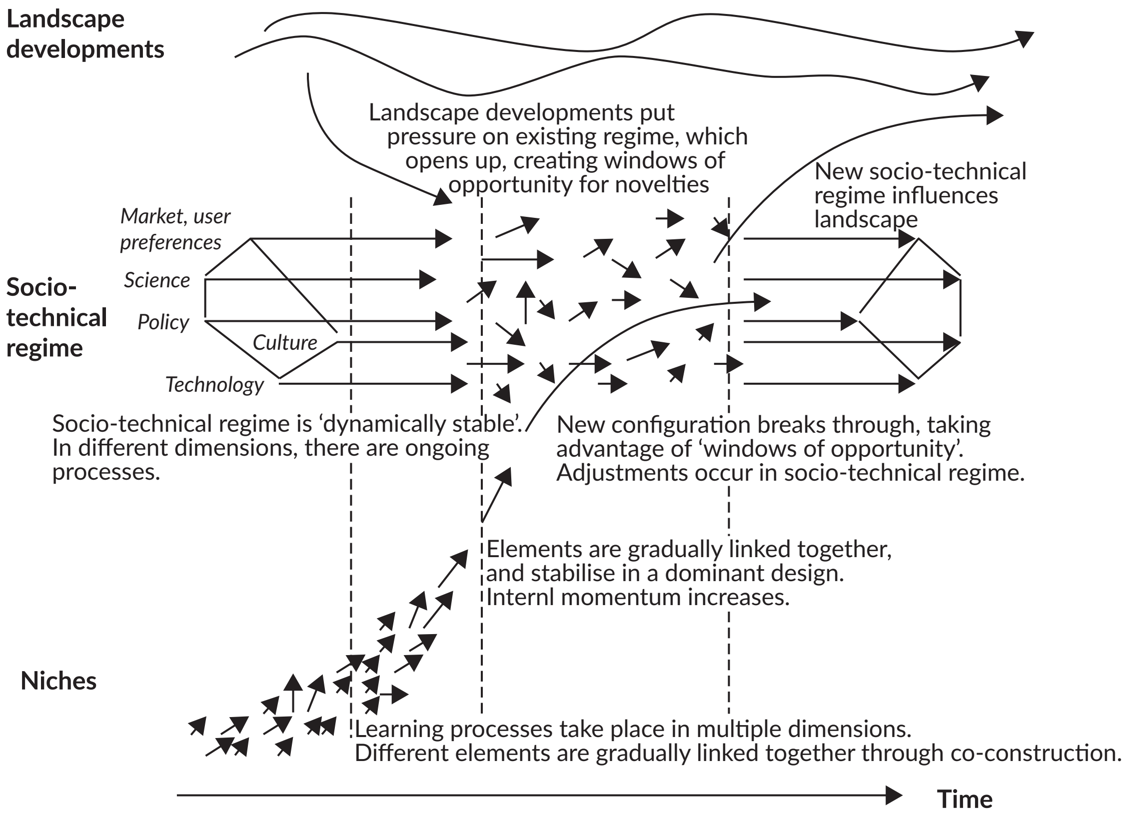

Figure 1. A dynamic MLP on system innovations. Source: Genus and Coles (2008), adapted from Geels (2004).

The MLP is particularly relevant for governance analysis because it highlights how structural change is shaped by institutional lock-ins, power relations, and path dependencies. Regime-level policies may stabilise existing inequalities, while niche innovations may benefit only those with sufficient resources, skills, or access. Landscape pressures, such as energy crises or extreme weather events, can further amplify vulnerabilities among specific social groups. Persson et al. (2025) recently claimed that the MLP can be beneficial for scenario planning thanks to the provision of a structure for understanding system dynamics and socio-technical change.

By making these interactions explicit, the MLP provides a useful conceptual lens for analysing how transition pathways may generate differentiated social outcomes and for identifying governance levers capable of steering transitions in more inclusive directions. In this article, the MLP is used as the overarching theoretical framework to examine the governance of the twin transition and to inform the design of exploratory scenarios across sectors.

The literature distinguishes between normative and exploratory scenarios in future studies (Börjeson et al., 2006; van Notten et al., 2003). While normative scenarios define desirable futures and pathways to achieve them (Robinson, 2003; Rotmans et al., 2000), exploratory scenarios examine multiple plausible futures under different uncertainties and socio-technical developments.

Within the context of the Fair and Inclusive Twin Transitions for a Stronger Social Europe (FITTER-EU) project, under the EU Horizon Europe programme (Grant Agreement no. 101132546), exploratory scenarios are particularly relevant. FITTER-EU aims to support anticipatory governance by helping policymakers identify how Europe's green and digital transitions may affect different social groups, especially those at risk of exclusion. Through predictive and participatory tools, the project seeks to promote fairer and more inclusive policy design, making exploratory scenarios an appropriate approach to analyse potential future inequalities, risks, and opportunities associated with the twin transition.

