

Foresight Study on the Future of Protein in Europe (2025-2035-2050)



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Glossary

Alternative proteins

Non-traditional protein sources—including plant ingredients, cultivated meat, precision-fermented proteins, microbial biomass, algae, and insects—developed to reduce environmental impacts while maintaining functionality and consumer appeal.

Cellular agriculture

The production of food and feed ingredients from cell cultures rather than from whole animals or crops. This includes use of microbial, algal, plant, insect, or animal cells. In practice, cells are grown and produced in bioreactors that at industrial scale are big factories with large steel tanks.

Participatory foresight

A collaborative approach to future planning that actively involves stakeholders—such as industry, policymakers, researchers, and consumers—in shaping scenarios and strategies for systemic change.

Protein diversification

The strategic shift from reliance on resource-intensive animal proteins to a balanced mix of sustainable alternatives (plant-based, cultivated, fermentation-derived, algae-based, insect-based) to improve resilience, nutrition, and environmental outcomes.

Roadmap building

A structured process for defining milestones, timelines, and actions to achieve long-term goals. It aligns stakeholders on priorities and provides a clear implementation path for innovation and policy.

Scenario building

The creation of multiple plausible future narratives to guide decisions under uncertainty. In this study scenario building is used by PDTT to test pathways for Europe's future food system and to e.g. surface policy and market implications.

Introduction

The European Union is at a pivotal moment in shaping the future of its food systems. With innovation strategies, funding frameworks, and regulatory approaches under review to support long-term sustainability, the diversification of food has emerged as a critical priority. EIT Food's Protein Diversification Think Tank (PDTT) initiated a structured foresight exercise to envision future pathways for protein diversification in Europe, establishing clear milestones to ensure that by 2050, diets are sustainable, resilient, healthy, safe, and both appealing and affordable.

This foresight builds on PDTT's foundational analyses—landscape reviews, policy briefs, and strategic recommendations—and leverages VTT's expertise in futures thinking and AI-assisted scenario building. The process aimed to:

- **Develop robust scenarios** for protein diversification in Europe, with clear milestones for 2035 and 2050.
- **Enable informed decision-making** by providing evidence-based insights suitable to policymakers, industry, academia, and civil society.
- **Identify leverage points** for accelerating adoption of diversified proteins, technological innovations, and regulatory adaptations.
- **Support strategic prioritization** of funding aligned with EU policies, including the EU Protein Strategy.

Through this process, four distinct scenarios were created, each reflecting different pathways for Europe's future food system. The PDTT group participated in the scenario and roadmap building processes. In addition, draft versions of the scenarios were enriched through stakeholder engagement across the agri-food ecosystem. Feedback highlighted priorities such as inclusiveness, climate-positive outcomes, and governance agility. Among the four, one scenario, Europe's Circular Protein Renaissance, emerged as the most desirable, offering a vision of systemic transformation through circular practices, innovation, and collaboration.

This report presents:

- The four scenarios and their defining characteristics.
- Stakeholder feedback and statistics of the survey study on draft scenarios.
- A transition roadmap for the preferred scenario, identifying critical leverage points, and actions needed to realize this future.

By providing these insights, the foresight equips EIT Food and its partners with a strategic framework to guide future work, foster collaboration, and shape EU agri-food policy—ensuring Europe's leadership in sustainable and resilient food systems.

Foresight process

The foresight process was designed to provide a structured, evidence-based approach for exploring plausible futures and guiding strategic decisions in Europe's protein diversification landscape. It combines systemic analysis, stakeholder engagement, and scenario development to anticipate long-term trends and identify critical leverage points for transformation.

Our process followed four key stages:

1. **Foundation and Context Setting**
Building on PDTT's prior analyses, policy briefs, and strategic recommendations, the scope and objectives of the study were defined. Background materials used are listed in Appendix 1.
2. **Scenario Development**
Using VTT's expertise and the **ScenAlrios tool**, we generated four distinct scenarios for Europe in 2050. These scenarios were further developed with data-driven insights and expert input collected during a PDTT workshop, ensuring robustness and credibility.
3. **Stakeholder Engagement**
Draft versions of the scenarios were presented to stakeholders in a survey study, asking them to rate the scenarios based on their relevance, probability and desirability. The participants were also asked to comment on the scenarios. Final versions of the scenarios were created benefiting from the stakeholder comments and PDTT expert input.
4. **Roadmap**
Stakeholder feedback guided the identification of the most desirable future and informed the creation of a transition roadmap with milestones for 2035 and 2050. PDTT experts participated in validating the roadmap and contributed to the final version of it.

VTT ScenAlrios tool

ScenAlrios is VTT's AI-powered scenario-building tool designed to make foresight processes faster, more systematic, and more transparent. It combines capabilities of large language models with machine learning algorithms and expert-driven inputs to generate diverse, credible future scenarios efficiently. By leveraging ScenAlrios, the foresight process becomes agile and data-driven, ensuring that strategic planning is grounded in robust evidence and future-oriented thinking. The different phases of the scenario-building process include:

1. Context definition: Providing the ScenAlrios tool with as precise information as possible about the context in which the scenarios are created
2. Morphological analysis
 - Identification and validation of uncertainty factors
 - Identification and validation of future states
3. Consistency analysis: Ensuring that the combinations of future states and variables being considered are coherent and internally compatible
4. AI- assisted selection of scenario combinations for narrative development
5. Preparation of scenario narratives

Figure 1 visualizes the ScenAlrios scenario building process with supporting AI algorithms.

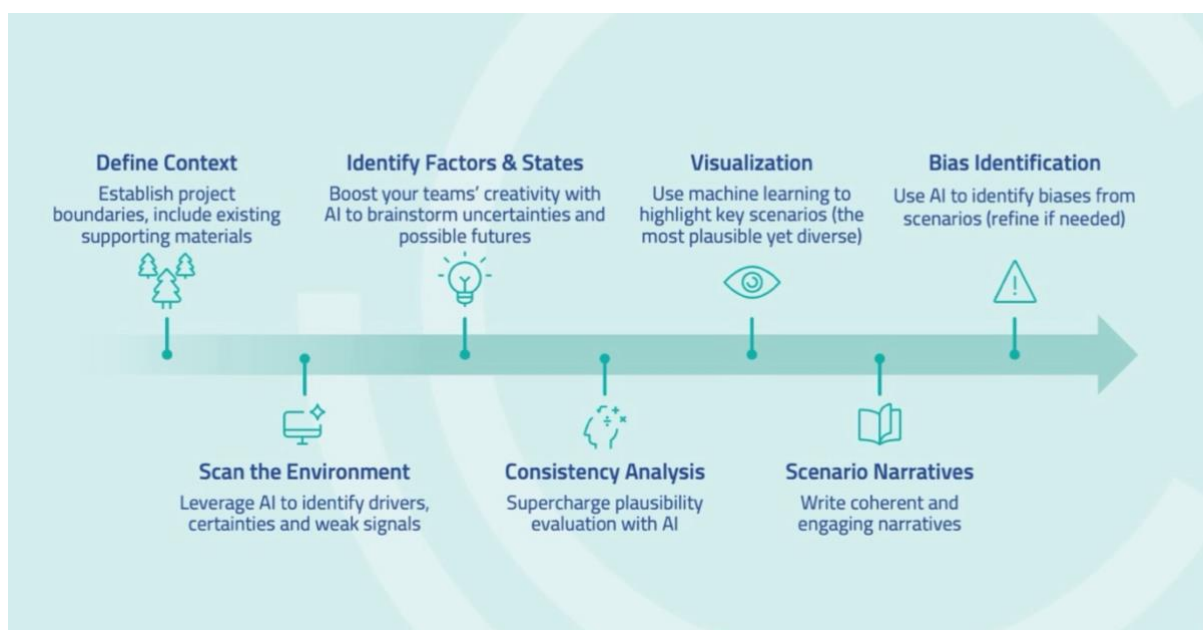


Figure 1. VTT ScenAIrios process for scenario building.

The four scenarios created were titled:

Scenario 1 Europe's uneven protein transition	Scenario 2 Europe's circular protein renaissance	Scenario 3 Europe's stalled protein transition	Scenario 4 Europe's food system reimagined
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Feedback collection

PDTT workshop

PDTT members were engaged in the foresight process by providing feedback on key uncertainties and potential future states shaping the scenarios. These uncertainties and states were initially generated by the ScenAIrios tool, which drew on four contrasting future orientations selected by PDTT members. This approach ensured that scenario development spanned a spectrum from conservative to bold, while incorporating two intermediate narratives. The insights and comments from PDTT members were used for refining the scenarios, ensuring they reflected diverse perspectives and strategic priorities.

Survey with draft scenarios

A stakeholder survey study was carried out with draft versions of the scenarios (Appendix 2) to collect feedback from the food value chain across Europe. The survey was launched at the EIT Food Next Bite event (October 15th to 16th, 2025) and continued until the project ended. In the survey, the participants commented on the relevance, probability and desirability of the four draft scenarios on the scale of 1 to 5. They were also given the possibility to comment on the scenario descriptions and give feedback if something essential was missing.

Results of the survey

The survey results were analysed at the point when the total number of respondents was 140. They represented 34 countries, from which 29 were European and five outside Europe. In the following analysis, only European countries are included (131 replies).

Research is the most represented sector, making up close to 40% of responses, followed by **Industry** representatives and **Other** than the defined sectors. **Public sector**, **NGO**, and **Primary sector** have smaller shares (Table 1). Only in the case of Research and Industry sectors is the number of respondents high enough for making a comparison of their replies. Unfortunately, a very low number of respondents from the Primary sector was received and hence, their responses could not be compared with Research and Industry at this stage.

Table 1. Number and share of respondents from different sectors.

Sector	Number of Responses	Proportion (%)
Research	48	36.6
Industry	29	22.2
Other	21	16.0
Public sector	13	9.9
NGO	12	9.2
Primary sector	8	6.1

The respondents represent evenly different parts of Europe as follows (Table 2):

Table 2. Number and share of respondents from different regions.

Region	Number of Responses	Proportion (%)
Northern Europe	33	25.2
Eastern Europe	30	22.9
Southern Europe	33	25.2
Western and Central Europe	35	26.7

Results from the stakeholder evaluation of the relevance, probability and desirability of the scenarios are presented in Figure 2. All scenarios were evaluated as relevant with scores ranging from 3.3 for Scenario 3 (Europe's stalled protein transition) to 4.1 for Scenario 2 (Europe's circular protein renaissance). Scenario 1 (Europe's uneven protein transition) is evaluated as the most probable, whereas Scenario 2 is seen as the most desirable of the possible futures presented by the scenarios.

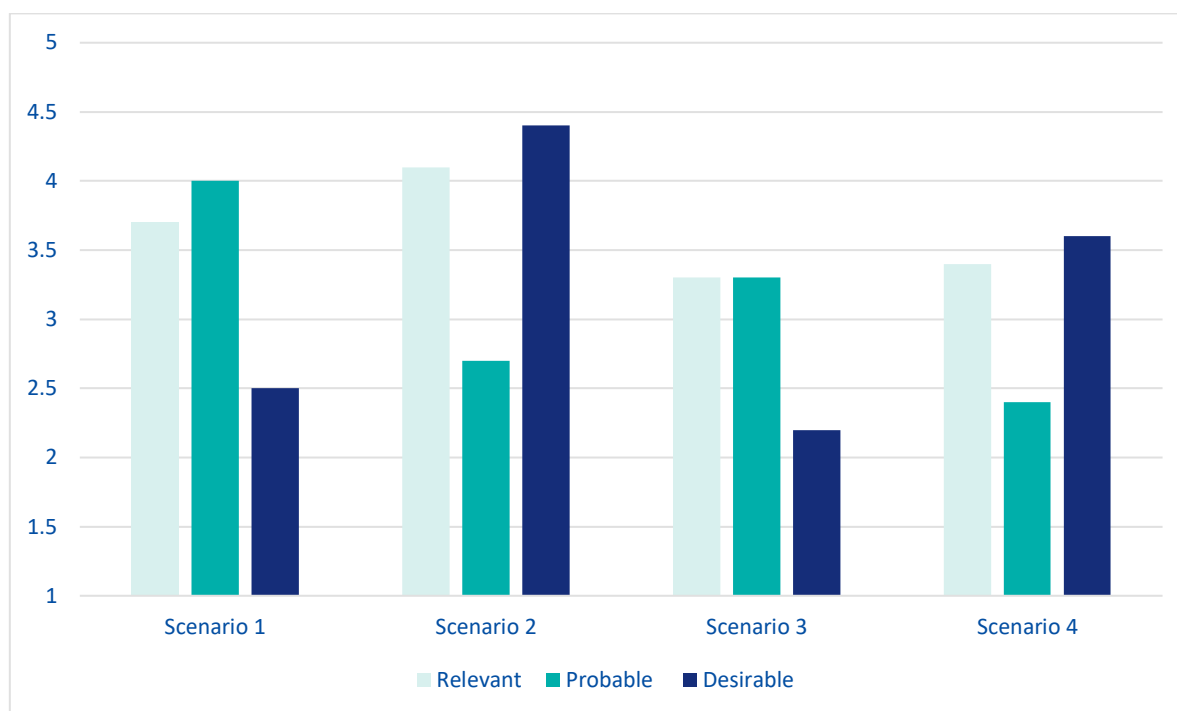


Figure 2. Survey results on the evaluation of relevance, probability and desirability of the scenarios. **Scenario 1** Europe’s uneven protein transition, **Scenario 2** Europe’s circular protein renaissance, **Scenario 3** Europe’s stalled protein transition and **Scenario 4** Europe’s food system reimagined.

