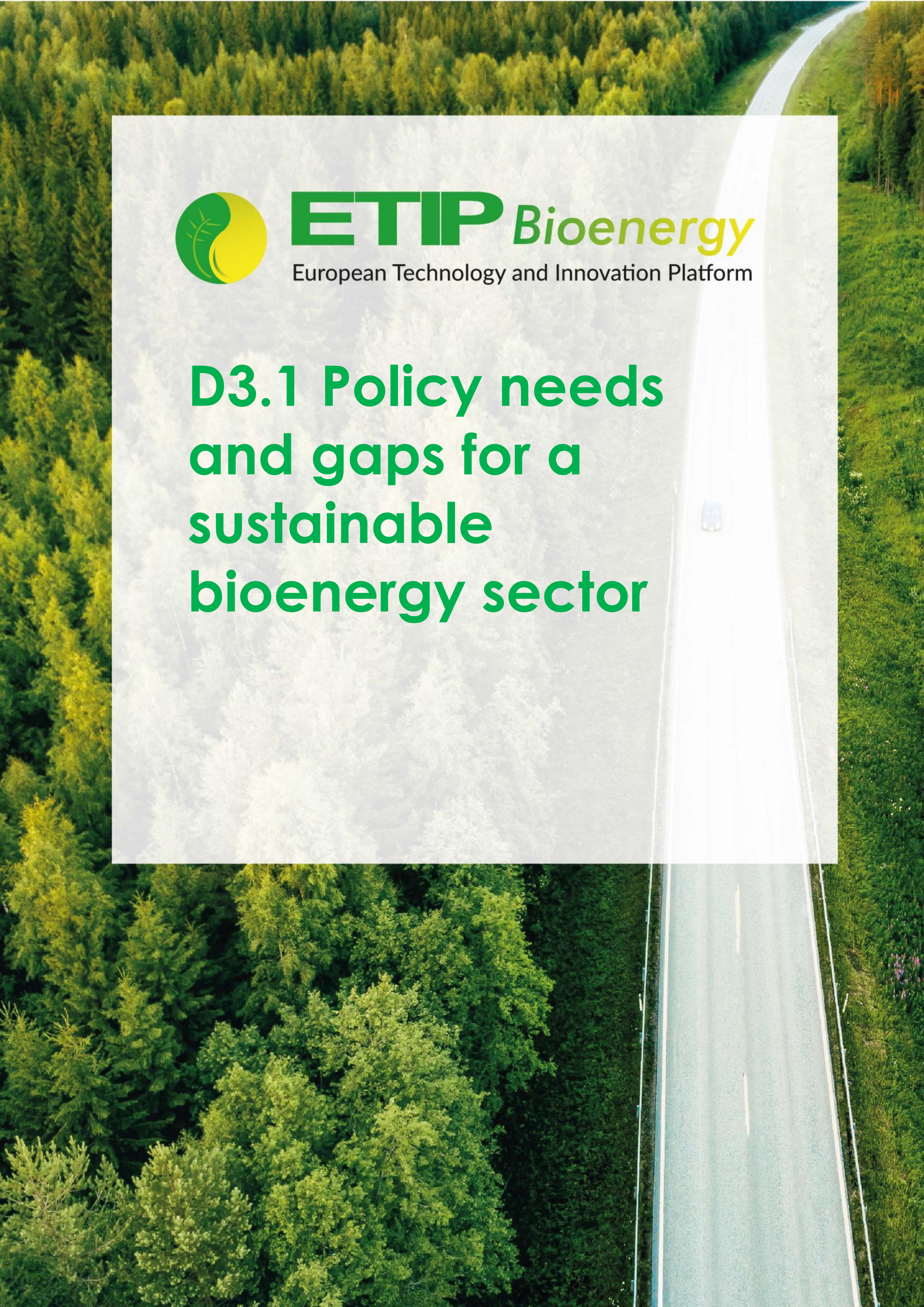

ETIP Bioenergy

European Technology and Innovation Platform

D3.1 Policy needs and gaps for a sustainable bioenergy sector

Project: ETIP-B2022-2025

European Technology and Innovation Platform Bioenergy – Support of Renewable Fuels and Advanced Bioenergy Stakeholders 2022-2025

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Policy needs and gaps for a sustainable bioenergy sector

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PROJECT PARTNERS

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CSD – Center For The Study Of Democracy, Bulgaria	CSD CENTER FOR THE STUDY OF DEMOCRACY

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Executive summary

D3.1 contains the results from feedback of relevant stakeholders that was collected at workshops and in interviews. It also summarizes the documents that used this information, like e.g. white papers or public hearings at the European Parliament. D3.1 refers to Task 3.3.