Exploratory scenarios, according to Andreescu et al. (2013), emphasise the study of diverse future alternatives, depicting the range of possible outcomes. Thus, this research offers a unique opportunity to (a) experiment with the use of the MLP for the creation of this kind of forecasting, (b) create a novel methodology to build exploratory scenarios using the MLP, and (c) develop participatory methods to engage related stakeholders in the elaboration of these scenarios. To support these objectives, this article presents and reflects on a novel and participative scenario-building methodology developed within the FITTER-EU project, built upon Persson et al.'s (2025) insights. This makes use of the MLP for scenario building, tailored to the concrete needs and challenges that FITTER-EU is addressing, and ensuring it is evidence-based through the involvement of experts.

The novelty of the proposed methodology lies in three dimensions: (a) the systematic operationalisation of the MLP as a guiding conceptual and analytical framework within a participatory scenario-building process, going beyond its typical descriptive use in transition studies; (b) the explicit integration of vulnerability and just transition considerations as structural design criteria throughout the foresight process, rather than as ex post add-ons; and (c) the iterative triangulation of semi-structured interviews and Delphi surveys across multiple expert rounds, enabling progressive convergence while preserving interpretative depth.

Prior work (Meinert, 2014; OECD, 2025; Persson et al., 2025) addresses foresight methodology or the MLP in isolation, but does not combine them in a structured participatory process centred on distributional justice across sectors.

2. Method

This study adopts an integrated qualitative-quantitative foresight approach with the primary objective of developing and testing a scenario-building methodology suitable for anticipatory governance of the twin transition.

To narrow the sectoral scope into a manageable analytical dimension, an analysis of policy objectives was conducted. Although no common policy framework existed across the six member states (Spain, Portugal, Italy, Ireland, Hungary, and Germany), shared national policy objectives were identified through the review of 58 EU and national strategy documents (listed in the Supplementary Material). Four policy objectives linked to the twin transition were selected, one per sector: (a) digitalisation of agriculture, (b) transition to electric vehicles, (c) transition to renewable energy, and (d) climate adaptation of housing and the built environment. These objectives served as structuring topics for exploring uncertainties, drivers, barriers, stakeholders, and governance dynamics associated with each transformation pathway.

The scenario-building methodology followed a six-step iterative process combining qualitative and quantitative evidence to produce coherent exploratory narratives for 2050 (see Figure 2). While insights from the six member states informed the analysis, the scenarios were developed at the EU sectoral level, focusing on sectoral transformation dynamics rather than cross-country comparisons.

The six-step process unfolded as follows: (a) a first round of semi-structured interviews to identify major trends, drivers, uncertainties, and vulnerabilities; (b) a first Delphi survey to elaborate and structure statements derived from interview findings and to assess preliminary convergence; (c) a second round of interviews aimed