Research sector respondents generally rated scenarios slightly higher in relevance and probability than the **Industry sector**. Both sectors found Scenario 2 the most desirable, giving it a score of 4.5. Scenario 3 was rated lowest in desirability by both sectors (2.2). Scenario 4 was seen as more relevant and desirable by Research than by Industry (3.5 vs 3.1 in relevance and 3.7 vs 3.3 in desirability).

Scenario 2 was consistently rated as the most relevant and desirable **across all regions**. Scenario 1 was generally seen as the most probable. Scenario 3 is the least desirable in all regions. The largest variance was in the rating of the relevance of Scenario 4. It was rated the highest in Western Europe (3.6) and the lowest in Southern Europe (2.9), Northern and Eastern Europe falling in between (3.4 and 3.2 respectively).

Comments on the scenarios were included in the finalization of the scenario narratives. The comments are summarized in Appendix 3.

Scenarios for protein diversification in Europe

Scenarios are structured narratives about possible futures, designed to explore how different trends, uncertainties, and decisions might shape long-term outcomes. They are not predictions; rather, they are analytical tools that help organizations prepare for multiple plausible futures. By considering diverse pathways, scenarios enable decision-makers to anticipate risks, identify opportunities, and stress-test strategies against a range of conditions.

In foresight work, scenarios serve several key purposes. They support strategic thinking by challenging assumptions and broadening perspectives beyond short-term planning. They enable informed decision-making by illustrating how complex drivers—such as technology, consumer behavior, and policy—interact over time.

They also facilitate dialogue and alignment among stakeholders by providing a shared framework for discussing future priorities and trade-offs.

In the following, the final versions of the four scenarios are presented. In each case, a general description is first given, after which a trajectory from 2025-2035 and 2036-2050 is presented. For all scenarios, there is also an imaginary day in the future narrative, with a visualization of it. After that, Table 3 presents a comparison of all four scenarios and Table 4 provides a comparison of the implications evaluated for those scenarios.

Figure 3 provides a two-dimensional overview of the main differences between the scenarios, based on two factors: consumer adaptation to novel proteins and the degree of protein diversification. Scenario 3 reflects low consumer adaptation and a low level of protein diversification, driven by strong scepticism among consumers and slow progress in biotechnology-based protein production. Scenario 1 achieves a higher degree of protein diversification, although this progress is unevenly distributed across Europe. Scenario 4 places strong emphasis on biotechnology-based protein production, resulting in high consumer adaptation to novel proteins. However, the decline in animal protein production leads to an overall low level of diversification. In contrast, Scenario 2 combines high consumer adaptation with a high degree of protein diversification, enabled by strong trust and transparency in the food system and a well-balanced mix of protein sources across Europe.

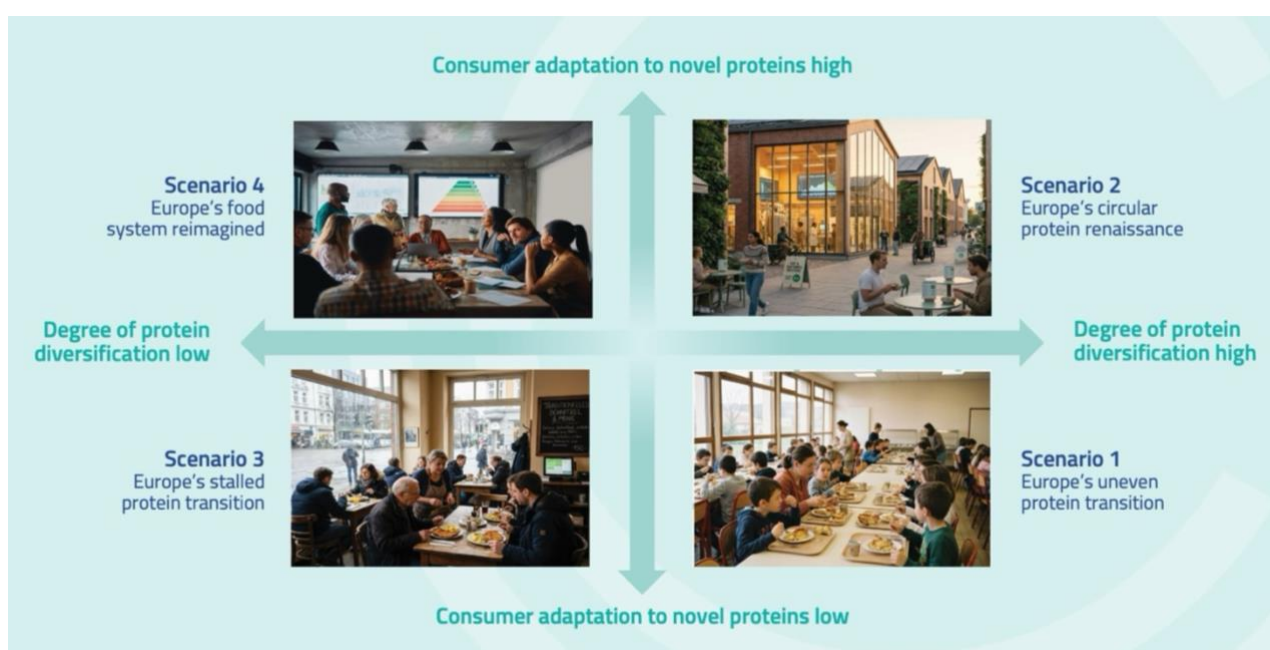


Figure 3. Scenarios mapped by consumer adaptation and protein diversification.

Scenario 1

Europe's uneven protein transition

Scenario description

By 2050, Europe's **shift toward sustainable protein sources is real but fragmented**. Europe's food system has advanced, but **progress is uneven and cautious**. Progress has come through **incremental steps** rather than comprehensive transformation, shaped by **regional diversity and cultural traditions**. Some areas lead with plant-based and blended products as well as with industrial innovation in advanced food biotechnology, while others remain anchored in traditional livestock and familiar diets, preserving culinary heritage. This unevenness creates vulnerabilities and raises concerns about food security in less advanced areas.

Climate-related disturbances remain a recurring challenge. Extreme weather events and acute resource shortages periodically strain supply chains, making resilience a priority. Europe responds to these drawbacks through regional food production, renewable energy integration, and improved waste recovery, but adaptation is gradual and costly. National emergency reserves help buffer crises, yet disparities persist between well-prepared and vulnerable regions.

Novel foods regulation has improved but remains uneven. A common European framework exists, yet national differences and slow administrative processes persist, despite corrective actions to speed approvals and support SMEs. Progress has been slow as the reforms have taken time to deliver impact. **European collaboration plays a stabilizing role**, including for example shared standards for carbon accounting, food safety, and resource allocation that prevent complete fragmentation. EU-level programs fund infrastructure upgrades and SME participation, but harmonization is slow, and conflicting national regulations still emerge. Agricultural policy nudges producers toward alternative crops and circular practices, but long-standing subsidies and trade protections keep conventional meat products competitive. Breeding of protein crops emerges as a strategic lever to enhance plant-based protein diversity, though adoption varies widely across regions due to resource constraints and cultural preferences. Public procurement introduces **gradual animal-based protein reduction targets**, influencing menus of public food services without radically changing consumer habits. Farmers adapt cautiously, exploring new business models for primary production, such as local protein crop cooperatives and value-added processing, but these remain niche and unevenly supported.

Industry reflects this patchwork. **Large corporations dominate with hybrid products** that mix meat and plant- or novel proteins, offering a compromise between sustainability and tradition. Smaller innovators survive through grants and niche markets, constrained by aging infrastructure and resource limitations. Water and energy shortages, coupled with uneven technical capacity, slow the spread of new technologies.

Consumers enjoy greater choice, but cultural attachments to animal-based diets remain strong. Hybrid foods are mainstream, while novel proteins are only occasional alternatives. Sustainability has improved, yet disparities between regions and social groups persist. Europe's **protein diversification has taken the shape of a complex patchwork**, that is woven from local initiatives, shaped by diverse regional governance, and marked by cautious adaptation.

Trajectory 2025 – 2035 – 2050

2025–2035: Incremental change under pressure

Europe enters a decade of cautious progress, framed by climate disruptions and geopolitical instability. Extreme weather events and resource shocks repeatedly expose vulnerabilities in food supply chains, reinforcing the urgency of resilience planning. In response, pilot programs begin to flourish: cooperative legume farms, small-scale cellular agriculture hubs, and circular economy initiatives emerge across regions, signaling early steps toward diversification. Early breeding programs for protein crops begin to surface, aiming to improve plant-based protein diversity and resilience, though uptake is uneven and resource-dependent.

EU-level collaboration strengthens, but only gradually. Common frameworks for carbon accounting and food safety start to take shape, yet national interpretations and administrative bottlenecks persist, slowing harmonization despite reforms aimed at accelerating approvals for new food ingredients, processes, and technologies. Public funding supports startups and research projects, helping them take root, though many struggle to scale commercially. Farmers experiment with new business models, but these remain niche. Large food groups seize the opportunity, acquiring promising innovations and consolidating market power.

Consumers encounter blended protein products in everyday life—not as futuristic novelties but as practical, affordable compromises. These products begin to normalize alternative proteins without radically changing eating habits. However, social divides become more visible: urban innovators embrace plant-based and hybrid foods enthusiastically, while rural communities cling to traditional diets, deepening cultural polarization and raising questions about inclusivity in the transition.

2036–2050: Consolidation and uneven adaptation

By the mid-2030s, Europe's protein transition accelerates modestly but remains fragmented. This tendency continues towards 2050. Plant-based and hybrid products gain steady market share, becoming familiar in retail and institutional settings, yet radical breakthroughs in technology or consumer habits are rare. Breeding innovations gradually improve crop performance and regional adaptability, but their impact is constrained by fragmented investment and slow knowledge transfer. Trade rules continue to protect European producers, slowing the entry of global innovations and reinforcing a cautious, inward-looking approach.

Climate adaptation measures—such as regional food production, investments in biotech-based protein facilities, and renewable energy integration—help reduce risks of food shortages but demand heavy capital outlays. These investments favor wealthier regions, leaving less-developed areas behind. Water constraints support some expansion of novel food technologies, but energy limitations restrict scaling, creating a two-speed food system: modernized regions thrive with advanced solutions, while others remain tied to conventional livestock and legacy infrastructure. Farmer-led initiatives expand in some regions, creating localized food networks, yet structural barriers and uneven support prevent widespread scaling.

Governance risks persist. Conflicting regulations and uneven technical capacity hinder cohesion, while corporate dominance grows in critical supply chains, concentrating influence among a few large players. Cultural attachment to meat remains strong, reinforcing regional identity and slowing behavioral change despite policy nudges and sustainability campaigns.

By 2050, Europe's protein diversification is greener and more diverse—but stitched together unevenly, a patchwork of success stories and missed opportunities. Progress is real, yet the lack of systemic integration leaves vulnerabilities and deepens disparities across regions and social groups.

A day in the future – 2050

In a mid-sized factory outside Lyon, a production line mixes pea protein and chicken mince into blended burgers. The plant is a renewed meat-processing facility — modernized but still dependent on legacy equipment that occasionally halts production due to part shortages. Each package carries a regional sustainability label, recognized in some EU countries but not all. The company competes against multinational brands that dominate supermarket shelves with their global supply chains and marketing.

Across town, in a public-school lunchroom, children eat a plant–meat casserole — the new norm in institutional catering. The meal reflects years of incremental policy change: small climate-based procurement rules, local sourcing contracts, and public messaging about balanced diets.



Figure 4. Visualization of the day in the future in Scenario 1, Europe's uneven protein transition.

Beyond the city, the rolling hills of rural Lyon show a patchwork of adaptation. Fields of wheat and maize share space with legumes like peas and lentils, encouraged by modest policy incentives. Farmhouses have solar panels and water recycling units, but upgrades are uneven. Farmers' markets still offer regional cheeses and meat alongside hybrid protein products, preserving cultural pride even as climate stress forces to use drought-resistant crops and cooperatives to have storage for emergencies. Rural communities value heritage and resist rapid change, while urban areas embrace innovation causing a social divide in Europe's uneven protein transition.

Policy Implications

- **Governance and regulatory agility remain limited:** National differences in regulation and slow harmonization continue to undermine the effectiveness of EU-level frameworks. Approval processes for novel foods and technologies are still slow, and SMEs face persistent challenges in navigating regulatory pathways.
- **Resilience and equity are unevenly addressed:** Policies responding to climate-related disruptions and resource shortages vary across regions. While some areas prioritize regional food security and adaptive infrastructure, disparities persist, with targeted funding and capacity-building programs not yet closing the gaps between advanced and lagging regions.
- **Tradition and transformation are in tension:** Agricultural policy continues to balance cultural heritage with sustainability goals, but the shift of subsidies from conventional livestock toward alternative crops and circular practices is gradual, reflecting ongoing negotiation between tradition and innovation. Additional emphasis is needed on breeding programs for protein crops to strengthen plant-based diversity and resilience, supported by targeted incentives and research funding.

Business Implications

- **Large corporations dominate a fragmented market:** Incremental change and regulatory complexity favour major players who can absorb costs and acquire innovations, resulting in increased market concentration and reduced diversity. SMEs face structural barriers and resource constraints, limiting their ability to compete and innovate.
- **Hybrid products have become mainstream:** The market has stabilized around blended solutions combining meat and plant-based or novel proteins. This mainstreaming limits radical innovation and niche breakthroughs, as consumer preferences and regulatory landscapes vary widely across regions.
- **Supply chain vulnerabilities and uneven resilience persist:** Climate shocks and resource shortages continue to increase operational risks. Investments in resilience, renewable energy, and waste recovery are essential, but adaptation remains uneven across regions and company sizes. Farmers explore new business models, but these remain niche and require strong financial and technical support to scale.