Introduction

Climate change demands swift and robust policies to achieve sustainability. Bioenergy and renewable fuels are crucial for reducing greenhouse gas emissions, decreasing fossil fuel dependency, and supporting the circular economy. Effective policies are essential for the development and deployment of these technologies.
This report builds further on the SET4BIO Report on R&D&D frameworks and following policy recommendations summarised in Summary paper for policy makers[1]. The SET4BIO report identified the following main policy gaps and recommendations:

Policy Gaps:

- Alignment Issues: Lack of alignment between national and EU research, development, and innovation (RDI) strategies and funding programs. Inconsistent data collection methods hinder effective monitoring and assessment of RDI contributions to targets.
- Support for Innovation: Insufficient support across the entire Technology Readiness Level (TRL) scale, especially in the transition from research to market deployment.
- Policy Framework Stability: Unstable and unpredictable policy frameworks fail to provide the necessary market pull for bioenergy and renewable fuels.
- Collaboration Gaps: Limited complementary collaboration at both EU and global levels, reducing the effectiveness of shared efforts and resources.

Recommendations from SET4BIO report:

- Align RDI Strategies: Harmonize national and EU RDI strategies and funding programs, ensuring synergy with industry priorities.
- Harmonize Data Collection: Standardize data collection processes to improve monitoring and assessment of RDI impacts.
- Support Across TRL Scale: Enhance support for innovation actions throughout the TRL scale, ensuring seamless transition from research to market.
- Stable Policy Framework: Establish a clear, stable, and predictable policy framework to drive market adoption of bioenergy and renewable fuels.
- Enhance Collaboration: Foster stronger collaboration at EU and global levels to leverage shared knowledge, resources, and efforts effectively.

These recommendations aim to accelerate the implementation of the Strategic Energy Technology Plan (SET Plan) and promote sustainable bioenergy and renewable fuel technologies across Europe. The work of SET4BIO was expanded through the policy needs and gaps identification carried out in ETIP B 2022-2025 as described in the following sections.

1. Policy Needs and Gaps Identification

Insights were mainly collected in three different ways: Citizens Panels, Foresight Bioenergy

[1] SET4BIO_D5.3_R&D&D_frameworks_and_policy_recommendations.pdf (etipbioenergy.eu)

2050, and an Online Stakeholder Survey.

Citizens Panels gathered diverse perspectives from citizens on bioenergy and its potential impacts.
Foresight Bioenergy 2050 explored potential future scenarios for bioenergy development and identified key drivers and uncertainties.
Online Stakeholder Survey collected a wider range of opinions and data from stakeholders involved in the bioenergy sector.

By combining these three methods, the researchers were able to obtain a comprehensive understanding of the diverse perspectives and priorities related to bioenergy. This approach helps to ensure that the insights collected are representative, relevant, and can be used to inform effective policy development and decision-making.

1.1. Stakeholder insights from the Citizen panels

As part of the citizen panels conducted with citizens from the four project countries (Task 5.2), some key issues identified were the need for knowledge-sharing and education, making circular economy measures more widespread, taking up more degrowth oriented initiatives, and enhanced cooperation with multiple stakeholders (local communities, citizens, CSOs, institutions, etc.). For a more sustainable bioenergy and biufuels sector, participatory foresight methodologies such as CIVISTI are an effective way for citizens to get informed about bioenergy and its potential developments that address important societal challenges Participants in the panels valued the implemented format as a way to foster communication between citizens, researchers and policy-makers.

1.2. Foresight Bioenergy 2050

During 2023 a foresight activity following the steps in figure 1 below was carried out to create an overview of potential and likely developments in the bioenergy sector towards 2050. As part of the ETIP-B Platform, RISE has conducted interviews and mini workshops to assess the implications of three different future scenarios on identified value chains within the bioenergy and biofuels industry. The focus has been on prioritized value chains mentioned in SRIA.