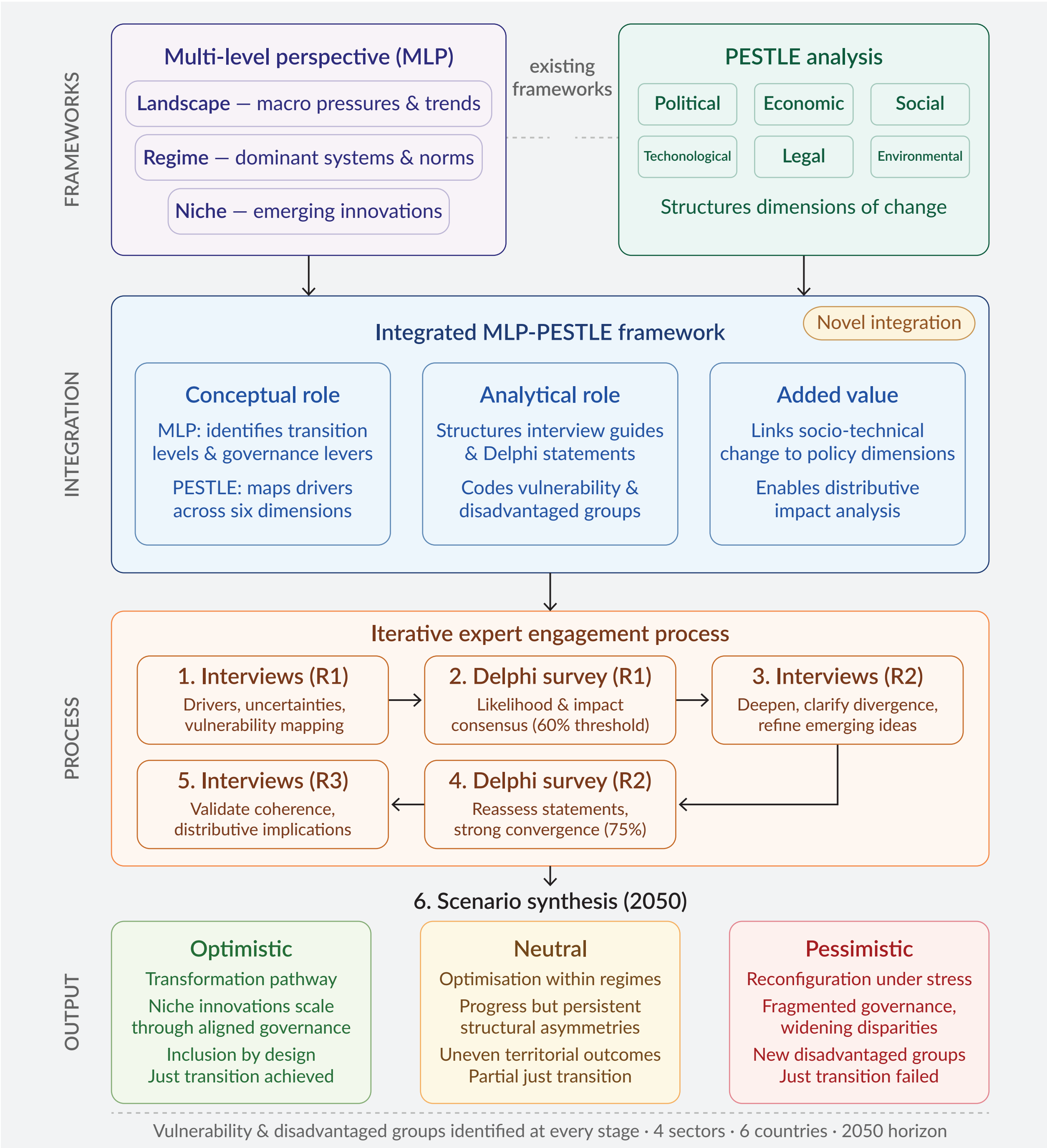

Figure 2. Scenario-building participatory methodology. Note: Developed by the authors; Claude.ai used for graphic design.

at deepening interpretation, clarifying divergences, and refining emerging key ideas based on Delphi #1 results; (d) a second Delphi survey to reassess updated statements and strengthen consensus patterns; (e) a third round of interviews focused on fine-tuning interpretations, validating coherence across sectors, and discussing distributive implications; and (f) a final synthesis into three exploratory future scenarios per sector.

To guide the comprehensive and comparable analysis across sectors, the MLP was complemented with a PESTLE framework (Aguilar, 1967; see Figure 2). This combination enabled systematic consideration of governance-related drivers, regulatory conditions, economic constraints, and social factors influencing sectoral transitions throughout the process. The MLP-PESTLE framework was used to structure the interview guide and the formulation of Delphi statements (Linstone & Turoff, 1975). For instance, interview questions were organised to elicit expert perspectives on key drivers, uncertainties, and expected developments within each dimension (e.g., technological innovation, regulatory change, social acceptance), and to explore their interactions across levels. Insights derived from the first round of interviews, coded according to this framework, were then translated into Delphi statements, maintaining alignment between the conceptual structure and the empirical data collection process.

2.1. Sample Description

A total of 86 experts contributed to the scenario-building through interviews and/or participation in the Delphi surveys (see Table 1). Of these, 24 participated in semi-structured interviews conducted by the two authors, and 62 took part in at least one Delphi round. Participation across phases was partially overlapping: 15 experts contributed to both the interview phase and the Delphi survey, while the remaining participants were involved in only one of the two components. This overlap was intentional, allowing continuity in reflection while simultaneously incorporating additional experts to broaden sectoral and geographical representation. Given the qualitative and foresight-oriented nature of the study, the objective was not statistical representativeness but analytical diversity across sectors, countries, and stakeholder types. These experts were part of the Cluster Community Group of Stakeholders created during the FITTER-EU project, which includes a wide range of stakeholders, policymakers, civil society representatives, sectoral experts, and representatives of disadvantaged groups, among others, reflecting the multi-actor nature of the twin transition. Additionally, during the interviews, the snowball technique was employed to identify additional experts. Each national representative partner was responsible for mapping and engaging the experts who were put in contact with the researchers.

Experts were selected through a purposive and iterative sampling strategy led by national partners, who identified relevant stakeholders based on their expertise, professional role, and involvement in key sectors (see Table 2). The sample includes a diversity of profiles, such as researchers, private sector representatives, policymakers, and practitioners. The composition of profiles varies across sectors and countries, reflecting structural differences in stakeholder ecosystems rather than the application of different selection criteria. Table 1 presents the aggregate distribution of roles, and the composition of each country is detailed in the Supplementary Material (Table 1), showing variations in stakeholder representation across national contexts.