Societal Implications

- **Cultural polarization and slow behavioral change persist:** Strong attachment to meat continues to create divides between urban innovators and rural communities, resulting in gradual shifts toward sustainable diets and limited adoption of novel proteins.
- **Access to innovation and sustainability gains remain uneven:** Novel proteins are still occasional alternatives, with affordability and availability varying across regions and social groups. Environmental improvements are occurring, but they fall short of transformative impact, leaving Europe vulnerable to global shocks and resource constraints.
- **Fragmentation complicates collective action:** Expanding consumer choice has not led to systemic change, as habits evolve slowly and stronger incentives are needed. Shared vision challenges persist, making stakeholder collaboration more important than ever. Greater engagement of farmers in the transition narrative is essential to build trust and ensure inclusiveness, particularly in regions where traditional practices dominate.

Scenario 2

Europe's circular protein renaissance

Scenario description

By 2050, Europe has transformed its food system through **agility, cooperation, and smart incentives**. What began as fragmented experiments has evolved into a **coherent strategy built on flexibility, transparency, and shared accountability among regulators, industry, and citizens**. Governance adapts dynamically as technologies advance, using **conditional approvals and real-time data** to ensure safety and sustainability of the food system without suppressing innovation.

Protein diversity is central to this transformation. Animal, plant, and biotech-based proteins coexist in a balanced ecosystem. Breeding of protein crops as well as agritech developments play a key role in improving the diversity and resilience of plant-based protein sources, ensuring adaptability to regional conditions and consumer needs. Traditional livestock practices persist in culturally significant regions, complemented by plant-based blends and breakthroughs in cellular agriculture. Modular manufacturing and distributed processing hubs link cities and rural areas, converting side streams and residues into new protein sources and reinforcing local resilience.

Renewable energy and resource efficiency underpin the system. Improved side stream and waste treatment technologies and renewable energy integration minimize environmental impact, while **circular principles** turn left over biomasses and waste into resources and close nutrient and energy loops. Economic incentives reward these practices, ensuring that sustainability is not just aspirational but operational.

Consumer behavior evolves through experience, not persuasion. Familiarization with new products happens via sensory engagement, by incorporating them into menus in schools, company canteens, and community programs. Personalization of food through adapting products to individual health needs, cultural preferences, and convenience factors drives adoption. **Sustainability becomes a normal part of life** because it feels practical and personal, not ideological.

Socio-economic shifts support **inclusiveness**. Policies and programs address affordability, regional investment gaps, and workforce transitions, ensuring that implementation of innovations does not deepen inequalities. Farmers are active partners in this evolving food system, supported by new business models for primary production that reward innovation, sustainability, and collaboration across the value chain. Intellectual property protection is balanced with open data to foster trust and collaboration without suppressing creativity.

The result is balanced: diversified diets, resilient multifaceted production networks, and widespread public trust. Europe's protein transition is not just sustainable but collaborative — each part of the system reinforcing the others. Markets operate on circular principles, governance of the European food system evolves through feedback and transparency, and technology remains accessible rather than exclusive. Europe's competitive edge now rests on **cooperation, circularity, and trust**.

Trajectory 2025 – 2035 – 2050

2025–2035: From experimentation to integrated transition

During this decade, Europe shifts from fragmented pilots to a coordinated transition. Geopolitical instability in the late 2020s, marked by trade tensions and supply chain disruptions, exposes Europe's vulnerability, accelerating efforts to localize production and reduce import dependency. This urgency strengthens EU cooperation and drives investment in distributed processing hubs and regional food systems, laying the foundation for food sovereignty.

Governance becomes adaptive and transparent: conditional licensing replaces rigid approvals, and real-time monitoring makes environmental and safety data accessible to all stakeholders. This fosters trust and accelerates collaboration among regulators, industry, and citizens. Innovation is increasingly viewed as a strategic asset for resilience.

Protein diversity begins to take root. Retailers and institutional kitchens introduce blended products combining animal, plant, and biotech-based proteins. Schools and company canteens lead adoption through experience rather than persuasion, normalizing alternatives while respecting traditions. Personalization emerges as a key driver, with products tailored to health needs, cultural preferences, and convenience. Breeding programs for protein crops start to scale, supported by EU research and regional initiatives, improving plant-based diversity and resilience. Farmers begin experimenting with new business models, though these remain in early stages.

Climate change and extreme weather and resource shocks in the early 2030s strain agriculture, making resilience planning essential. Circular principles gain traction as public programs reward companies converting side streams to food, reclaiming water, and integrating renewable energy. Workforce reskilling and regional investment funds address socio-economic gaps, ensuring innovation does not deepen inequalities. By 2035, Europe has laid the foundations of an inclusive, adaptive food system resilient to geopolitical and climate risks.

2036–2050: Scaling the complementary system

From 2036 onward, the transition accelerates into a complementary food ecosystem shaped by lessons from earlier crises. Distributed processing hubs connect urban and rural regions, converting side streams into new protein sources and strengthening local resilience. Circularity becomes the norm, with systems designed for efficiency and robustness against climate and geopolitical shocks.

Breakthroughs in cellular agriculture and advanced treatment technologies cut energy use and costs, making biotech-based proteins widely accessible. These innovations are vital as climate change pressures resources, driving Europe toward low-energy, water-saving solutions. Breeding and agritech innovations deliver high-performing protein crops adapted to diverse European conditions, reinforcing plant-based protein diversity. Farmers evolve into strategic partners in distributed production networks, leveraging new business models integrated with circular systems and modular processing hubs.

Consumer behavior evolves as sustainability becomes effortless. Products are familiar, affordable, and personalized, blending innovation with culinary traditions. Hybrid recipes and regional adaptations preserve cultural heritage. Governance adapts dynamically, using open data for traceability while balancing IP protection with collaboration. Inclusive policies prevent "protein inequality," and circular business models create jobs in resource recovery and distributed manufacturing.

By 2050, Europe's food system operates as a resilient, cooperative network built on circularity, transparency, and trust. The protein transition is not just sustainable but complementary—each part reinforcing the others. Challenges remain, such as balancing innovation with tradition and ensuring equitable access, but progress and well-being are achievable when collaboration and balance guide decisions, even amid climate volatility and geopolitical uncertainty.

A day in the future

The sun rises over Helsinki, casting soft light on a former logistics warehouse that now hums with quiet efficiency. Inside, stainless-steel bioreactors and modular processing units convert yesterday's food scraps and agricultural side streams into protein powders, cultured seafood, and flavor enhancers. The facility runs on renewable energy and reclaimed water, and its systems are optimized to minimize energy input and environmental impact. It's not a corporate giant but a cooperative hub, shared by local SMEs and farmers who once feared being left behind.

Every process is transparent. Emissions, water use, and nutrient recovery data flow automatically to an open platform accessible to regulators, suppliers, and citizens. Trust isn't an abstract concept — it's visible in real time. Across the city, cafés and canteens display menus featuring oat-based products, hybrid protein wraps blending different proteins, and fermenter cultivated fish fillets. Each item carries a verified climate and nutrition score, making sustainability as easy to read as a price tag.

For consumers, these choices feel familiar, not futuristic. Years of recipe innovation, from reimagined traditional dishes to entirely new creations, have made diverse textures and flavors a natural part of everyday meals, experienced simply as food rather than defined by their protein source. Personalization is the norm: apps suggest meals tailored to health goals, cultural preferences, and convenience.

Outside, delivery bikes glide past vertical gardens and solar arrays, reminders of how climate volatility and geopolitical shocks in the 2020s reshaped priorities. What began as scattered policy pilots and crisis-driven adaptations has matured into a resilient and circular food economy.



Figure 5. Visualization of the day in the future in Scenario 2, Europe's circular protein renaissance.

Policy Implications

- **Adaptive and transparent governance for food systems:** Regulatory systems evolve from rigid approval processes to dynamic, data-driven oversight, incorporating a conditional approval process and real-time monitoring. This shift is complemented by open data platforms for food safety, environmental impact, and supply chain traceability, ensuring that innovation is balanced with safety and public trust.
- **Embedding circularity and inclusiveness in food system policies:** Circular economy principles become embedded in legislation, with incentives for resource recovery, renewable energy integration, and waste-to-value systems. At the same time, policies prioritize inclusive transition strategies, addressing affordability and regional investment gaps while supporting workforce reskilling programs to prevent socio-economic disparities. Additional emphasis is placed on breeding programs and agritech for protein crops as a strategic lever for resilience and diversity, supported by targeted funding and knowledge-sharing initiatives.
- **Innovation frameworks balancing IP and collaboration:** Future policy frameworks strike a balance between intellectual property protection and open innovation, fostering creativity and competitiveness while maintaining fairness and accessibility. This approach encourages collaboration across industry, academia, and civil society without compromising innovation incentives.

Business Implications

- **Circularity as a strategic imperative:** Companies that embed circular business models—such as resource recovery, side-stream utilization, and renewable energy integration—will gain competitive advantage. This approach not only ensures compliance with tightening sustainability regulations but also reduces costs and creates new revenue streams from waste valorization.
- **Ecosystem collaboration accelerates innovation:** The shift from competition to collaboration will redefine industry dynamics. Partnerships among corporations, SMEs, and public actors under shared accountability frameworks will enable faster innovation cycles, reduce market fragmentation, and unlock access to complementary capabilities and resources. Farmers emerge as active partners in these ecosystems, creating opportunities for value-added production and regional resilience.
- **Distributed, data-driven personalization:** Combining modular production systems with advanced analytics will allow businesses to deliver personalized food solutions at scale. Decentralized hubs increase resilience against global disruptions, while personalization based on health, cultural, and convenience factors becomes a key differentiator in consumer markets.

Societal implications

- **Sustainability embedded in daily life:** Sustainable practices become normalized through convenience and personalization. Circularity and resource efficiency are perceived as lifestyle enhancements rather than restrictions, supported by practical exposure in schools, workplaces, and communities.
- **Inclusive and culturally adaptive food systems:** Equity-driven policies ensure affordability and regional balance in access to novel proteins, while traditional culinary practices coexist with innovations. This cultural continuity reduces resistance and fosters broad acceptance across diverse populations. Farmer engagement in the transition narrative strengthens trust and inclusiveness.
- **Trust through transparency and participation:** Open data and participatory governance strengthen public confidence in food safety, environmental performance, and fairness. Transparency becomes a cornerstone for societal trust in evolving food systems.

Scenario 3:

Europe's stalled protein transition

Scenario description

By 2050, Europe's protein transition has **advanced in technology but stalled in spirit**. Development that began as a pursuit of safety and control to achieve stability ultimately came at the expense of diversity, flexibility, and trust. Faced with geopolitical shocks, climate volatility, and food security concerns in the late 2020s, policymakers chose an uncompromising path to protect citizens with **tight regulation and strict defense of domestic production**. These choices created a situation where **stringent safety rules, centralized decision-making, and defensive trade barriers dominate**.

The result is a food system that prizes **caution above all else**. Licensing and documentation requirements are exhaustive, ensuring world-leading safety standards but imposing slow, costly approval cycles for food ingredients, processes and technologies that only large corporations can navigate. Regulation is essential for attracting private investment, but because the rules are so strict and inflexible, smaller innovators are unable to participate. **Clustered investments dominate** the landscape, concentrating capital and technical capacity in a few industrial corridors while leaving other regions behind. **Conflicting governance approaches across EU member states and uneven technical capacity deepen fragmentation**.

Protein diversity exists on paper but not in practice. Industrial clusters produce vast quantities of biotech-based proteins, alongside limited plant-based options, primarily for institutional markets such as hospitals and schools. Breeding programs for protein crops remain underdeveloped, constrained by lack of funding, thus **limiting progress in plant-based diversity**. Farmers are largely excluded from innovation ecosystems, operating under strict compliance regimes that prioritize carbon caps over entrepreneurial flexibility. Attempts to introduce **new business models for primary production are rare**, leaving little room for adaptation.

Retrofitted breweries and sugar plants achieve impressive resource efficiency, sharing energy and water through interconnected networks. Yet outside these hubs, traditional animal farming persists under strict carbon caps, and **consumer skepticism towards novel food ingredients remains strong**. Cultural attachment to meat endures, and the cost of transition to alternative protein sources for households is a critical barrier. Dietary guidelines have changed, but they remain poorly understood and fail to build trust. **Behavioral change advances very slowly**, and old habits continue to outweigh sustainability in everyday choices.

Public narratives are fractured. Conflicting messages in the media fuel confusion and polarization, leaving consumers uncertain about what is safe, sustainable, or affordable. Incentives for adoption of sustainable choices in major retail chains and catering services exist but are uneven, and national policies often fail to align with institutional procurement strategies. Meanwhile, Europe's inward focus has made it less competitive on the global stage. Non-EU oligopolies, particularly from the US and China, increasingly define standards and dominate emerging markets, **leaving Europe secure but strategically behind**.

Europe has achieved control over the food system and possesses technical competence, but not openness or renewal. Consumers enjoy safety and consistency but lack variety and choice. People's trust in institutions is divided. While some appreciate the accuracy and efficiency these organizations offer, others feel frustrated by the complicated and rigid bureaucracy. **The food system is stable, yet fragile; efficient, yet uninspired**. It can withstand shocks but does not adapt quickly. Europe has achieved stability through strict rules and financial support, but this has come at the expense of innovation and imagination.