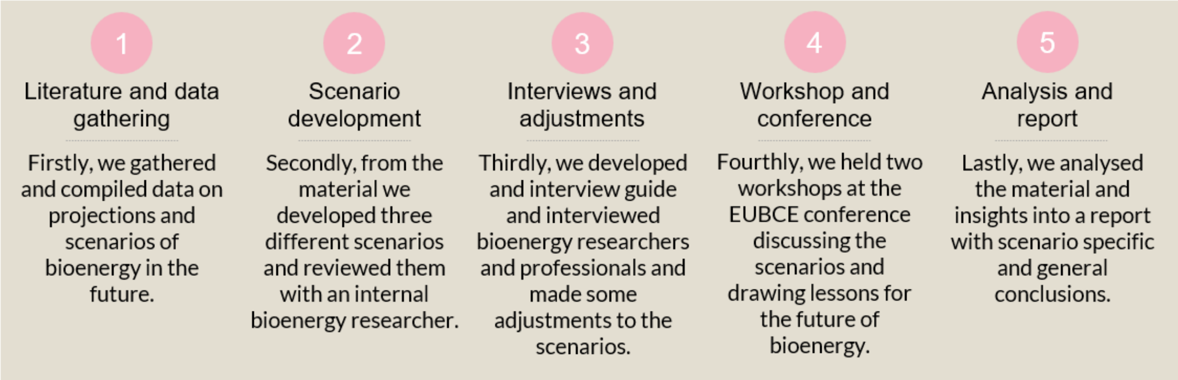


Figure 1 Foresight Methodology for Bioenergy 2050

First Experts within the area have been interviewed to develop the basis of the Bioenergy 2050 scenarios. These scenarios were thereafter tested and refined, and lessons for the future was drawn during two physical mini-workshops at the EUBCE 2023 in Bologna on 7th June 2023. The following scenarios where discussed.

Parameters	Scenario 1	Scenario 2	Scenario 3
Bioenergy - Part of the future global energy mix *(excluding biomass for process industry)*	9% (76 EJ) Availability for electricity is high and price low	42% (355 EJ) Availability for electricity is limited and price is high	17% (144 EJ) Availability for electricity is moderate and price fluctuate
Total energy landscape	Fossil-free electricity production, mainly solar and wind, has expanded significantly, providing cheap energy for rapid electrification. Advances in storage technologies mitigate fluctuations.	Most of the increase in electricity productions has been in solar, wind and bioenergy, while storage technology has failed to deliver.	Most of the increase in energy productions has been in solar and wind, while fossil-based production is still in service.
Paris target	limiting global temperature increase to 1,5°C by 2100	limiting global temperature increase to 2°C by 2100	limiting global temperature increase to 2,5C by 2100
Reduction in GHG emissions since 2019	84%	64%	24%
Reduction in transport GHG emissions since 2019	90%	70%	35%
Feedstock	Advanced biofuels derived from domestic residues, biowastes and crops on degraded land. Conventional biofuels have been phased out by 2050.	Biofuels is derived from energy crops 54%, woody biomass 18% and the rest from domestic residues. Most of the conventional biofuels have been phased out by 2050, some are still processed using palm and rapeseed oil.	The majority of these biofuels are sourced from woody biomass, comprising 53% of the feedstocl followed by waste and domestic residues, along with 3% from energy crops. Most conventional biofuels have been phased out by 2050.
Usage of bioenergy	With **all** road transport being electrified, advanced bioenergy is only used for aviation, long-haul heavy-duty vehicles, and shipping.	With **most** road transport being electrified. Advanced bioenergy is required for aviation, long-haul heavy-duty vehicles, and shipping. Additionally, bioenergy is also used for generating minor amounts of electricity.	Fossil-fuels is still used to some extend in the transport system. Advanced biofuels are used in **some** aviation and marine industries, while solid biomass is increasingly utilized for residential demand. Additionally, bioenergy is used for electricity and heat and in system services such as grid balancing.

Figure 2 Scenarios for Bioenergy 2050

Value-chain	Scenario 1	Scenario 2	Scenario 3	Comments
PVC1: Transport fuels via gasification	++++	+	++	Electrify processes to gain higher efficiency
PVC2: Power and heat via gasification		+++	+++	Not so flexible today...
PVC3: Transport fuels via pyrolytic & thermolytic conversion	++++	+	+	Methanol to jet
PVC4: Intermediate bioenergy carriers	+++	+++		Maritime
PVC5: Transport liquid fuels & fuel intermediates from fermentation	++	+++	++++	Alcohol to jet, use for energy crops in scenario 2
PVC6: Gaseous biological transport fuels	++		++	

Analysing Value Chain Usage Across Three Scenarios

Figure 3 Value chain dominance across scenarios for Bioenergy 2050

1.2.1.Scenario 1 – the Climate Triumph

In 2050, the Paris Agreement's goal of limiting global temperature rise to 1.5°C is achieved, thanks in part to the European Union's significant reductions in GHG emissions. Strict standards on imports have lowered the ecological footprint of consumption. Carbon Dioxide Removal (CDR) methods like improved forest management have enhanced biodiversity, ecosystems, employment, and livelihoods. Urban-rural disparities have diminished, improving access to necessities and technology.