Expert inclusion required: (a) a minimum of five years of demonstrated professional or research experience in the relevant sector; (b) a role directly connected to at least one of the four policy objectives under study (digitalisation of agriculture, electric mobility, renewable energy, or housing climate adaptation); and

Table 1. Description of the sample: Role categories.

Role category	Description	Share of sample (%)
Research and academia	Researchers, professors, scientific advisors, postdoctoral fellows, research officers, academic experts in socio-technical transitions	38.37%
Private sector and industry	Business developers, CEOs, engineers, consultants, project managers, technical experts, innovation and sustainability professionals	40.70%
Policy and public sector	Policy officers, public advisors, institutional representatives, regulatory and governance experts	9.30%
Civil society and practitioners	Farmers, cooperative members, practitioners, community-based actors and sectoral professionals with applied experience	11.63%

(c) availability for multi-round engagement. Representation of vulnerable groups and civil society was ensured through the FITTER-EU Cluster Community Group of Stakeholders, which explicitly included practitioners, cooperative members, and community-based actors. This was further facilitated by the consortium's composition: Several FITTER-EU partners are NGOs or organisations with established networks in initiatives where representatives of vulnerable groups play a central role. National partners were given specific guidance to balance profiles across researcher, private sector, public sector, and civil society categories, supported by ongoing monitoring of engagement levels and identification of underrepresented profiles. Nevertheless, structural differences in stakeholder ecosystems across countries meant that perfect symmetry was not achievable, as reflected in Table 2 and discussed under the study's limitations.

Table 2. Description of the sample: Experts per country and sector.

Country	Number of experts per sector	Total number of experts and geographical coverage in %
Spain	Mobility (12) Agriculture (8) Housing (6) Energy (7)	33 (38.37%)
Italy	Mobility (2) Agriculture (2) Housing (1) Energy (7)	11 (12.79%)
Hungary	Mobility (1) Agriculture (0) Housing (0) Energy (1)	2 (2.33%)
Ireland	Mobility (3) Agriculture (4) Housing (0) Energy (3)	10 (11.63%)

Table 2. (Cont.) Description of the sample: Experts per country and sector.

Country	Number of experts per sector	Total number of experts and geographical coverage in %
Germany	Mobility (3) Agriculture (2) Housing (3) Energy (5)	13 (15.12%)
Portugal	Mobility (2) Agriculture (3) Housing (3) Energy (5)	13 (15.12%)
EU Level	Mobility (3) Agriculture (1) Housing (0) Energy (0)	4 (4.65%)

A total of 24 semi-structured interviews were conducted in three rounds to explore sectoral transition dynamics, governance challenges, and potential social implications of the twin transition. The interviews were structured in three blocks: horizon scanning, scenario building, and implications. Initially, experts were asked to list the factors that, according to the PESTLE dimensions, would still be important in 2050, what factors may still be reasonably certain in 2050, and what would be more uncertain. For the second block, the interrelation between factors was explored, focusing on their implications and the new opportunities and challenges that could arise from these interactions (MLP factors). Finally, the third block considered the identification of potential winners and losers of these scenarios. Our goal was to, following the wording of Meinert (2014), recognize and divide two types of factors: "givens," the general assumptions that may continue to remain stable in the future; and "drivers," the factors with more risk and uncertainty.

2.2. Data Analysis and Final Scenario-Building

Interview data were analysed using deductive coding with the Atlas.ti software based on the MLP-PESTLE categories, vulnerability dimensions, and identified disadvantaged groups. Insights from each interview round informed the formulation and refinement of Delphi survey statements and guided subsequent rounds of data collection. Two rounds of Delphi surveys were conducted, with a sample of 62 experts, to assess and refine key assumptions identified through the interviews. Statements were formulated in the future tense and evaluated by experts, with qualitative comments used to contextualise responses and capture uncertainty or disagreement.

To assess whether a Delphi statement reached expert consensus, a quantitative threshold based on the distribution of responses was applied. For each statement, experts evaluated two dimensions (likelihood and impact) using a five-point ordinal scale ("very low," "low," "neutral," "high," "very high"). Consensus was defined as being reached when at least 60% of responses fell within the two highest categories ("high" or "very high") for a given dimension in a given round. This threshold was calculated relative to the total number of responses per statement and per round. If this condition was not met, the statement was classified as showing no consensus. Likelihood and impact were analysed independently for each statement. In addition, an indicator capturing the percentage of "very high" responses among those who agreed (i.e., selected "high" or "very high") was used to assess the strength of agreement within the expert group. Statements reaching consensus on likelihood were prioritised as robust signals for scenario development, even when consensus on impact was not achieved. The 60% threshold was selected as a pragmatic balance between inclusiveness and stringency, taking into account the heterogeneity of the expert panel across sectors and countries. In applied policy Delphi studies, consensus thresholds typically range between 55% and 75%, depending on panel size and diversity; the 60% criterion allows for the identification of convergent signals without artificially suppressing minority but potentially relevant viewpoints.