Trajectory 2025 – 2035 – 2050

2025–2035: Building the fortress

In the late 2020s, a series of global health crises and geopolitical disruptions push Europe toward an uncompromising stance on food security. Policymakers respond to the crises by prioritizing safety and public reassurance over flexibility, introducing stringent regulations that make approval processes for novel food ingredients long, costly, and highly complex. These measures succeed in restoring confidence and stabilizing markets, but they create barriers that only large corporations can navigate. Smaller innovators either disappear or are absorbed by major players, narrowing the competitive landscape and reducing diversity in innovation.

Public funding and private finance converge to drive large-scale industrial conversions, repurposing breweries, sugar plants, and food factories into standardized biotechnology-based protein hubs. These facilities achieve impressive resource efficiency through shared energy and water systems, showcasing technical competence. However, the focus remains firmly on risk minimization rather than creativity or regional experimentation. Early optimism about a vibrant, diverse alternative-protein sector fades as consolidation accelerates and mergers dominate the industry. Breeding programs for protein crops are discussed but remain marginal, constrained by lack of prioritization and funding. Farmers operate under strict compliance regimes, leaving little room for entrepreneurial flexibility or new business models.

By 2035, Europe has built a food system fortified by rigid rules—technically advanced and resilient against shocks yet increasingly closed to flexibility and diversity. While safety and efficiency are guaranteed, the system sacrifices openness and innovation, setting the stage for a plateau in progress.

2036–2050: Efficiency over diversity

By the 2040s, Europe's protein economy has become highly centralized, with most production concentrated in a few industrial hubs and new developments proceeding cautiously. Cellular agriculture reaches cost parity with conventional meat and dairy, yet adoption remains largely confined to institutional markets such as hospitals, schools, and urban catering services. For everyday consumers, cultural attachment to traditional foods persists, and skepticism toward industrial processes continues to limit demand for alternatives despite their availability.

Trade restrictions and rigid sustainability rules shield domestic producers from global competition, ensuring stability but raising consumer prices and isolating Europe from external innovations. Attempts at reform, such as patent-sharing initiatives and proposals to decentralize regulation, emerge late and struggle against entrenched interests and bureaucratic inertia. These efforts fail to reverse the trend toward consolidation and rigidity. Breeding innovations remain underdeveloped, as centralized investments favour biotech hubs over crop diversity. Farmers remain largely excluded from innovation ecosystems.

By 2050, Europe's food system delivers safety, consistency, and resilience against shocks, but at the cost of adaptability and diversity. Progress has slowed, innovation is constrained, and consumer trust remains conditional. The continent stands on a secure plateau: efficient and technically competent, yet uninspired, as a system that can withstand crises but lacks the flexibility and imagination needed for renewal.

A day in the future

The sky hangs low over the port city of Hamburg, where a converted brewery hums with quiet precision. Inside, rows of stainless-steel tanks bubble steadily, monitored by screens displaying real-time data on energy use and emissions. Figures that regulators carefully review to grant or renew production licenses. Every process is optimized: waste heat warms nearby greenhouses, wastewater is purified and reused, and every gram of protein output is logged in digital records for compliance audits.

This facility supplies biotech-based protein ingredients to hospitals and schools across northern Europe. Ownership rests with a multinational food consortium, sponsored by cautious institutional investors who favor predictability over risk. The atmosphere is clinical, efficient, and tightly controlled — a fortress of food security.

A few blocks away, life feels different. In a family café, the scent of a traditional schnitzel fills the air, attracting a steady group of regular lunchtime customers. When asked about the new “biotech proteins,” the owner shrugs: *“People still want what they trust.”* Beyond the city, livestock farms operate under strict carbon caps, struggling to remain viable and frustrated that participation in the new protein economy remains out of reach.



Figure 6. Visualization of the day in the future in Scenario 3, Europe’s stalled protein transition. Hamburg reflects the essence of Europe’s fortified plateau: a system that delivers safety and technical competence but leaves diversity, flexibility, and imagination behind.

Policy Implications

- **Regulatory rigidity creates systemic slowdown:** Strict safety rules and centralized decision-making safeguard stability but slow down approvals and discourage experimentation. This rigidity limits innovation and delays market entry for novel solutions.
- **Fragmented governance undermines cohesion:** Conflicting national interpretations and uneven technical capacity increase fragmentation, weakening EU-level alignment and reducing the effectiveness of collective strategies.
- **Protectionism and unequal investment threaten competitiveness:** Defensive trade barriers isolate Europe from global innovations, while concentrated investment in industrial hubs worsens regional disparities. Corrective policies are needed to ensure equity and maintain strategic positioning. Policies fail to support funding for protein crop breeding. Farmer-led initiatives or local processing models receive little support, thus reinforcing dependence on centralized industrial clusters.

Business Implications

- **Market consolidation reduces diversity:** Regulatory complexity and high compliance costs favor large corporations, accelerating oligopolistic structures. SMEs either disappear or are absorbed, narrowing the innovation pipeline and limiting disruptive breakthroughs. Farmers remain locked into compliance-driven systems, with little opportunity to adopt new business models or participate in value-added production.
- **Institutional dominance restricts consumer adoption:** Alternative proteins remain confined to institutional markets such as hospitals, schools, and catering services. Mainstream retail adoption stagnates, slowing the transition toward sustainable diets.
- **Efficiency over bold innovation weakens global position:** Industrial clusters prioritize resource efficiency and risk minimization over creativity, while non-EU corporations dominate emerging markets and set global standards. Europe remains secure but strategically marginalized. Crop breeding and regional diversification are neglected, leaving Europe vulnerable to supply shocks.

Societal Implications

- **Persistent skepticism slows change:** Cultural attachment to meat and distrust of industrial processes hinder adoption of alternative proteins, even when safety standards are high. Behavioral change remains incremental rather than transformative.
- **Limited accessibility reinforces traditional diets:** Protein diversity exists in theory, but alternative options remain costly or inaccessible. Everyday diets stay traditional, and convenience continues to outweigh sustainability in consumer choices. Farmers' exclusion from innovation ecosystems deepens rural-urban divides, reducing trust and inclusiveness in the transition.
- **Social frustration undermines cohesion:** Rigid food systems create tension. While some citizens value stability, others dislike the lack of flexibility and innovation. This divergence weakens societal consensus around food policy.

Scenario 4

Europe's food system reimagined

Scenario description

By 2050, Europe's food system combines **advanced technology with modernized farming** and **strong community collaboration**. Protein is widely produced in automated bioreactors powered by renewable energy, but agriculture remains essential being reimagined as part of a highly circular network. Farms supply feedstock for cell factories while producing food for people as every side stream is captured and reused. Plant proteins complement biotechnology-based and synthetic protein sources, ensuring diversity and resilience. Breeding of protein crops plays a critical role in ensuring plant-based diversity and resilience, supporting both human nutrition and feedstock needs for bioreactors. This integration minimizes waste and strengthens local autonomy.

Animal farming persists for biodiversity and cultural reasons, but **meat has become a rare, premium product**, enjoyed mainly on special occasions. Crop production is carefully planned to balance human nutrition and feedstock needs of cell factories and small animal farms, ensuring that local loops remain efficient and sustainable. Energy demand is significant, so renewable sources and advanced side stream and waste treatment technologies are critical to keep the system climate positive.

Trade operates through carbon-accountable "green corridors", and citizens manage **personal carbon budgets with dynamic pricing that rewards environmentally low-impact choices**. **Communities co-own local cell factory hubs** through municipal bonds and cooperatives, reinforcing inclusivity and trust. **Farmers are active partners in this ecosystem, adopting new business models** such as feedstock cooperatives, local breeding ventures, and shared ownership of bioreactor hubs, creating value-added opportunities and strengthening rural economies. Advanced regional facilities synthesize critical inputs like ammonia and methanol, reducing reliance on global suppliers. However, resource planning remains vital. Europe cannot take availability for granted, and governance must ensure fair allocation of food, chemical and other material inputs.

The **market landscape is mixed**: large players provide stability and scale, while local ecosystems foster start-ups and innovation. This balance requires harmonized governance to avoid conflicting regulations and uneven technical capacity across regions. **Participatory decision-making and SME support** are crucial safeguards for the system.

For consumers, taste remains the ultimate driver in food. Technology delivers appealing flavors and textures, while digital platforms personalize nutrition. Dietary recommendations integrate sleep, mood, budget, and lifestyle data, offering real-time recipe guidance and nudges that connect well-being with sustainability. Food choices are shaped not only by carbon budgets but by emotional and health insights, making **eating both climate-conscious and personally meaningful**.

Europe's **food economy is abundant, transparent, and climate-resilient**, having still a balancing act e.g. in technological efficiency versus cultural diversity, automation versus human connection. Success depends on resource stewardship, inclusive governance, and innovation that respects Europe's cultural diversity and social values.

Trajectory 2025 – 2035 – 2050

2025–2035: Foundations in a time of instability

The late 2020s bring geopolitical turbulence: trade disputes, energy shocks, and regional conflicts disrupt supply chains and accelerate Europe's push for food sovereignty. Climate change continues to stress traditional agriculture, but the transforming food system begins to reverse emissions trends: early adoption of circular farming and cell factory hubs reduces land use and greenhouse gas output, cutting agricultural emissions significantly.

Digital traceability becomes mandatory, enabling real-time oversight of safety and carbon footprints of food ingredients. Circular farming gains traction as farms partner with cell factories to supply side streams as feedstock. Breeding programs for protein crops emerge as a priority, supported by EU research and regional initiatives, to ensure plant-based diversity and resilience for both human diets and bioreactor feedstock. Farmers begin adopting new business models, such as feedstock cooperatives and shared ownership of local hubs, creating early examples of integrated rural innovation.

Energy integration becomes critical: renewable power and advanced side stream and waste treatment technologies support feedstock synthesis and nutrient recovery. Governance focuses on harmonization of different European regions to prevent fragmented regulations and uneven technical capacity for biotechnology-based protein production.

As the farming population ages and fewer people are interested in traditional agriculture, the adoption of new technologies in farming speeds up. Modernized, tech-enabled farming and circular systems attract a new generation, offering roles that implement sustainability, data-driven management, and entrepreneurship. Personalized nutrition platforms emerge, linking carbon budgets with health, mood, and lifestyle data. Developing new and appealing flavours and taste helps consumers accept and adopt new food products.

2036–2050: Deep integration and climate impact

By the mid-2030s, Europe enters a phase of system-level integration. Automated cell factory hubs and modern farms form a resilient network, co-owned by communities and supported by municipal bonds. Energy systems and food production operate as one, ensuring renewable supply for bioreactors and feedstock generation. Breeding innovations deliver high-performing protein crops adapted to diverse conditions, reinforcing plant-based diversity and reducing reliance on imports. Farmers evolve into strategic partners in circular ecosystems, managing feedstock flows, co-owning bioreactor hubs, and driving local resource loops.

The food system becomes a climate solution: emissions from agriculture drop dramatically, land is freed for biodiversity, and carbon-negative processes scale. Markets balance fragmentation for innovation with consolidation for resilience. Governance evolves to harmonize standards and build technical capacity across regions.

Consumers experience food as personalized and climate-conscious: taste remains key, supported by real-time recipe guidance and digital nudges that connect well-being, carbon budgets, and lifestyle. Integrating sleep and mood data into dietary recommendations becomes common, making eating both sustainable and emotionally attuned.

Europe achieves abundance and climate resilience—but success depends on continuous resource stewardship, inclusive governance, and innovation that respects cultural diversity and social license.

A Day in the Future – 2050

In a neighborhood kitchen in Barcelona, a family checks their weekly carbon and nutrition dashboard. They've reached 75% of their carbon allowance, and the app suggests a recipe for a Mediterranean lentil stew featuring local plant proteins and microbial-based nutritious side dish. The recommendation isn't just about sustainability. It's tailored to their sleep patterns and mood data, aiming to boost energy for the day ahead. A quick tap orders the missing ingredients; all sourced from nearby farms and cell factory hubs.



Figure 7. Visualization of the day in the future in Scenario 4, Europe's food system reimagined.

Outside the city, modular cellular agriculture units line the coast, powered by wind and tidal energy. Some are mobile, shifting seasonally to capture renewable surpluses. These hubs work in tandem with circular farms inland, which grow crops for both human consumption and feedstock for cell factories. Every side stream, from crop residues to nutrient-rich wastewater, is recovered and reused, closing the loop.

In a rural town, a cooperative of citizens and municipal workers meets to review open data from their community-owned bioreactor. They check nutrient yields, energy efficiency, and feedback from local households. Pride runs high: their system not only produces protein but also supports regional biodiversity and cultural food traditions. Meat remains available, although expensive and reserved for special occasions, keeping culinary heritage alive.

Europe's food system feels abundant and connected. Technology hums quietly in the background, enabling transparency and personalization, while governance and community engagement ensure fairness and resilience. Eating is no longer just about sustenance, it's about taste, well-being, and shared responsibility.

Policy Implications

- **Integrated governance for circular food systems:** Harmonized EU frameworks align regulations across regions, embedding circular principles like resource recovery and renewable energy integration to ensure sustainability and resilience. This approach supports both environmental sustainability and operational resilience.
- **Carbon accountability and inclusive ownership:** Policies enforce personal carbon budgets and green trade corridors, supported by transparent reporting. Community co-ownership of cell factory hubs via municipal bonds and cooperatives builds trust, equity, and local engagement in sustainable protein production.
- **Resource stewardship and participatory decision-making:** Oversight of feedstock, energy and chemical inputs ensures fair allocation and resilience. Collaborative governance balances efficiency with cultural diversity, empowering stakeholders in shaping Europe's food system. Agricultural policy explicitly supports breeding programs for protein crops to secure plant-based diversity and resilience, linking these efforts to circular feedstock strategies for bioreactors. Incentives encourage farmer participation in cooperative ownership and integrated production models.