Bioenergy remains at 9% of the global energy mix since 2022 and is declining. Electrification is complete for road transport, while aviation, heavy-duty vehicles, and shipping use advanced biofuels and electro fuels. Bioenergy feedstock is sourced from energy crops and waste residue. Woody biomass utilization is regulated to minimize carbon impacts.

The shift from bioenergy to solar, wind, and geothermal sources occurs, while conventional biofuels phase out by 2050. Adoption of sustainable practices has reduced biodiversity degradation, restored degraded land, and improved soil carbon and water availability. Forest productivity has increased by 10%, and the EU has surpassed its land use and forestry removal targets. Sustainable wood supply meets the demand for construction, non-energy products, and bioenergy.

Agriculture and forest land haven't expanded since 2020. A New Green Deal, established in 2030, aims for carbon neutrality by 2050. Member States collaborate and utilize EU funds for climate change programs.

In scenario 1, gasification for large-scale methanol production is highlighted, which can be used in shipping, aviation, and the chemical industry. Methanol can be produced from various raw materials, including biomass, captured carbon dioxide, and hydrogen. Value chains converting methanol will be more widely used. Methanol can serve as an intermediate for hydrocarbons to produce aviation fuel or olefins for the chemical industry. The transportability and cost-effectiveness of liquid methanol make it preferable to other biomass options such as LPG and ammonia. This would require large facilities close to the raw material source to achieve cost efficiency.

Electrofuels, produced using renewable electricity, can offer sustainable and carbon-neutral options in aviation and maritime sectors. Methanol-to-jet processes are gaining momentum, and another option is Fischer-Tropsch, providing similar products but lacking flexibility and distributed capabilities.

Renewable marine diesel from gasification methods could also be used for shipping, as marine engines are not very sensitive to fuel types. Advanced value chains may not be feasible from a cost perspective, making HVO or hydrogen-treated pyrolysis oil more viable options. Biogas from difficult-to-handle wet waste materials is expected to remain a useful energy source through anaerobic digestion.

Given the abundance of cheap or cost-effective electricity and electrofuels in this scenario, value chains heavily reliant on high hydrogen usage, such as hydrogenation of various bio-oils (HTL PVC3), could have a competitive advantage. PVC6 could also benefit from cheap electricity. The 1.5-degree goal is likely to be surpassed, requiring significant efforts not currently being made.

Parameters	
Bioenergy - Part of the future global energy mix	9% (76 EJ) Availability for electricity is high and price low
Paris target	limiting global temperature increase to 1,5°C by 2100
Reduction in GHG emissions since 2019	84%
Reduction in transport GHG emissions since 2019	90%
Reduction in agricultural GHG emissions compared to 1990 levels	85%
Feedstock	Advanced biofuels derived from crops, domestic residues and biowastes, on degraded land, together with electro fuels. Conventional biofuels have been phased out by 2050.
Usage of bioenergy	With all road transport being electrified, advanced bioenergy is only used for aviation, long-haul heavy-duty vehicles, and shipping.

1.2.2. Scenario 2 – Balancing Success and Sustainability in a Polarized World

By 2050, bioenergy dominates the energy landscape, constituting 42% of global consumption. Achieving the Paris target of limiting temperature increase to 2°C by 2100 is credited to a 64% reduction in GHG emissions and carbon neutrality by 2050. Consumption patterns shift, causing a divide between urban elites and rural areas. Small-scale bioenergy systems thrive in rural regions, creating jobs and economic growth but also leading to land competition and social conflicts.

The New Green Deal, initiated in 2030, focuses on carbon neutrality by 2050. While bioenergy has been heavily regulated over the years, its implementation was initially poor in the early 2020s, and policymakers continue to grapple with competing demands on land and potential conflicts with food security. Increased bioenergy usage contributes to deforestation, biodiversity loss, and soil erosion, despite regulations on forest harvest.

Advanced biofuels is derived from woody biomass which make up 18%, energy crops 54% and the rest from domestic residues. Most of the conventional biofuels have been phased out by 2050 but some are still processed using palm oil and rapeseed oil. Electrification prevails in most road transport, while some road transport, aviation, heavy-duty vehicles, and shipping rely on advanced bioenergy. Additionally, bioenergy is also used for generating minor amounts of electricity. The short-term benefits of bioenergy align with the Paris target, but the drawbacks include polarization, declining biodiversity, and soil quality. Strict regulations and sustainable practices are essential.

A bioenergy share of 40% in the energy mix is considered unlikely. In this scenario, it is probable that a significant amount of biomass will still be used for combustion compared to scenario 1, where biomass is insufficient, and its usage is prioritized where it is truly needed.

Refining techniques vary depending on the type of crops used. However, for oil crops, traditional value chains such as HVO (hydrotreated vegetable oil) and HEFA (hydroprocessed esters and fatty acids) are likely to dominate for aviation.