A higher threshold of at least 75% agreement in the second round was used to indicate strong convergence, signalling robust expectations among experts rather than initial alignment. This stepwise approach enabled differentiation between moderate consensus and consolidated agreement, supporting nuanced scenario construction. In parallel, statements were categorised according to their expected effect on the twin transition. Based on expert assessments and contextual interpretation, trends were classified as positive when they were expected to support both green and digital dimensions; negative, when they were likely to hinder transition dynamics; or mixed, when their effects could operate in different directions depending on context. This classification supported the interpretation of consensus results and informed subsequent scenario development. The complete table can be found in the Supplementary Material.

The final step synthesised the results of interviews and Delphi surveys, including the qualitative comments through deductive analysis, into three exploratory scenarios (optimistic, neutral, and pessimistic) for each sector based on the achievement (non, partial, or complete) of the policy objective within a just transition context, with a time horizon of 2050. This synthesis did not consist of a direct translation of individual Delphi statements into scenarios. Instead, the process combined the patterns of convergence and divergence identified in the Delphi rounds with the interpretative insights obtained in the third round of interviews. In this phase, interview evidence was used to validate, refine, and contextualise the emerging configurations, clarifying relationships between drivers, uncertainties, and governance conditions across sectors. Scenarios were thus constructed as internally coherent combinations of these elements, where consensus-based trends provided the backbone of each configuration and areas of disagreement or uncertainty were incorporated to differentiate between optimistic, neutral, and pessimistic trajectories. The final scenarios, therefore, represent analytically derived narratives grounded in iterative validation between quantitative convergence patterns and qualitative interpretation, rather than outputs directly extracted from a single stage of the process.

3. Results

3.1. From Delphi Statements to Scenario Narratives

The Delphi exercise generated a structured set of forward-looking statements reflecting expert assessments of the likelihood and impact of key developments related to the twin transition, derived from the interviews. These statements were subsequently interpreted through a normative lens, distinguishing between dynamics expected to support an inclusive and sustainable articulation of a just twin transition and those likely to hinder such alignment, that is, how different narratives were created (see Figure 3).

Across sectors, positive dynamics were associated with accelerated deployment of low-carbon technologies, expansion of digital infrastructures, consolidation of circular economy mechanisms, and the emergence of governance instruments capable of coordinating innovation and inclusion. From a PESTLE perspective, these dynamics were most often embedded in technological and environmental change, supported by political and legal steering instruments, and enabled by economic investment capacity. Negative dynamics were linked to rising transition costs, uneven infrastructure coverage, labour displacement due to automation, strategic dependencies on critical materials, and forms of digitalisation that risk reinforcing exclusion. These risks frequently reflected economic constraints, social vulnerability factors, and landscape-level pressures such as geopolitical instability and the climate emergency.

This classification provided the analytical foundation for constructing three internally coherent exploratory scenarios. When positive dynamics were assumed to scale coherently across sectors and to be supported by anticipatory governance, the resulting configuration corresponded to a transformation pathway in MLP-PESTLE terms, characterised by alignment between niche innovation, regime reform, and landscape adaptation (optimistic scenario). When both positive and negative dynamics coexisted under uneven implementation (neutral scenario), the pathway resembled optimisation within existing regime structures, with selective adjustments but persistent lock-ins. Finally, when negative dynamics accumulated and governance responses proved fragmented or reactive, the scenario reflected a reconfiguration under stress, where landscape pressures intensified while regime transformation remained incomplete and socially misaligned (pessimistic scenario). The complete scenarios can be found in the Supplementary Material based on a FITTER-EU report (Armayones Carranza & Viñé Rius, 2025a); a short summary is presented in the following section.