Business Implications

- **Resilient and adaptive market structures:** Europe's food system is shaped by a dual market structure, where large corporations provide scale, stability, and reliability, while local foster start-ups and innovation. This dynamic environment requires businesses to adopt flexible strategies that can respond to both global supply chain challenges and local opportunities for growth.
- **Climate-positive and circular business models:** Companies gain a competitive edge by investing in circular and carbon-negative practices, such as resource recovery, renewable energy integration, and waste-to-value systems, helping to meet climate targets but also to create new revenue streams. Distributed local production networks strengthen regional resilience and reduce dependency on global supply chains. Farmers become strategic partners in these networks, creating value-added opportunities and strengthening rural economies.
- **Digitalization, personalization, and consumer-centric innovation:** Growth in the sector is increasingly driven by digital nutrition platforms that leverage health, mood, and lifestyle data to create personalized food solutions. Businesses prioritize sensory appeal and cultural adaptation to accelerate consumer acceptance of novel protein products.

Societal Implications

- **Climate-conscious eating and everyday sustainability:** Citizens increasingly experience food choices as part of personal carbon budgeting and broader sustainability goals, making climate-conscious eating a normalized and integral aspect of daily life.
- **Inclusive communities and trust in the food system:** Community co-ownership of production hubs and participatory governance models strengthen social cohesion, build public confidence, and ensure that diverse voices are represented in shaping the future of food. Farmer engagement in innovation ecosystems reinforces rural inclusion and trust, bridging the gap between advanced technology and traditional practices.

- **Personalized, culturally rooted, and equitable nutrition:** Digital platforms integrate health, emotional well-being, and sustainability into everyday food decisions, making eating more meaningful. Traditional culinary practices coexist with advanced protein technologies, fostering inclusivity and reducing resistance to change. Policies and cooperative models safeguard equity and accessibility, ensuring affordability and fair access to innovations across regions and social groups.

Table 3. Comparison of the scenarios.

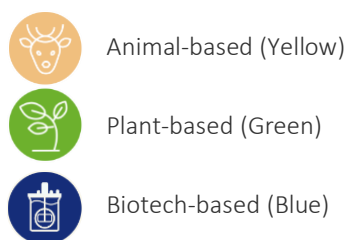
Dimension/ Scenario	1 Europe's uneven protein transition	2 Europe's circular protein renaissance	3 Europe's stalled protein transition	4 Europe's food system reimagined
Tone	Cautious, pragmatic, uneven progress	Optimistic, collaborative, balanced	Controlled, rigid, somewhat pessimistic	Ambitious, innovative, community-driven
Governance Model	Mixed: EU framework with slow harmonization; national differences persist	Adaptive, participatory, data- driven; conditional approvals	Centralized, top-down, highly regulated	Harmonized but participatory; strong regional autonomy
Policy Direction	Incremental reforms; subsidies shift slowly; procurement nudges	Incentives for circularity, inclusivity, and open data	Defensive: strict safety rules, trade protectionism	Carbon-accountable trade, resource stewardship, SME support
Technological Landscape	Hybrid: plant-based blends, some biotech; uneven adoption	Diverse: cellular agriculture, modular hubs, plant and animal	Narrow: some biotech; retrofitted industrial sites	Integrated: automated bioreactors + modernized agriculture; advanced treatment tech for waste and side streams
Market Structure	Patchwork: regional leaders + lagging areas; SMEs in niches	Decentralized and competitive; SMEs thrive alongside large firms	Highly consolidated; dominated by multinationals and institutional markets	Mixed: large players for scale + community-owned hubs; strong start-up ecosystem
Consumer Behavior	Hybrid foods mainstream; novel proteins occasionally; cultural attachment strong	Sustainability normalized; adoption via tasting experience, personalization, convenience	Skeptical; cultural attachment persists; convenience outweighs sustainability	Taste, personalization and overall well-being drive choices; carbon budgets and lifestyle integration
Social Equity	Moderate: disparities between regions and social groups persist	High: affordability, regional investment, workforce reskilling	Low: rural regions and SMEs marginalized; economic divide deepens	High: inclusive governance, community co-ownership, dynamic pricing for fairness
Environmental Outcome	Improved but inconsistent; resilience costly	Strong: circular loops, renewable integration, low emissions	Moderate: industrial hubs efficient but lack adaptability	Strong: climate-positive loops, resource optimization, biodiversity preserved
Economic Resilience	Moderate: emergency reserves help, but vulnerabilities persist	High: distributed networks and adaptive governance buffer shocks	Fragile: system withstands shocks but cannot adapt quickly	High: diversified production, local autonomy, green trade corridors
Overall Image	A quilt-like system: uneven, cautious adaptation	A complementary, inclusive, and resilient food economy	A secure but uninspired plateau: efficient yet socially divided	A climate-positive, tech- enabled, community- driven system balancing innovation and tradition

Table 4. Comparison of the political, business and societal implications of the scenarios.

Dimension	Political implications	Business implications	Societal implications
Scenario 1: Europe's Uneven Protein Transition	Incremental reforms; fragmented EU governance; slow harmonization of rules.	Limited incentives; uneven adoption of plant-based and biotech; high uncertainty for SMEs.	Consumer trust grows slowly; affordability concerns persist; cultural resistance remains.
Scenario 2: Circular Protein Renaissance	Adaptive, participatory governance; conditional approvals; strong incentives for circularity.	Diverse technologies (cellular agriculture, modular hubs); open data fosters collaboration; SME-friendly.	High transparency; personalized diets; strong citizen engagement; sustainability mainstreamed.
Scenario 3: Stalled Protein Transition	Centralized, rigid regulation; defensive trade policies; strict safety rules dominate.	High compliance costs; innovation slows; reliance on domestic production; limited global competitiveness.	Slow consumer adoption and limited inclusion create trust gaps and regional disparities.
Scenario 4: Food System Reimagined	Harmonized and participatory governance; carbon-accountable trade; strong regional autonomy.	Distributed high-tech production; resilient supply chains; SMEs thrive under resource stewardship policies.	Climate-conscious eating; community co-ownership; personalized nutrition; cultural continuity.

Based on the scenario descriptions, rough estimates of the proportions of animal-, plant- and biotech-based proteins were prepared to allow comparison of the scenarios over time. The estimates start with the situation in Europe in 2025.

Table 5. Comparison of the rough estimates of the proportions of animal-, plant- and biotech-based proteins in the different scenarios in the time frame of 2025, 2035 and 2050 in Europe, based on the scenario descriptions.



Roadmap towards the vision

A roadmap is a strategic tool that translates long-term vision into actionable steps. It provides a structured pathway for moving from the current state to desired future outcomes, aligning stakeholders around shared priorities and timelines. Unlike scenarios, which explore alternative futures and uncertainties, a roadmap focuses on implementation, offering clarity on what needs to happen, when, and by whom.

The purpose of a roadmap is to guide decision-making by helping organizations prioritize investments, allocate resources, and sequence actions effectively. It also serves as a mechanism for coordination across actors by outlining interdependencies and fostering collaboration among businesses, policymakers, and societal stakeholders. Importantly, a roadmap is not static; it provides a framework for monitoring progress and adapting strategies as conditions evolve.

In complex transitions, such as the shift toward sustainable food systems, a roadmap ensures that ambition translates into measurable progress. It bridges the gap between vision and execution, turning strategic intent into practical milestones that can be tracked and refined over time.

Scenario 2 was selected as the most desirable future in the stakeholder survey study. The scenario narrative is simplified in this vision statement:

By 2050, Europe's food system is agile, cooperative, and inclusive, built on transparency, circularity, and shared accountability. Diverse food sources, from traditional livestock to plant-based and biotech innovations, coexist in a balanced ecosystem powered by renewable energy and resource efficiency. Governance adapts dynamically, enabling innovation while safeguarding safety and sustainability. Communities, industry, and policymakers collaborate to create resilient networks of food production and consumption, whereas personalization and cultural diversity shape everyday choices. Sustainability is effortless, trust is widespread, and Europe's competitive edge rests on cooperation and climate-positive practices, delivering abundant, healthy, and equitable diets for consumers.

The transition towards the vision takes place in phases. In the following, the transition process is described, followed by a PESTEL summary that examines the political, economic, social, technological, environmental, and legal dimensions of the transition (Figure 8), and a visualization of the roadmap (Figure 9). The original roadmap figure that was created in the PDTT workshop may be found in Appendix 4.

Transition to Europe's circular protein renaissance

Europe's transition to a circular food system begins with a decade of foundational work and integration. From 2025 to 2035, an EU-wide Protein Strategy aligns food, energy, and waste policies, introducing adaptive governance frameworks and a conditional approval process for novel food ingredients supported by real-time monitoring. Distributed processing hubs convert agri-food side streams into protein and to other food and feed ingredient sources, enabled by technology development for modular manufacturing systems in rural and urban areas. Breeding programs for protein crops are launched to improve plant-based diversity and resilience, ensuring adaptability to regional conditions and supporting feedstock needs for bioreactors. Farmers become active partners in this transition, adopting new business models such as cooperatives and shared ownership of local hubs, creating value-added opportunities and strengthening rural economies.

Consumer familiarization programs normalize blended protein meals in schools, hospitals, and workplaces, while campaigns emphasize sensory experience and science-based information on diverse options for proteins. Open-access dashboards provide environmental and safety data to build trust in the entire value chain. European reskilling programs are built to prepare farmers and food industry workers for biotech, circular and highly digitalized systems. Implementation of socio-economic inclusion measures ensure that workforce development and affordability gaps are prevented. During 2025 to 2035, Europe is focusing on three main priorities: expanding incentives for circular resource recovery, introducing adaptive governance for faster technology approval, and strengthening climate resilience and regional equity to prevent innovation gaps. In addition, scaling personalized nutrition platforms enables new services for the support of health-driven food choices.

However, challenges may be faced. Extreme weather events may affect raw material availability and stress infrastructure through problems in transportation, energy or freshwater availability. On the other hand, geopolitical instability could disrupt supply chains and slow policy harmonization. Achieving regulatory alignment will require overcoming fragmented governance structures that risk delaying technology adoption. In addition, public trust must be actively cultivated to counter misinformation and unclear terminology, which could otherwise hinder acceptance of novel foods. Uneven adoption of breeding programs and lack of farmer inclusion in innovation ecosystems could create regional disparities. Finally, restrictive intellectual property frameworks may limit collaboration and slow innovation, making open and inclusive approaches essential for progress.

From 2036 to 2050, the focus shifts to scaling and consolidation. Technological breakthroughs such as advanced, low-energy cellular agriculture processes and advanced waste and side stream treatment technologies are commercialized, while renewable energy becomes mandatory for all protein production facilities. Breeding innovations deliver high-performing protein crops adapted to diverse conditions, reinforcing plant-based diversity and reducing reliance on imports. Farmers evolve into strategic partners in distributed production networks, managing feedstock flows, co-owning bioreactor hubs, and driving local resource loops. Cultural integration programs promote hybrid recipes, blending traditional and biotech-based food ingredients, safeguarding culinary heritage and reducing resistance. Open data governance ensures traceability and fosters collaborative innovation, while socio-economic inclusion measures expand workforce programs and affordability schemes to prevent protein inequality. By 2050, nutrient and energy loop closure is enforced across all food systems, and Europe positions itself as a global leader in sustainable food trade and standards, embedding adaptive regulation and real-time monitoring as permanent features.

Despite this progress, several challenges may arise. Delays in renewable energy integration could slow the shift toward climate-positive production, while consumer scepticism or cultural resistance may hinder acceptance of new food technologies. Maintaining robust monitoring systems will be critical, as gaps in safety checks, traceability, or environmental compliance could undermine trust and performance. Additionally, geopolitical fragmentation may disrupt supply chains and complicate policy harmonization, requiring proactive strategies to maintain resilience and global competitiveness.



Figure 8. PESTEL summary of the transition.