To achieve such high levels of bioenergy, relying solely on by-products and waste will not suffice. Efficient land use is crucial to enable high biomass production levels and avoid negative consequences of overexploitation. Maximizing raw material efficiency becomes paramount in this scenario. One possible approach is to cultivate energy crops in winter and food crops in summer. The choice of crops will depend on soil and climate conditions, varying from country to country.

To harness the potential of raw materials mentioned in this scenario (which are more or less new to the industry), new technologies are needed since current utilization rates are not sufficient. It is essential to effectively manage and allocate biomass resources to prevent conflicts and ensure sustainable utilization.

When comparing value chains for ethanol and biogas, there is a slightly more marginal advantage for value chains related to ethanol and biogas processes. Coal-based facilities are being converted to use pellets (PVC4) in this scenario. Water consumption will be a significant concern for this scenario, requiring careful consideration and management.

Parameters	
Bioenergy - Part of the future global energy mix	42% (355 EJ) Availability for electricity is limited and price is high
Paris target	limiting global temperature increase to 2°C by 2100
Reduction in GHG emissions since 2019	64%
Reduction in transport GHG emissions since 2019	70%
Reduction in agricultural GHG emissions compared to 1990 levels	55%
Feedstock	Biofuels is derived from energy crops 54%, woody biomass 18% and the rest from domestic residues. Most of the conventional biofuels have been phased out by 2050, some are still processed using palm and rapeseed oil.
Usage of bioenergy	With **most** road transport being electrified. Advanced bioenergy is required for aviation, long-haul heavy-duty vehicles, and shipping. Additionally, bioenergy is also used for generating minor amounts of electricity.

1.2.3.Scenario 3 – A World Adapting to a Changed Future

By 2050, global temperatures have risen by 2.5°C, missing the Paris target. GHG emissions have only reduced by 29% since 2019, with a 20% reduction in agricultural emissions. Climate change impacts primary production, but efforts to protect biodiversity and halt species extinction have intensified. The impact of climate change on primary production has been severe, with pest diseases, droughts, and other extreme weather events ravaging the environment.
Consumer patterns shift, reducing animal protein consumption in the EU. COVID-19 leads to decreased business travel and commuting. The rural-urban gap narrows, and wood supply from EU forests meets demand, though imports rise. Imports of wood have also increased to keep up with demand, and policies on carbon impacts have been weakly enforced due to pressure from the forestry, wood products, and bioenergy sectors.
The European Green Deal goals face funding and implementation challenges, impacting bioenergy regulations. Bioenergy provides heat in rural areas and is used in aviation, marine industries, residential demand, and grid balancing. Uncertainty surrounds the future of

bioenergy, requiring policymakers to balance risks and benefits.
By 2050, fossil-fuels is still used to some extend in the transport system and bioenergy accounts for 17% of the global energy mix, with woody biomass as the primary feedstock and some percentage of energy crops. Advanced biofuels are increasingly used in aviation and marine industries. Biomethane is also playing a small role in industrial processes and heat. Additionally, bioenergy is used for electricity in system services such as grid balancing. Conventional biofuels phase out by 2050.
Scenario 3 predicts that biomass will be extensively utilized in combined heat and power (CHP) plants, where it will be burned to produce both electricity and heat. This suggests that biomass will play a significant role in energy production within the power sector.
In this scenario, value chains involving bio-oil become entirely irrelevant, and even alcohol value chains are not particularly interesting. For aviation, the focus may shift towards HVO (hydrotreated vegetable oil) and then transition to HEFA HVO or alcohol-to-jet fuels. As for maritime transport, pyrolysis oil or other suitable alternatives might be utilized, considering that the engines can withstand certain variations.
Notably, stem-wood will only be utilized for other products before its use in bioenergy within this scenario.

Parameters	
Bioenergy - Part of the future global energy mix	17% (144 EJ) Availability for electricity is moderate and price fluctuate
Paris target	limiting global temperature increase to 2,5°C by 2100
Reduction in GHG emissions since 2019	24%
Reduction in transport GHG emissions since 2019	35%
Reduction in agricultural GHG emissions compared to 1990 levels	40 %
Feedstock	The majority of these biofuels are sourced from woody biomass, comprising 53% of the feedstock, followed by waste and domestic residues, along with 3% from energy crops. Most conventional biofuels have been phased out by 2050

Usage of bioenergy	Fossil-fuels is still used to some extend in the transport system. Advanced biofuels are used in **some** aviation and marine industries, while solid biomass is increasingly utilized for residential demand. Additionally, bioenergy is used for electricity and heat and in system services such as grid balancing.