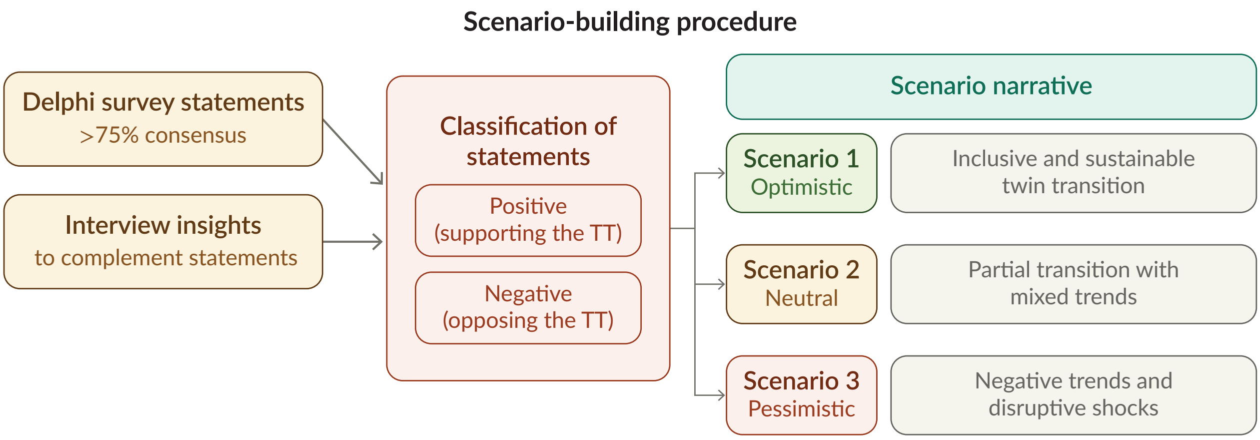

Figure 3. From Delphi statements to scenario narrative. Note: Developed by the authors; Claude.ai used for graphic design.

3.2. Optimistic, Neutral, and Pessimistic Scenario Dynamics

In the optimistic scenario, the twin transition develops through coordinated transformation across sectors. Technological innovation is supported by institutional reform, sustained investment, and governance mechanisms designed to prevent the emergence of new disadvantaged groups. Political commitment, regulatory clarity, and social safeguards reduce distributive risks.

A key feature of this pathway is the alignment between digitalisation and decarbonisation. Renewable energy systems are strengthened through smart grids, energy storage, and circular battery production, while digital platforms enable more participatory and community-based energy models. Technological innovations become progressively integrated into existing governance and market structures.

Electrified and service-based mobility systems are similarly supported by interoperable digital infrastructures and targeted reskilling programmes, limiting unemployment and regional decline during workforce restructuring. In rural and peripheral areas, integrated mobility solutions reduce transport poverty and improve access to services.

In the agri-food sector, cooperative digitalisation models lower entry barriers for small producers. Precision agriculture, traceability systems, and AI-supported irrigation improve productivity and environmental performance without concentrating benefits among large actors. Institutional support also prevents regulatory requirements from disproportionately affecting small farms.

Within the built environment, climate adaptation and digital innovation are combined with affordability measures and inclusive planning. Deep renovation strategies prevent displacement and maintain access to quality housing for low- and middle-income households, while universal accessibility standards are integrated from the outset.

Across sectors, inclusion is not treated as a compensatory add-on but as a structural design principle. Landscape pressures such as climate risks or geopolitical volatility act as catalysts for reform rather than as destabilising shocks. In MLP terms, this configuration reflects a transformation pathway in which niche innovations scale through coordinated political, economic, and legal support, reshaping regime structures in line with just transition objectives.

The neutral configuration is characterised by measurable progress in both green and digital dimensions, yet without fully overcoming structural asymmetries. Technological adoption proceeds at scale, but implementation capacity, fiscal resources, and administrative coordination vary significantly across territories and institutional contexts.

Renewable energy penetration increases substantially, although fossil fuels remain present as a backup in several systems, reflecting partial regime adaptation. Digital participation expands, yet connectivity gaps, usability barriers, and administrative complexity limit uptake among specific groups. Electrified mobility becomes mainstream in metropolitan areas, while peripheral regions experience slower infrastructure rollout and continued reliance on conventional vehicles. These differentiated outcomes reflect uneven interaction between technological innovation and socio-economic conditions.

In the agri-food sector, advanced digital tools and cooperative arrangements operate effectively in regions with strong institutional support, but remain absent or weakly developed elsewhere. Consequently, disparities persist between well-integrated producers and those operating outside formal support networks, indicating that regime change remains incomplete.

In the built environment, renovation and climate adaptation progress unevenly, generating spatial divergence between municipalities able to mobilise funding and those constrained by limited capacity.

Affordability protections are effective in some contexts but insufficient in others, leading to differentiated exposure to housing and climate risks.

Overall, this scenario reflects optimisation within existing regimes. Emission reductions and digital integration are substantial, yet inclusion remains contingent on local governance quality and economic resources. Political commitment and technological development are present, but economic and social dimensions are unevenly addressed. Structural inequalities are mitigated but not fundamentally transformed.

In the pessimistic configuration, negative dynamics accumulate, and governance responses fail to provide coherence or protection. Transition processes become fragmented, reactive, and unevenly financed, leading to widening disparities. Landscape-level pressures, such as climate extremes, geopolitical tensions, and supply chain disruptions, interact with economic constraints and weak political coordination, amplifying system fragility.

Renewable energy deployment slows due to infrastructure bottlenecks and material dependencies, while fossil-fuel reliance persists as a short-term stabilisation strategy. Grid fragility and exposure to extreme weather generate recurrent instability, illustrating how environmental and geopolitical factors at the landscape level can reinforce regime lock-ins when institutional capacity is insufficient.