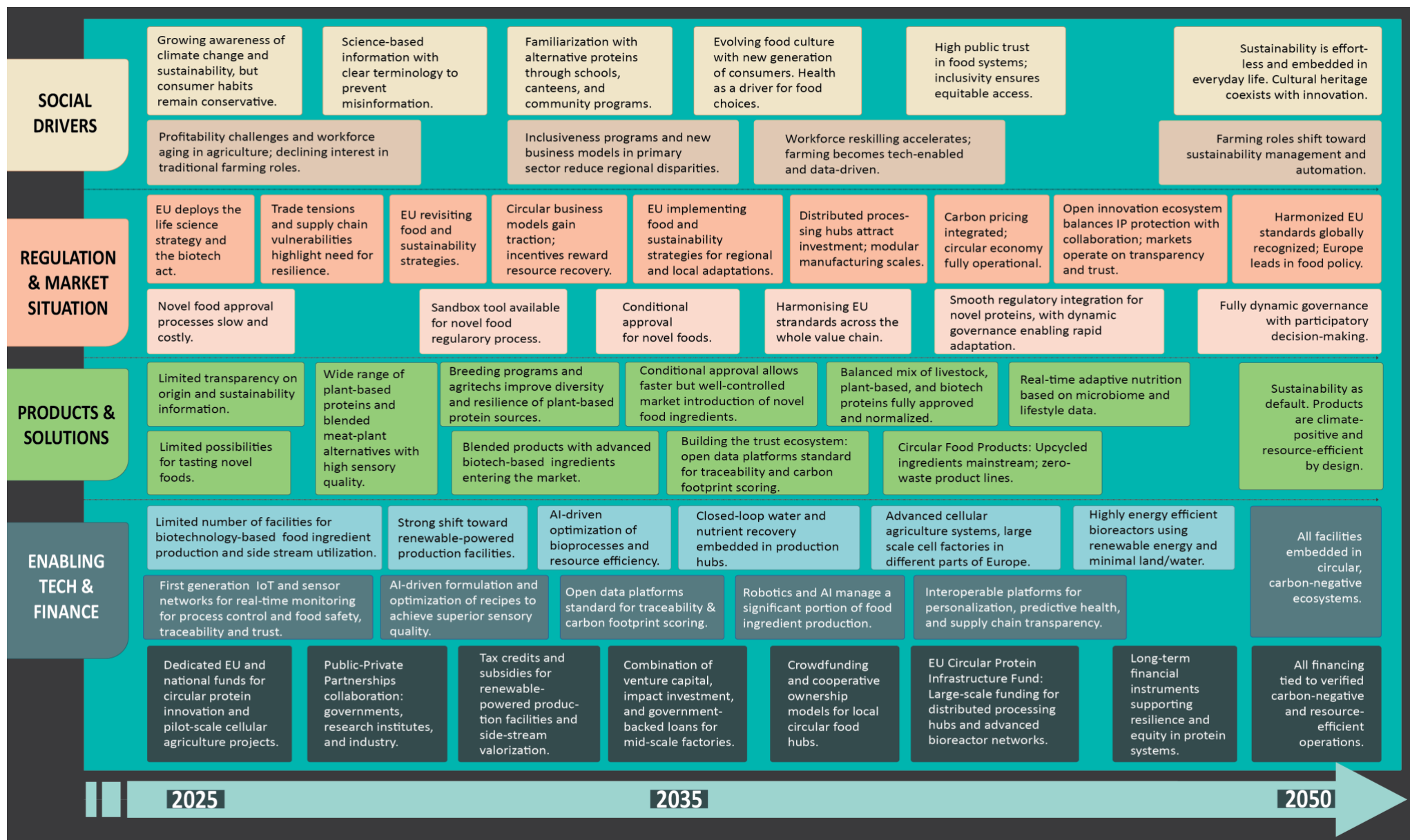


Figure 9. Transition roadmap.

Leverage points for the roadmap

Leverage points are strategic areas within a system where targeted actions can create significant and lasting impact. In the context of a transition roadmap, they represent critical drivers that can accelerate progress toward the vision. By identifying where interventions will deliver the greatest systemic change, organizations can prioritize efforts that unlock cascading benefits, reduce barriers, and build resilience.

However, leverage points are not just opportunities, they are also dependencies. If these points are missed or poorly addressed, they can become bottlenecks, creating delays, inefficiencies, or even systemic challenges that make achieving the vision much harder. Acting early and effectively on leverage points ensures momentum and minimizes risks that could derail the transition.

Key leverage points for the roadmap have been analyzed based on strong influence on Europe's ability to reach Scenario 2, but also for a high risk of failure if not implemented successfully:

1. Regulatory breakthroughs

Conditional approval and a streamlined EFSA process are critical enablers for faster yet well-controlled market entry of novel food ingredients. Regulatory delays or fragmented EU governance could potentially stall investment and slow down the adoption of new technologies.

Equally important is the development of harmonized EU frameworks for adaptive governance. Such frameworks are essential for rapid technology approval and dynamic oversight, ensuring that innovation can scale across regions. In addition, open and inclusive intellectual property frameworks are vital to avoid innovation bottlenecks and enable collaborative progress.

2. Financing and infrastructure

Dedicated EU and national funding programs play a pivotal role in kick-starting pilot projects and early commercial activities for the development and scaling of innovative solutions across the entire food system, encompassing a broad spectrum of sustainable food ingredients. These initiatives provide the foundation for innovation and help Europe maintain competitiveness in the global protein transition.

To move from pilot projects to large-scale bioreactor networks, co-financing models are essential.

Combining public and private investments ensures scalability and long-term viability. Beyond infrastructure, financing must also support socio-economic inclusion measures and affordability schemes to prevent protein inequality.

3. Technology deployment

A strong shift toward renewable-energy powered production facilities and energy-efficient processes is critical for achieving climate-positive goals and maintaining cost competitiveness. This applies not only to cellular agriculture processes but also to regional processing hubs for plant-based proteins and side-stream valorisation facilities, ensuring that all parts of the food system minimize land and water use while reducing environmental impact.

Equally important is embedding closed-loop water and nutrient recovery within production hubs. This approach is key to circularity and resource efficiency, ensuring that valuable inputs are reused rather than wasted. Yet, technical complexity and high capital expenditure remain significant risks, potentially slowing adoption and limiting scalability.

4. Consumer familiarization and trust

Science-based communication and harmonized terminology are essential for building trust and countering misinformation around novel proteins. Clear, consistent messaging should not only explain benefits and safety but also address socio-economic and cultural dimensions to foster broad acceptance.

Familiarization programs in schools, hospitals, and community settings should integrate diverse protein sources and blended products, making them part of everyday life. To strengthen cultural acceptance, initiatives can promote hybrid recipes, safeguarding culinary heritage while supporting sustainability goals.

5. Digital transparency

Open-access dashboards for traceability, safety data and carbon footprint scoring are vital for building consumer trust and ensuring regulatory compliance. Transparency on origin, safety, and sustainability strengthens confidence in the food system, while real-time data sharing supports EFSA's approval processes for novel food ingredients.

To maximize impact, shared data should expand beyond environmental metrics to include socio-economic indicators and consumer affordability measures, reinforcing equity and inclusivity in the protein transition.

Strategic priorities for Europe's food system and opportunities for PDTT

The strategic priorities and opportunities listed below are based on the foresight study including stakeholder survey results and the roadmap developed. They reflect stakeholder insights and priorities identified through collaborative analysis of Europe's food system challenges and opportunities.

The identified strategic priorities are designed to drive evidence-based decision making by turning foresight findings into actionable guidance for policymakers, industry, academia, and civil society as well as giving directions to funding priorities by aligning future funding with EU strategies to maximize impact and policy coherence. The recognized opportunities translate the study's insights also into areas where PDTT can take an active role, driving initiatives that strengthen Europe's transition toward a sustainable food system.

1. Bridging the trust gap in EU food system

The stakeholder survey results highlight a significant disconnect between Europe's current trajectory and the preferred future envisioned by stakeholders in the food value chain. Respondents perceive that Europe is moving toward Scenario 1 (Europe's uneven protein transition), a conservative path characterized by incremental change and regulatory rigidity, while they strongly favour Scenario 2 (Europe's circular protein renaissance), a progressive and innovation-driven future as a preferred path for Europe. This divergence signals a mistrust in EU decision-making processes, raising concerns that delayed policy responses could hinder Europe's competitiveness in global food innovation.

The European Commission, EFSA, and relevant directorates (DG AGRI, DG SANTE) should lead harmonization efforts on regulatory standards, transparency and labelling frameworks to guide policy choices that accelerate Europe's shift toward a circular, inclusive, and innovation-driven food system. National ministries should adapt these strategies locally, ensuring regional inclusivity. Industry associations and food companies should collaborate on innovation roadmaps and co-develop transparency standards, while civil society and consumer organizations should bring public perspectives into trust-building campaigns. Research networks such as EIT Food, universities and research institutes can provide evidence-based insights and scenario modelling, and media partners amplify science-based narratives to reach large audiences and counter misinformation.

To address this, PDTT can take a proactive role by convening multi-stakeholder dialogues, embedding participatory foresight into its activities, and creating evidence-based policy briefs that highlight pathways toward sustainable, circular and diversified protein futures. By acting as a trusted connector between industry, research, and policymakers, PDTT can accelerate alignment with Scenario 2 principles, rebuild trust, and catalyse Europe's leadership in resilient and equitable food systems.

Timeline	Immediate (2025–2027)	Next (2028–2035)	Long term- (2035–2050):
Actions	Publish policy briefs highlighting pathways toward Scenario 2 (Europe's circular protein renaissance) and PDTT priorities. Launch multi-stakeholder dialogues and focused participatory foresight workshops to initiate discussion, joint prioritization of activities and roles of stakeholders for the future EU Food System.	Embed participatory foresight in EU Protein strategy updates with PDTT examples of multi-stakeholder collaboration.	Support integration of adaptive governance and trust-building mechanisms as permanent features in the EU Food System.

KPIs to track progress:

Engagement metrics:

- Number of multi-stakeholder dialogues/participatory foresight workshops held annually.
- Diversity of participants (industry, research, policy, civil society).

Policy influence:

- References to PDTT briefs in EU or national policy documents.

Trust indicators:

- Reduction in gap between current trajectory and preferred scenario of the future Food System in foresight assessments validated through stakeholder survey studies.

2. Creation of regulatory agility

To accelerate innovation in food system, Europe should move beyond fragmented and slow approval processes. EU institutions and EFSA should champion harmonized frameworks for adaptive governance and collaborate with national authorities during the transformation process to ensure consistent implementation. Industry actors entering the approval process should participate in research and demonstration activities e.g. in EU funded projects together with research organizations to confirm safety and performance of the system.

PDTT can play a pivotal role in reducing fragmentation and supporting more agile approval pathways. Rather than waiting for regulatory change, PDTT can facilitate dialogue between innovators and regulators, and help to develop evidence-based recommendations for conditional approval frameworks. Furthermore, PDTT can also coordinate European knowledge sharing and best practices to build consensus among European actors, helping to reduce governance bottlenecks.

Timeline	Immediate (2025–2027)	Next (2028–2035)	Long term (2035–2050):
Actions	Initiate dialogue between innovators and regulators to define regulatory obstacles and possible solutions. Draft evidence-based recommendations for improved approval frameworks for novel food ingredients.	Support the launch of a sandbox tool and pilot programs for conditional approval of novel food ingredients in selected EU regions, e.g. with EU funding. Further disseminate the outcomes to share e.g. best practices.	Institutionalize conditional approval and adaptive regulation of novel food ingredients as permanent features in EU food policy.

KPIs to track progress

Engagement metrics:

- Number of regulator–innovator dialogues facilitated annually.
- Participation diversity (policy, industry, research).

Policy influence:

- References to PDTT recommendations in EU regulatory updates.
- Adoption of harmonized conditional approval frameworks for novel food ingredients.

Innovation indicators:

- Reduction in approval timelines for novel food ingredients.

3. Financing for scale-up

Scaling sustainable food ingredient production requires significant upfront investment in bioreactors and renewable energy powered facilities but also in regional hubs for processing of plant-based ingredients and agri-food side-streams. In addition to biotechnology advancements, breeding programs for protein crops will play a critical role by improving yields and resilience, ensuring a steady supply for processing and blended products. EU funding bodies and national governments should provide strategic grants and incentives, while private investors and impact funds should bring capital for commercialization. Industry partners should contribute to co-investment and technical expertise, while civil society should monitor affordability and equity. Financial solutions should be designed towards risk-sharing mechanisms to attract private capital.

PDTT can help catalyze this process by promoting co-financing models that combine public funds, impact investors, and industry partnerships. PDTT can act as a supportive convener, bringing together financial institutions, policymakers, and innovators to co-create co-investment schemes and risk-sharing mechanisms. Through its network, PDTT can also develop investment roadmaps, identify priority infrastructure needs, and showcase successful pilot projects to attract private capital.

Timeline	Immediate (2025–2027)	Next (2028–2035)	Long term (2035–2050):
Actions	Launch matchmaking events for innovators and investors and convene stakeholders to discuss co-financing models for scale-up. Provide compiled information on service providers and open-access scale-up facilities.	Collect and share information on successful pilot projects related to scale-up as well as on breeding programs.	Follow realization of scale-up infrastructure and outcomes of breeding programs. Propose corrective measures if needed.

KPIs to track progress:

Stakeholder engagement:

- Number of matchmaking events held.

4. Reaching energy efficiency in biotech-based production of food ingredients

Current biotech-based food ingredient production processes are highly energy-intensive, creating cost and sustainability barriers when scaled. EU R&D programs and funding bodies should include next-generation energy-efficient food production processes. Technology developers and research institutes should innovate in this sector, while industry partners should take in use renewable energy solutions and closed-loop systems.

PD TT can play a key role by engaging in EU-level funding dialogues and shaping priorities for R&D programs that target next-generation energy-efficient food and feed ingredient production processes. PD TT can leverage its network to connect funding bodies, technology developers, research institutes, and industry partners, fostering joint projects and knowledge exchange.

Timeline	Immediate (2025–2027)	Next (2028–2035)	Long term (2035–2050):
Actions	Support initiation of collaborative R&D projects for energy-efficient bioreactors and closed-loop systems for food production. Advocate for renewable energy integration in EU funding agendas.	Collect and share information on energy-efficient bioreactors and resilience protocols in pilot hubs. Support discussion on contingency strategies for extreme weather and geopolitical disruptions.	Advocate for renewable energy for all food ingredient production facilities and institutionalize resilience measures.

KPIs to track progress:

Technology metrics:

- Collect and share information on the number and contents of R&D projects launched for energy efficiency and closed-loop systems in EU.
- Publish information on production facilities powered by renewable energy.

5. Generating digital transparency platforms

Building consumer trust and enabling adaptive governance requires transparency across the whole food value chain, including all animal-, plant- and biotech-based food production sectors. EU regulators and technology providers should co-develop open-access dashboards for traceability, safety data, carbon footprint scoring, and socio-economic indicators. Industry partners should supply verified data, while civil society ensures accessibility and equity.

PD TT can take a leading role by initiating multi-stakeholder discussions on digital transparency tools and advocating for open-access dashboards that provide traceability, safety data and carbon footprint scoring. In addition, PD TT can engage with EU regulators and funding bodies to integrate these solutions into policy frameworks and approval processes, demonstrating how real-time data can support conditional approvals and oversight for novel food ingredient production.