1.2.4. General conclusions from the Foresight Bioenergy 2050

Information from the interviews and workshops was assessed. As a result, the following general conclusions can be drawn.

Flexible and universally applicable value-chains are preferred. The preference lies in value chains that are flexible and versatile, capable of functioning with various raw materials and existing infrastructure/fuel systems. Due to the diversified nature of biomass, multiple technologies will be employed, tailored to different feedstocks such as sewage sludge, wood chips, or grass, depending on geographical availability. However, developing flexible technologies is more expensive, whereas less flexible ones are cheaper to develop and can be made more efficient. Moreover, the ever-changing list of approved feedstocks poses challenges in developing a cost-effective bioenergy technology.

Investments are directed towards electrofuels despite it might not be the most effective technology. Some system analysis comparing costs between bio-methanol and electrofuels demonstrates that investing in gasification is much more cost-effective. Gasification and intermediate value chains, will be highly robust and versatile. Gasification's efficiency makes it a valuable candidate for increased dominance in the future. If electrification progresses as planned, it will bring about electrofuels and hydrogen-based solutions, and by then biomass will be strategically integrated where it makes the most sense.

Future requirements for renewable raw materials in the chemical industry. Chemical industry currently lack requirements for 'scope 3' emissions, which for example includes the materials purchased and used to manufacture products and goods in the industries. Companies often overlook these emissions in their sustainability goals for 2030, which could account for as much as 80% of their overall impact. Increased requirements and demand for renewable raw materials would lead to higher competition for biomass but could also result in positive synergies from process facilities. With the introduction of the Corporate Sustainability Reporting Directive (CSRD Directive) by 2030, this could soon become a reality.

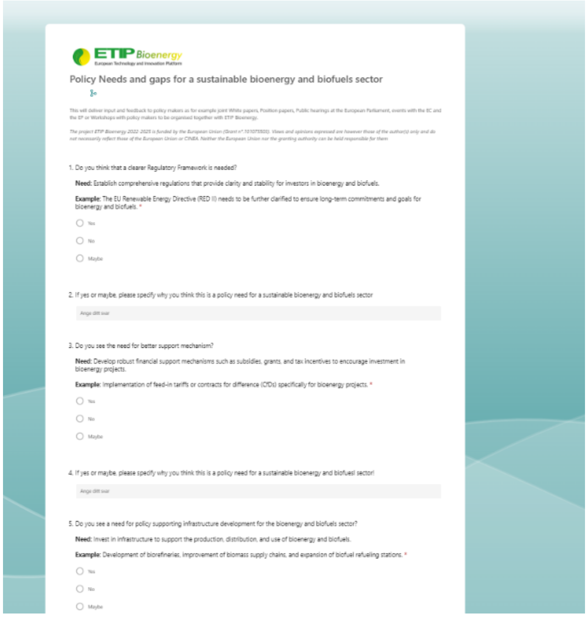
Locally sourced biomass and energy can secure national electricity supply. Uncertainty may favour the "locally sourced" energy sector if large global energy supply chains, where flexibility and breadth provide security, can't be counted on. Moving towards a more decentralized and locally distributed approach may result in higher costs, but it brings reassurance, reliability and national or regional sovereignty.

Liquid biofuel dominates, but the use of gas is expected to increase. The dominant existing infrastructure in the transport sector is designed to handle liquid fuels. If a transition to gas-based fuels occurs, significant changes to the infrastructure are needed to support this shift. This implies that liquid bioenergy fuels are likely to be preferred to facilitate a smooth and cost-effective transition. In the aviation sector, the use of liquid fuels, increasingly bio-based, is expected to continue. In maritime transport, the use of gas products is anticipated to rise, but liquid fuels will remain an essential source of energy.

Importance of increased acceptance and willingness to pay from society. Many researchers have a positive outlook on the advancement of technology and research within bioenergy. However, they do recognize challenges that might impede its development. One prominent concern revolves around the acceptance and willingness of society to pay for a transition towards renewable energy sources.

1.3. Online survey

An online survey was carried out during spring/early summer 2024.



Policy Needs and gaps for a sustainable bioenergy and biofuels sector

This will deliver input and feedback to policy makers as for example joint White papers, Position papers, Public hearings at the European Parliament, events with the EC and the EP or Workshops with policy makers to be organised together with ETIP Bioenergy.

The project ETIP Bioenergy 2022-2025 is funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them

1. Do you think that a clearer Regulatory Framework is needed?

Need: Establish comprehensive regulations that provide clarity and stability for investors in bioenergy and biofuels.