Simultaneously, automation and digitalisation advance without adequate anticipatory reskilling. Labour displacement affects traditional manufacturing, logistics, and low-skilled agricultural roles, with insufficient transition pathways for affected workers. High-skilled employment opportunities concentrate in limited hubs, reinforcing regional polarisation and socio-economic segmentation.

Digital platforms increasingly replace analogue services across sectors; however, insufficient attention to accessibility, language support, and digital literacy exacerbates exclusion. Administrative complexity further restricts access to subsidies and support schemes, favouring actors with greater institutional capacity and reinforcing social inequalities embedded within the regime.

Housing affordability deteriorates in major urban centres, renovation remains incomplete, and climate adaptation is unevenly distributed, intensifying vulnerability to extreme weather events. In rural areas, insufficient infrastructure investment exacerbates transport and energy poverty, illustrating how economic and territorial disparities compound social vulnerability.

In this scenario, landscape pressures amplify rather than transform regime dynamics. The twin transition ceases to function as a driver of cohesion and instead becomes a vector of stratification, disproportionately affecting low-income households, renters, migrants, older adults, people with disabilities, and small-scale producers. This pathway corresponds to a reconfiguration under stress, where technological change occurs but fails to align with social and institutional reform.

3.3. Common Patterns and Differences Among Sectors

Several cross-sectoral patterns emerge from the comparative analysis. First, infrastructure coverage consistently operates as a primary determinant of distributive outcomes. Whether in relation to energy grids, digital connectivity, charging networks, irrigation systems, or renovation capacity, access to enabling infrastructure shapes the ability of actors and households to participate in transition benefits.

Second, governance coherence proves decisive. Where political commitment, legal frameworks, and stable funding mechanisms are aligned, technological innovation translates into inclusive transformation. Where coordination is weak, even advanced technologies generate fragmented and unequal outcomes. This shows why it is crucial to guide or influence what happens in the regime, the dominant system, when using the MLP framework.

Third, labour market restructuring constitutes a shared vulnerability axis because it acts as a key transmission channel through which decarbonisation and digitalisation generate distributive effects. Across sectors, the twin transition tends to reallocate tasks rather than simply create or eliminate jobs, increasing demand for high-skilled technical and digital profiles while reducing reliance on routine and medium-skill roles. This shift interacts with existing occupational structures and regional labour market conditions, producing uneven exposure to displacement and unequal capacity to benefit from emerging opportunities.

A central risk lies in the mismatch between the pace of technological adoption and the adaptability of education, training systems, and social institutions. Where reskilling strategies are not anticipatory, territorially embedded, and closely aligned with sectoral demand, workers in carbon-intensive or routine-intensive occupations may experience prolonged unemployment, downward mobility, or labour market exit. These dynamics can reinforce polarisation, as high-value employment clusters in innovation hubs, while peripheral areas struggle to absorb transition shocks. Labour market outcomes are therefore not technologically predetermined but institutionally mediated. The interaction between technological change, active labour market policies, and social protection frameworks becomes decisive in shaping whether the twin transition mitigates or deepens socio-economic divides.

Fourth, digital access to transition-related services emerges as an ambivalent area across sectors. When embedded within inclusive design standards and supported by accessible interfaces and assistance services, it enhances transparency and efficiency. Conversely, when digital-by-default administrative platforms govern access to subsidies, information, or support without safeguards, they produce new exclusion mechanisms, thereby requiring inclusive regime reform.

Notwithstanding these commonalities, sector-specific sensitivities remain. The energy transition is particularly exposed to geopolitical material dependencies and grid stability challenges located at the landscape level. Mobility systems depend heavily on interoperability and business model integration to achieve systemic effects within the regime. Agricultural transitions are strongly shaped by farm scale and cooperative governance arrangements that influence the scaling of niche technologies. Housing outcomes are closely linked to property regimes, municipal capacity, and planning instruments, which determine how climate adaptation interacts with affordability in relation to private owners and public funding.

3.4. Identification of Disadvantaged Groups and Vulnerability Dimensions for the Pessimistic Scenario

The sectoral analysis allows for a more explicit identification of disadvantaged groups emerging across transition pathways. While the intensity of exposure varies across scenarios, recurrent patterns of vulnerability can be observed within each sector, shaped by employment restructuring, skill requirements, and financial capacity.

In the energy sector, vulnerable groups include low-income households, renters, older adults, and digitally excluded individuals who face barriers to accessing renewable energy, smart systems, and subsidies. Workers in fossil-fuel industries and small energy producers are also exposed to transition and financing challenges.

In transport and mobility, workers in traditional automotive and logistics sectors risk displacement due to electrification and digital mobility. Low-income households, rural residents, and digitally excluded users may struggle with access to EVs, charging infrastructure, and digital transport services.

In agriculture, small-scale and older farmers face difficulties adopting digital and AI-based technologies, while seasonal workers may be affected by automation. Unequal access to finance, advisory systems, and innovation networks can further widen inequalities.