Timeline	Immediate (2025–2027)	Next (2028–2035)	Long term (2035–2050):
Actions	Launch stakeholder dialogues on dashboard design and initiate pilot projects for traceability systems. Define standards for carbon footprint and socio-economic indicators.	Share information on scaling dashboards across regions and integrating them into regulatory processes. Provide metrics on affordability and equity indicators.	Standardize open data governance as a cornerstone of Europe's food system.

KPIs to track progress:

Platform metrics:

- Number of dashboards deployed and operational.
- Percentage of novel protein products covered by traceability systems.

Transparency indicators:

- Inclusion of socio-economic and affordability metrics in dashboards.
- References to dashboard data in regulatory decisions.

6. Transforming workforce to meet sustainable food system needs

The transition to sustainable food systems requires skills beyond biotech and digital capabilities. Farmers and food industry professionals need expertise in operating advanced technologies, developing new business models, and applying circular economy strategies. Expanding plant-based food production also demands agronomic knowledge, processing skills, and consumer engagement competencies. EU bodies and agricultural organizations should lead reskilling initiatives, supported by professional training providers. In addition, research networks could contribute to curriculum development.

PDTT can help by mapping skill gaps, providing foresight insights, and designing strategic frameworks for reskilling programs for workforce. PDTT can also advocate for workforce development needs in EU policy dialogues, support funding applications for collaborative training projects, and showcase best practices from innovation pilots.

Timeline	Immediate (2025–2027)	Next (2028–2035)	Long term (2035–2050):
Actions	Map skill gaps of future food systems and advocate for workforce development in EU policy dialogues. Support strategic frameworks for reskilling programs of future food system workforce together with other stakeholders.	Collect and publish information on collaborative training projects and reskilling initiatives of food system workforce.	Standardize continuous learning frameworks for future food system workforce.

KPIs to track progress:

Training metrics:

- Provide data on the number of reskilling workforce programs launched and participants trained.
- Provide data on the diversity of participants (farmers, industry professionals).

Policy influence:

- References to PDTT workforce frameworks in EU strategies.

7. Ensuring regional equity in protein diversification

Achieving a fair and inclusive protein transition requires innovation to be distributed across regions and across multiple protein sources. National governments and regional authorities should support and fund local innovation clusters, while SMEs, cooperatives, and industry actors should initiate and participate in development programs for diverse production models. Research organizations should collaborate with

industry stakeholders to support the progress. Civil society should ensure cultural sensitivity, and media can help to amplify success stories.

PDTT can help advance balanced protein diversification by advocating for regional innovation clusters that integrate different sustainable protein solutions. PDTT can use its foresight insights to mobilize partnerships between SMEs, cooperatives, and local actors to ensure successful development of diverse production models and local ecosystems.

Timeline	Immediate (2025–2027)	Next (2028–2035)	Long term (2035–2050):
Actions	Initiate regional dialogues and identify priorities for protein diversification. Develop cultural integration campaigns for novel protein sources.	Encourage to establish regional innovation ecosystems and scale cultural integration initiatives. Mobilize partnerships between SMEs, cooperatives, and local actors.	Consolidate regional networks and embed cultural integration into mainstream food systems.

KPIs to track progress:

Regional development metrics:

- Collect and publish information on the number and contents of regional innovation clusters established.
- Collect and publish information on the geographic distribution and outcomes of protein diversification projects.

Cultural integration indicators:

- Consumer acceptance levels measured through surveys.

Strategic alignment with EU policy frameworks

The European Union is shaping a robust policy framework to accelerate biotechnology and sustainable food systems through several key initiatives. Central to this effort is the **EU Life Sciences Strategy**, which focuses on regulatory agility, digitalization, and cross-sector innovation spanning health, agriculture, and food systems. Complementing this, the forthcoming **EU Biotech Act**, expected in 2026, aims to simplify regulatory pathways, foster investment, and embed biotechnology into industrial and agri-food ecosystems. Additionally, the EU Innovation Act reinforces these efforts by promoting cross-sector collaboration, accelerating technology transfer, and creating enabling conditions for breakthrough innovations in sustainable food systems and biotechnology.

These initiatives are reinforced by broader sustainability policies. The **EU Green Deal** anchors climate neutrality by 2050, driving systemic transitions in energy, food production, and resource use. The **Circular Economy Act** promotes resource efficiency, waste valorisation, and integrated circular value chains, ensuring that industrial and food systems operate within planetary boundaries. Finally, the **updated EU Bioeconomy Strategy**, seeks to scale bio-based innovations, secure sustainable biomass supply, and create lead markets for biomanufacturing and agri-biotech solutions.

Together, these frameworks form a comprehensive policy landscape that shapes Europe's approach to innovation, sustainability, and competitiveness in the food sector. This chapter analyses how these frameworks intersect with the recommendations outlined above and identifies strategic opportunities for alignment and advocacy.

Regulatory agility & improved approval process for novel food ingredients that would allow controlled but efficient market entry while ensuring safety and compliance.

- **Policy signals:** The Life Sciences Strategy and the upcoming Biotech Act emphasize streamlined approval processes and regulatory sandboxes for biotech products, signalling a shift toward more adaptive governance.

Financing for scale-up

- **Policy signals:** The EU Bioeconomy Strategy introduces co-financing instruments such as InvestEU and the Scale-up Europe Fund, designed to de-risk investments and accelerate commercialization of sustainable technologies. These mechanisms aim to combine public funds with private capital to support innovation at scale.

Energy efficiency in biotech production

- **Policy signals:** The Green Deal and Circular Economy Act emphasize industrial decarbonization and resource efficiency, creating strong incentives for technologies that reduce energy use and environmental impact. These frameworks aim to accelerate low-carbon innovation across sectors, including food and biotech.

Digital transparency platforms

- **Policy signals:** The Life Sciences Strategy promotes AI-driven regulatory tools to improve efficiency and oversight, while the Circular Economy Act supports traceability across value chains to ensure accountability and sustainability. These signals indicate a strong policy push toward digital solutions that enhance transparency and compliance.

Consumer familiarization & trust

- **Policy signals:** The Biotech Act and the Green Deal's Farm-to-Fork strategy emphasize public engagement and science-based communication as critical enablers for food system transformation. These frameworks aim to build consumer confidence in novel technologies and sustainable practices through transparency and education.

Workforce transformation for sustainable food systems

- **Policy signals:** The Bioeconomy Strategy and EU Skills Agenda highlight the need for skills development in biotech and circular economy sectors, recognizing that workforce readiness is essential for scaling innovation and achieving sustainability goals.

Regional equity in protein diversification

- **Policy signals:** The Circular Economy Act and Bioeconomy Strategy promote distributed innovation hubs and rural development, aiming to prevent concentration of resources in a few regions and ensure inclusive growth across Europe.

Conclusions

Europe's protein transition is at a crossroads. Stakeholder insights and evaluation of four future scenarios for Europe's protein diversification reveal a **clear contrast between the current trajectory and the preferred future**. Today, Europe appears to be following **Scenario 1: Europe's uneven protein transition**, a conservative path marked by incremental change, regulatory rigidity, and fragmented progress. This scenario risks widening disparities, slowing innovation, and undermining Europe's global competitiveness. In contrast, stakeholders strongly favor **Scenario 2: Europe's circular protein renaissance**, an innovation-driven future characterized by systemic collaboration, regulatory agility, and inclusive approaches that embrace diverse protein sources. Scenario 2 envisions a food system that is sustainable and resilient, where biotechnology, circular economy principles, and socio-economic inclusion facilitate delivery of equitable access to healthy diets.

Closing the gap between these two trajectories, uneven protein transition and circular protein renaissance requires **systemic action**. Europe should adopt strategies that combine **trust-building, policy alignment, and inclusive innovation**. This means harmonizing regulatory frameworks, embedding foresight-driven planning into governance, and ensuring that cultural and socio-economic dimensions are integral to the protein transition.

Trust and governance are foundational. Transparent decision-making, harmonized regulatory standards, and participatory foresight processes can support that policies reflect societal priorities and foster confidence in diverse food ingredient sources, ranging from novel plant-based and biotech-derived options to traditional ingredients. Strategic alignment with several EU initiatives offers a unique opportunity to embed protein diversification within Europe's sustainability and competitiveness agenda.

Financing innovation and equity is essential. EU and national funding programs, complemented by private investment and risk-sharing mechanisms, should scale innovation while safeguarding affordability and socio-economic inclusion to prevent inequality. In addition, **cultural acceptance** is critical: science-based communication, harmonized terminology, and locally relevant familiarization programs will normalize novel food ingredients and blended products, preserving culinary heritage and advancing sustainability goals.

As a convening network, **PD TT is uniquely positioned to catalyze this transformation**. PD TT can take an active role accelerating Europe's shift toward a circular, inclusive, and innovation-driven food system by:

1. Producing evidence-based policy briefs to point out relevant topics for discussion. Based on this study, the first policy brief should be on **Bridging the trust gap in EU food system**, pointing out the wish to transition the trajectory of the food future towards systemic collaboration, regulatory agility, and inclusive approaches. The trust gap should be followed by e.g. repeating the stakeholder survey study on a regular basis. It is important to ensure feedback from different parts of Europe, and from different sectors.
2. Arranging **participatory foresight workshops with different stakeholders** to encourage and enable collaboration towards joint goals. Based on this study, these efforts should first be directed to promote regulatory agility. After that, it is also essential to work on regional equity in protein diversification.
3. Identifying and **influencing EU funding calls to support** the PD TT vision of sustainable, resilient, innovative, fair and inclusive food system. Based on this study, it is essential to ensure that research efforts are focused on **energy efficiency, circularity and digital transparency** in future food systems, and that these efforts are supported by EU funding programs.
4. Facilitating multi-stakeholder dialogues and match-making events to **promote knowledge sharing and collaboration activities**, e.g. through bringing together experts from the food value chain and financing. This approach may also be used to promote collaboration within the food value chain to discuss future business opportunities and skills development.

This paper was commissioned by EIT Food under the Protein Diversification Think & Do Tank and prepared by Anu Seisto, Anneli Ritala, Arto Wallin and Tiina Kymäläinen of VTT Technical Research Centre of Finland, based on background materials and analytical inputs developed within the Think & Do Tank.

The EIT Food Protein Diversification Think Tank convenes stakeholders and partners, combining the expertise of academics, research and technology organisations (RTOs), companies, and NGOs.

It fosters broad and inclusive participation and aims to create structured dialogue to overcome barriers to innovation in the field of protein diversification.

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About EIT Food

EIT Food is the world's largest and most dynamic agri-food innovation community. We accelerate innovation to build a future-fit agri-food system that produces healthy and sustainable food for all.

Supported by the EU, we invest in projects, organisations and individuals that share our goals for a healthy and sustainable food system. We unlock innovation potential in businesses and universities and create and scale agri-food startups to bring new technologies and products to market. We equip entrepreneurs and professionals with the skills needed to transform the food system and put consumers at the heart of our work, helping build trust by reconnecting them to the origins of their food.

We are one of nine innovation communities established by the European Institute for Innovation & Technology (EIT), an independent EU body set up in 2008 to drive innovation and entrepreneurship across Europe.

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Appendix 1

Background literature for the scenario building:

Report	Link
Whitepaper on Protein Diversification	https://www.eitfood.eu/reports/whitepaper-on-protein-diversification
Protein Diversification Think Tank Policy Brief on Accelerating Protein Diversification for Europe	https://www.eitfood.eu/reports/protein-diversification-think-tank-policy-brief
EIT Food PDTT Worldwide Protein Diversification Landscape Analysis	
CellAg roadmap for Finland. Sustainable growth from cellular agriculture value chains - Action plan for Finland	https://doi.org/10.32040/2025.CellAg.en
EIT Food Net Zero Food System insight report.	https://www.eitfood.eu/files/Missions/A-Net-Zero-Food-System-Insight-Report_FINAL_10052023.pdf
The economic potential of alternative proteins	https://www.systemiq.earth/economic-potential-alternative-proteins/
A new land dividend: The opportunity of alternative proteins in Europe	https://green-alliance.org.uk/publication/a-new-land-dividend-the-opportunity-of-alternative-proteins-in-europe/
Plant-based meat manufacturing capacity and pathways for expansion	https://gfi.org/resource/plant-based-meat-manufacturing-capacity-and-pathways-for-expansion/
Closing the EU protein gap – drivers, synergies and trade-offs	https://publications.jrc.ec.europa.eu/repository/handle/JRC137180
What could the UK agri-food system look like in 2050?	https://www.agrifood4netzero.net/wp-content/uploads/2024/04/UK-agri-food-system-scenarios.pdf
Innovating agriculture	https://royalsociety.org/science-events-and-lectures/2024/06/agriculture-tof/
Roadmap Paving the way towards animal free milk proteins	https://www.foodbiocluster.dk/Files/Images/FBCD/Biosolutions%20-%20ressourcer/Paving%20the%20way%20towards%20animal%20free%20milk%20proteins.pdf
Recipe for a Livable Planet: Achieving Net Zero Emissions in the Agrifood System	https://openknowledge.worldbank.org/entities/publication/406c71a3-c13f-49cd-8f3f-a071715858fb
8 EU Policy Priorities for Global Decarbonization. Pathways to European Climate Leadership	https://future-matters.org/8-eu-policy-priorities-for-global-decarbonization/
Alternative protein sources for food and feed	https://www.europarl.europa.eu/RegData/etudes/STUD/2024/757806/EPRS_STU(2024)757806_EN.pdf
The potentials of bio solutions	https://copenhageneconomics.com/wp-content/uploads/2022/09/The-potentials-of-biosolutions_final_20SEP2022.pdf