Example: The EU Renewable Energy Directive (RED II) needs to be further clarified to ensure long-term commitments and goals for bioenergy and biofuels. *

Yes
No
Maybe

2. If yes or maybe, please specify why you think this is a policy need for a sustainable bioenergy and biofuels sector

Ange ditt svar

3. Do you see the need for better support mechanism?

Need: Develop robust financial support mechanisms such as subsidies, grants, and tax incentives to encourage investment in bioenergy projects.

Example: Implementation of feed-in tariffs or contracts for difference (CfDs) specifically for bioenergy projects. *

Yes
No
Maybe

4. If yes or maybe, please specify why you think this is a policy need for a sustainable bioenergy and biofuesl sector!

Ange ditt svar

5. Do you see a need for policy supporting infrastructure development for the bioenergy and biofuels sector?

Need: Invest in infrastructure to support the production, distribution, and use of bioenergy and biofuels.

Example: Development of biorefineries, improvement of biomass supply chains, and expansion of biofuel refueling stations. *

Yes
No
Maybe

Figure 4 Picture of the online survey

1.3.1. Summary of Survey Results on Policy Needs for Sustainable Bioenergy and Biofuels

Below is a summary of the Key Findings of the online survey

- Regulatory Framework: A clear and comprehensive regulatory framework is essential for sustainable bioenergy and biofuels development.
- Financial Support: Subsidies, grants and tax incentives are needed to encourage investment in bioenergy projects.
- Specific Policy Priorities:
  - Update research results and address long-term industry policies.
  - Improve investor confidence and promote sustainability criteria.
  - Create a favorable policy environment and simplify investment processes.
- Infrastructure: Policies supporting infrastructure development, such as biorefineries and refueling stations, are necessary.
- Research and Innovation: Increased funding for R&D in advanced biofuels and bioenergy technologies is crucial.
- Policy Clarity and Harmonization: Clearer policies, sustainability criteria, and harmonization across EU member states are needed to address barriers for cross-border trade and project development.
- Market Incentives: Insufficient market incentives compared to fossil fuels and other renewables need to be addressed.
- Market Barriers: Overcoming barriers like extra infrastructure costs, expertise shortages,

rural area challenges, and competition from traditional energy sources is essential.

- Integration with Other Sectors: Policies integrating bioenergy with agriculture, waste management, and forestry are needed.
- Public Awareness: Increased public awareness and acceptance of bioenergy and biofuels are crucial for market uptake and policy support.
- Data and Monitoring: Standardized and comprehensive data collection is necessary for monitoring progress and impacts.

Overall, the survey results highlight a significant demand for stronger policy measures to address these challenges and enable the sustainable growth of the bioenergy and biofuels sector.

2. Policy Needs and gaps for a sustainable bioenergy and biofuels sector

The assessment of the information gathered as described in section 2 resulted in needs and gaps as described hereafter.

Policy needs

The need for stable and clear policy frameworks has been a central point in discussions over decades starting on national level and on the European level with the launch of the first version of the Renewable Energy Directive in April 2009. On national levels the policy schemes have often been short term and relying on tax reduction and later on blending mandates/reduction quotas. In general there is a clear need to develop policies and adjust given improved knowledge and increased complexity. Too many changes will however risk investments since comprehensive long term policy support is still needed to be able to compete with the cheaper fossil energy that still dominates the markets that bioenergy is aiming towards. A summary of identified needs and gaps is described below.

Clear Regulatory Framework

Need: Establish comprehensive regulations that provide clarity and stability over time for investors in bioenergy and biofuels.
Example: The EU Renewable Energy Directive needs to be further clarified to ensure long-term commitments and goals for bioenergy and biofuels. The different regulations need to be more interconnected to ensure that complexity and uncertainty is minimized.

Support Mechanisms

Need: Develop robust financial support mechanisms such as subsidies, grants, and tax incentives to encourage investment in bioenergy projects.
Example: Implementation of feed-in tariffs or contracts for difference (CfDs) specifically for bioenergy projects.

Infrastructure Development

Need: Invest in infrastructure to support the production, distribution, and use of bioenergy and biofuels.

Example: Development of biorefineries, improvement of biomass supply chains, and expansion of biofuel refueling stations. The major cost item for the bioenergy value chain is the production facilities. To reduce the risk investment support is needed for this part.

Research and Innovation Support

Need: Increase funding for research and development (R&D) in advanced biofuels and bioenergy technologies. **Example:** EU Horizon Europe funding allocated to advanced biofuel technologies and demonstration projects. Continued support is needed in order to develop new technologies that can support development of sustainable and efficient value chains.

Sustainability Criteria

Need: Implement and enforce stringent, clear and fair sustainability criteria to ensure that bioenergy and biofuels contribute positively to environmental goals.