In housing and construction, low-income households, renters, and residents in climate-exposed areas are especially vulnerable to renovation costs and uneven adaptation measures. Digitally excluded individuals may struggle to access services and subsidies, while low-skilled construction workers risk instability if training does not keep pace with new requirements.

Across sectors, vulnerability rarely operates along a single dimension. Economic constraints, limited digital or technical skills, and exposure to labour market restructuring frequently overlap, producing cumulative disadvantage for specific populations. The emergence and intensity of these disadvantaged groups depend not solely on technological change but on how governance frameworks shape access to employment opportunities, training systems, and financial support mechanisms. Integrating this identification within scenario-building processes strengthens the anticipatory capacity of policymakers to address distributive risks before they materialise.

Taken together, the results indicate that the distributive consequences of the twin transition are institutionally mediated rather than technologically predetermined. A detailed table containing the main drivers, risks, disadvantaged groups, and governance implications by sector can be found in the Supplementary Material based on a FITTER-EU deliverable (Armayones Carranza & Viñé Rius, 2025b).

4. Conclusions

The findings highlight the value of using the MLP-PESTLE framework as a conceptual and analytical tool for foresight processes. Its application reveals that the distributive consequences of the twin transition are determined by the degree of alignment between governance capacity, policy coherence, and inclusion mechanisms across sectors and territories. The methodology made it possible to systematically identify recurrent patterns of vulnerability, such as the interaction between labour market restructuring, infrastructure access, and digital exclusion, as well as cross-sector drivers that may otherwise remain fragmented or implicit in traditional analyses.

In addition, the iterative combination of interviews and Delphi surveys demonstrates the contribution of participatory and iterative methods for anticipatory governance, as claimed by Muiderman et al. (2022), to encompass the plurality of perspectives.

From a policy perspective, the proposed methodology offers a tool to help public institutions reflect on mechanisms to support anticipatory and evidence-informed decision-making. MLP-PESTLE is a theoretical methodology designed to assist policymakers in understanding unexpected consequences that a specific policy, through a regime change, might have. Thus, it can become a key tool during the problem framing and strategic assessment phase of policy design, for example when developing a policy planning procedure.

Concretely, the MLP-PESTLE framework and participatory rounds can be used by public administrations to: (a) identify potential transition-induced risks, and (b) support the design of mitigation and inclusion measures before policies are designed.

The MLP-PESTLE framework is, therefore, a tool that can be useful for any organisation related to policymaking that is interested in including an inclusivity perspective in its work.

At the same time, several limitations should be acknowledged. The uneven distribution of experts across countries and sectors introduces potential biases that merit explicit acknowledgement (Supplementary Material, Table 1). Countries with higher participation, particularly Spain, may have exerted greater influence. Sectors with lower engagement, such as housing and the built environment, offer less triangulated evidence and should be interpreted with greater caution.

This imbalance is partly structural: Stakeholder ecosystems in some national contexts are more densely organised. However, the iterative design of the methodology, combining three interview rounds with two Delphi surveys, partially mitigates this limitation by allowing emerging patterns to be validated and challenged across rounds.

Findings should therefore be understood as exploratory and indicative, not representative of national transition pathways. Future replications should aim for a more systematically balanced sample, ideally with a minimum quota per country–sector combination.

Beyond participation aspects, the approach relies substantially on expert judgement and qualitative interpretation. While expert-based foresight enables informed and forward-looking analysis, it may also reproduce dominant narratives. Also, focusing the analysis around policy objectives provides a necessary methodological anchor, but cannot fully capture the broader systemic complexity of socio-technical transformations. Sectoral futures are shaped by multiple interacting dynamics that extend beyond the achievement or non-achievement of a specific policy objective. The scenarios developed are therefore exploratory and context-dependent, intended to inform strategic reflection.

Future research could include the integration of complementary quantitative modelling tools, dynamic monitoring indicators, or system simulations to enhance analytical robustness. Expanding participation to informal citizens would also improve inclusiveness, as it would increase the total sample. Such extensions would further align anticipatory governance practices with democratic and socially embedded transition processes. In addition, a larger and more systematically balanced cross-country sample could support more robust comparative analysis and enable the identification of context-sensitive national transition pathways and policy strategies.

Overall, this study provides a structured methodology for participative scenario-building under conditions of uncertainty. By operationalising an MLP-PESTLE framework and iterative expert engagement, it sets a coherent basis for future methodological refinement and policy-oriented foresight processes, fostering anticipatory policymaking to ensure a just transition.

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Conflict of Interests

The authors declare no conflict of interests.

LLMs Disclosure

ChatGPT (Premium) was used for language editing and stylistic improvement of the manuscript's text. Claude was used for the improvement of the graphical design of the figures.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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