Sustainable Food Systems Partnership for People, Planet and Climate	https://scar-europe.org/images/FOOD/Main_actions/SFS_Partnership_SRIA_31012023.pdf
Danish Action Plan for Plant-based Foods	https://en.fvm.dk/Media/638484294982868221/Danish-Action-Plan-for-Plant-based-Foods.pdf
The dependency of the EU's food system on inputs and their sources	https://www.europarl.europa.eu/RegData/etudes/STUD/2024/747272/IPOL_STU(2024)747272_EN.pdf
Concepts for a sustainable EU food system	https://publications.jrc.ec.europa.eu/repository/handle/JRC126575
Turning point: Feeding the world sustainably	https://www.deloitte.com/global/en/issues/climate/feeding-the-world-sustainably.html
The Future for Cultivated Meat in Europe	https://www.systemiq.earth/future-of-food/
The future of the future foods: understandings from the past towards SDG-2	https://www.nature.com/articles/s41538-025-00484-x
The Future of Food. Can we meet the needs of 9bn people?	https://www.research.hsbc.com/C/1/1/320/WgCK7Wv
Economic growth and prosperity to 2035	https://www.thevalueofbiosolutions.com
Trust Report 2024	https://www.eitfood.eu/reports/trust-report-2024
Imagining a sustainable Europe in 2050	https://www.eea.europa.eu/en/analysis/publications/imagining-a-sustainable-europe-in-2050
Is there Enough Biomass to Defossilise the Chemicals and Derived Materials Sector by 2050?	https://biconsortium.eu/sites/biconsortium.eu/files/publications/Is%20there%20enough%20biomass%20to%20defossilise%20the%20chemicals%20and%20derived%20materials%20sector%20by%202050.pfd
Future transitions for the Bioeconomy towards Sustainable Development and a Climate-Neutral Economy - Foresight Scenarios for the EU bioeconomy in 2050	https://publications.jrc.ec.europa.eu/repository/handle/JRC123532
Roadmap for achieving net-zero emissions in global food systems by 2050	https://www.nature.com/articles/s41598-022-18601-1
What vegetable oils and proteins for 2030? Would the protein fraction be the future of oil and protein crops?	https://www.researchgate.net/publication/304996942_What_vegetable_oils_and_proteins_for_2030_Would_the_protein_fraction_be_the_future_of_oil_and_protein_crops
Quel avenir de l'agriculture et de la forêt françaises en 2050 ?	https://agriculture.gouv.fr/quel-avenir-de-lagriculture-et-de-la-foret-francaises-en-2050
Analysis of climate change impacts on EU agriculture by 2050	https://publications.jrc.ec.europa.eu/repository/handle/JRC119632
SUMMARY REPORT: A Net Zero Transition Plan for the UK Food System	https://www.bsas.org.uk/assets/files/IGD_A-Net-Zero-Transition-Plan-for-the-UK-Food-System-Summary_Nov-2024.pdf

Agro-economic-environmental modelling in the context of the Green Deal and sustainable food systems.	https://publications.jrc.ec.europa.eu/repository/handle/JRC135313
The Afterres 2050 scenario 2016 version	https://afterres.org/wp-content/uploads/2021/06/solagro_afterres_2050_version2016_english.pdf
Four Futures for the Global Food System	https://www.bcg.com/publications/2022/four-scenarios-for-the-future-of-the-global-food-system
Agriculture, forestry and food in a climate neutral EU	https://www.agora-agriculture.org/fileadmin/Projects/2024/2024-09_EU_Agriculture_forestry_and_food_in_a_climate_neutral_EU/AGR_336_Land-use-study_WEB.pdf
EU biorefinery outlook to 2030 Studies on support to research and innovation policy in the area of bio-based products and services	https://op.europa.eu/en/publication-detail/-/publication/7223cd2e-bf5b-11eb-a925-01aa75ed71a1
The JRC Biomass Mandate	https://knowledge4policy.ec.europa.eu/projects-activities/jrc-biomass-mandate_en
The Economics of the Food System Transformation	https://foodsystemeconomics.org/wp-content/uploads/FSEC-Global_Policy_Report.pdf
Mansholt lecture	https://www.wur.nl/en/news-insights/activities-at-wur/mansholt-lecture
The future of food and agriculture. Trends and challenges	https://openknowledge.fao.org/server/api/core/bitstreams/2e90c833-8e84-46f2-a675-ea2d7afa4e24/content

Appendix 2

Draft versions of the scenarios for the stakeholder survey

Scenario 1: Europe's Uneven Protein Transition, 2050

Europe's protein transition has advanced, but not evenly. Europe has moved from vision to reality through hundreds of small, localized steps rather than a unified march. Regulations have gradually aligned, yet national interpretations persist. The result is a mosaic of overlapping initiatives: one region thriving on legumes and fermentation hubs, another clinging to livestock traditions. Resource constraints, aging infrastructure, and limited investment slow the spread of new technologies.

By 2050, Europe's protein transition has achieved partial success.

- Blended and plant-based foods are common, but not universal.
- Technological advances remain steady but incremental.
- Regulation is clearer yet still fragmented across borders.
- Energy and water constraints make investors cautious.
- Large corporations dominate, while smaller producers depend on public support.
- Sustainability has improved, but disparities between regions and social groups persist.

Scenario 2: Europe's Circular Protein Renaissance, 2050

Europe has transformed its food system through agility, cooperation, and smart incentives. Europe has learned to govern dynamically, adjusting rules as technologies evolve and encouraging shared accountability between regulators, industry, and citizens. Transparent data systems have replaced bureaucratic bottlenecks, making food safety and sustainability measurable in real time. Investment incentives reward circularity: using local resources efficiently, minimizing side streams and waste, and closing nutrient and energy loops. Technological breakthroughs in advanced biotechnology-based production of proteins and other food ingredients has enabled small and mid-sized players to join what was once an exclusive field. Cities and rural regions alike benefit from distributed processing hubs that turn agri-food side streams and food waste into new protein sources and other ingredients.

By 2050, Europe's protein landscape is both diverse and balanced.

- Governance is adaptive: rules evolve through feedback and transparency rather than command and control.
- Markets are circular: waste streams feed new value chains, and resource use is optimized locally.
- Technology is distributed: small producers access shared infrastructure once reserved for industry giants.
- Distributed manufacturing and circular design have become Europe's competitive edge.
- Consumers are informed and trusting, viewing sustainability as part of normal life rather than a sacrifice.

Scenario 3: Europe's Stalled Protein Transition, 2050

Europe's protein transition has advanced in technology but stalled in spirit. Regulation and trade policy have created stability, yet at the cost of diversity and dynamism. Stringent safety rules, centralized decision-making, and defensive trade barriers have built a fortress of compliance where a handful of powerful firms dominate. Capital flows toward safe, predictable projects rather than experimentation. Retrofitted breweries and sugar plants across Europe produce vast quantities of fermentation-based protein, supplying institutional markets with affordable substitutes for dairy and meat. But outside these industrial clusters, progress is slow. Traditional animal farming persists, consumers remain skeptical, and smaller innovators struggle to survive under heavy regulation.

By 2050 Europe's protein landscape has settled into a pattern of concentrated production and cautious expansion.

- Fermentation technology achieves cost parity with meat and dairy, but adoption remains limited to institutions and urban elites.
- Trade restrictions and rigid sustainability rules prevent cheaper imports but also raise prices for consumers.
- Attempts at reform, such as opening patent pools or decentralizing regulation, come late and struggle against entrenched interests.
- Consumers enjoy safety and consistency but not variety.
- The system's strengths are its control and reliability; its weaknesses are rigidity and inequity. It can withstand shocks but not adapt quickly.

Scenario 4: Europe's Food System Reimagined, 2050

Europe's food system has been reshaped by a convergence of radical technology, open trade, and civic innovation. Decades of experimentation and crisis have pushed Europe toward a more flexible global partnership model: foods approved in trusted countries can enter European markets quickly, provided they are monitored through real-time data and safety systems. Trade has become greener — carbon-accountable “green corridors” ensure that imported crops and fermentation inputs meet strict environmental standards. Fully automated cell factories hum beneath cities, along coastlines, and in rural hubs, producing affordable protein and other food ingredients with minimal land use. Everyday life is governed by carbon awareness. Households receive dynamic rebates for low-carbon meals, while public kitchens and retailers must operate within carbon budgets.

By 2050, Europe's protein system is abundant, digital, and largely decoupled from nature.

- Production is fully automated, resilient to weather and climate.
- Governance is open and data-driven, emphasizing transparency and reciprocity.
- Consumption is guided by personal carbon budgets and dynamic pricing.
- People can see exactly where their food comes from, and what its footprint is.
- Finance is hybrid: communities share ownership, but global suppliers still hold strategic leverage.

Appendix 3

Summary of the feedback for the scenarios from survey participants

Scenario	Comments
1	- Many respondents emphasize the importance of supporting small producers through subsidies, grants, and cooperatives. They see local production as vital for preserving food traditions, rural livelihoods, and a fairer economy. - There is concern that uneven progress could leave small producers behind, especially in regions with weaker innovation capacity. - Several comments highlight the risk of increased fragmentation and inequality across Europe. Respondents note that progress in the protein transition is likely to be uneven, with some regions advancing faster than others. - Some see this scenario as realistic, reflecting current trends of regional disparities and policy differences. - Respondents mention that regulatory fragmentation and inconsistent policies could slow down the transition and create barriers for innovation and small actors. - There is a call for more harmonized and supportive policies at the EU level to bridge regional and social gaps. - Concerns are raised about the dominance of large corporations and the potential for small producers to struggle under heavy regulations. - While some see Scenario 1 as probable and reflective of current realities, others find it less desirable due to its potential to entrench inequalities and slow overall progress. - There is a sense that this scenario may be a "status quo" or "business as usual" path, which could hinder innovation and sustainability goals. - Some express that the scenario lacks boldness ambition for transformative change.
2	- Many respondents view Scenario 2 as highly positive, inspiring, and desirable. They appreciate its vision of a circular, resilient, and inclusive food system, with strong collaboration between government, industry, and research. - The scenario is seen as a model for how Europe could lead in sustainable protein production, with benefits for climate, community, and innovation. - Several comments highlight that the success of this scenario depends on clear EU-wide data standards, fair funding access for SMEs, and consistent safety and labeling rules to maintain trust. - Respondents stress the need for harmonized policies, shared infrastructure, and real-time sustainability measurement to make the circular system work. - Some participants express scepticism about the feasibility of achieving such a transformation by 2050, citing technological, political, and cultural challenges. - There are concerns about the influence of large corporations, the need for more investment in new technologies, and the risk that traditional livestock farming may continue to dominate in some regions. - Many comments emphasize the importance of supporting small and medium-sized enterprises (SMEs) and local innovators. Respondents see distributed processing hubs, open innovation, and knowledge-sharing platforms as key enablers. - There is a call for more support mechanisms for pilot-scale production, scale-up, and consumer education to build trust in sustainable food systems. - Some respondents note that the scenario could better address the human and social aspects of the protein transition, such as just transition for farmers, affordability and nutrition, and the impact on rural livelihoods. - The importance of community engagement, education, and participatory governance is highlighted as essential for making the transition inclusive and lasting.

	Some respondents suggest that the scenario is overly optimistic or idealistic, and that more realism about the pace and complexity of change is needed.
3	- Many respondents express worry that Scenario 3 describes a future where regulation and trade policy create stability but at the cost of innovation and diversity. - There is a recurring theme that heavy regulation and centralization could favor large corporations, making it difficult for small producers and innovators to thrive. - Several comments highlight the risk that the protein transition could stall, with traditional livestock farming remaining dominant and alternative proteins struggling to gain traction. - Respondents fear that this scenario could entrench existing inequalities, limit consumer choice, and slow the adoption of sustainable practices. - Scenario 3 is often described as undesirable, with some respondents calling it the “worst” or “least likely” scenario. - Some comments mention that regulatory oversight alone does not guarantee nutritional integrity or public trust. - There is a call for greater transparency in food composition and production processes, as well as more meaningful oversight and consumer empowerment. - Respondents are concerned that small producers might struggle under heavy regulations, and that public trust in new alternatives could remain low. - There is a desire for policies that support local innovation and ensure accessibility to new technologies for a more diverse and resilient food system. - A few comments link this scenario to broader issues such as declining food quality, public health risks, and the erosion of biodiversity. - Some respondents urge policymakers to prioritize full disclosure, meaningful oversight, and the empowerment of consumers through accessible, verifiable information.
4	- Many respondents describe Scenario 4 as ambitious, exciting, and positive, envisioning a radically transformed food system driven by technology, open trade, and civic innovation. - Some see this scenario as a “dream” or “utopian” vision, expressing hope that Europe could achieve such a transformation, but also scepticism about whether it is realistic within 25 years. - The scenario is praised for its focus on advanced technologies, data-driven transparency, and climate resilience. - Respondents highlight the potential benefits of automation, real-time sustainability measurement, and circular systems, but also raise concerns about over-reliance on technology and the risk of disconnecting food production from nature and local communities. - Several comments stress the importance of ensuring that the transition is inclusive, with safeguards to protect equity, farmer livelihoods, and democratic consent. - There are concerns that heavy automation and global supply chains could lead to job losses, rural decline, and concentration of power among large corporations or global suppliers. - Respondents note that success would depend on harmonized standards, robust data governance, and effective public policy at both EU and national levels. - Comments point out that the scenario could better address consumer acceptance, food culture, and the preservation of regional diversity and culinary traditions. - There is a call for more attention to affordability, nutrition, and the social license required for such a radical transformation. - Some respondents warn that the scenario may be overly optimistic, with risks of public pushback against personal carbon budgets, automation, and loss of traditional food systems.

PDTT Roadmap workshop result