Example: Enhanced sustainability certification schemes for biomass sources, ensuring minimal impact on biodiversity and food security. Any sustainability criteria must be based on a sound level playing field approach in order to ensure a fair competition in the market. Sustainability criteria that is transparent, comprehensive and easy to understand could increase the trust in bioenergy value chains.

2.1. Policy Gaps

Lack of Harmonization

Gap: Inconsistent policies and regulations across EU member states create barriers for cross-border trade and development of bioenergy projects.

Example: Variations in sustainability criteria and subsidies for biofuels between member states. Varied implementation efforts of member states increase uncertainty.

Market Barriers

Gap: Insufficient market incentives for bioenergy and biofuels compared to fossil fuels and other renewables.

Example: Lack of competitive pricing mechanisms for biofuels that can match the market presence of conventional fuels. Need to close the cost gap to ensure that bioenergy and biofuels can contribute with its part to the energy supply and demand.

Integration with Other Sectors

Gap: Poor integration of bioenergy policies with other sectors such as agriculture, waste management, and forestry.

Example: Limited policies promoting the use of agricultural residues and waste for bioenergy production. Bioenergy and Biofuels can play an important role in other sectors with improved energy security and reduced emissions and more. Sector integration would likely need to a stronger business case for the bioenergy and biofuels sector as having multiple market outlets leads to stability and protection from swings in single markets. The cascading principle is crucial to ensure that bioenergy is an integrated part of the above-mentioned sectors.

Public Awareness and Acceptance

Gap: Low public awareness and acceptance of bioenergy and biofuels hinder market uptake and policy support.

Example: Insufficient public information campaigns highlighting the benefits and sustainability of bioenergy. Lack of system perspective in the energy debate in society.

Data and Monitoring

Gap: Lack of standardized and comprehensive data collection for bioenergy and biofuels, making it difficult to monitor progress and impacts. Example: Fragmented reporting systems across member states lead to incomplete data on bioenergy production and use. Lack of or fragmented data leads to uncertainty of the current role as well as the future role for bioenergy and biofuels.

3. Recommendations

Considering the above mentioned policy needs and gaps, the following recommendations can be made.

An overall goal shall be to provide a policy framework that will lead to a competitive bioenergy sector in Europe. Thus, providing the prerequisite to make bioenergy more profitable compared to fossil energy. In order to achieve this it is crucial to streamline the policies and provide incentives that will unlock the potential contribution that bioenergy has linked to a wide range of areas. These areas are defossilisation of transport and other sectors, reduced emissions of carbon dioxide, improved energy security through less imports of fossil energy, job creation throughout Europe and improved social aspects through citizen involvement in energy supply.

Advanced biofuels and bioenergy have a clear role to play as longterm permanent solutions in the shipping and aviation sectors. This is highlighted in the work on FuelEU Maritime and ReFuelEU Aviation. The focus on these sectors is important however it is equally important to continue to focus on the role in the road sector as the primary track of electrification takes time and is uncapable of addressing the current fleet of vehicles and long distance segments.

Continued support to research and innovation in accordance with the targets of the SET Plan to reduce cost and CO2 emissions and increase energy efficiency of value chains remains a high priority. In addition to developing technologies, comprehensive and well-defined policies and policy development is needed. The policy landscape in Europe is in general very complex and the bioenergy sector needs more clarity and less fragmented policies. The complex societal challenges where Europe needs to handle competitiveness, sustainability, security, defence and more presents a very complex and uncertain market development. It should however be very clear that many of the problems stems from the use of fossil energy and that a multitude of technologies including bioenergy can contribute to reduced use of fossil energy in EU. Thus, it is essential to include a comprehensive system perspective where sustainable energy technologies can contribute with their respective share.

Integrate the different policy initiatives and strategies (Net Zero Industry Act, Critical Raw Materials Act; SET plan, REPowerEU, etc) in a more comprehensive way and avoid overregulating and overcomplicating the market conditions for sustainable energy technologies. Policy interventions that support sustainable technogies would also benefit from more clearer regulations that phase out and step by step limit the market for all types of fossil energy going forward.

The transport sector which still is relying heavily on fossil energy will need to transition fast if set targets should be met. In this transition a new realistic mindset is needed where bioenergy will take a significant share during the transition and permanently for sectors where electrification is less suitable.

Implement local, national and EU-level policy co-creation initiatives that involve citizens in the policy-making process, taking into account the local socio-cultural dynamics. An integrated approach to citizen engagement is needed in order to ensure inclusive and effective involvement throughout the policy-making process - from vision-making to its implementation.

4. References

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