

D6.1: Report on description of baseline scenario for EU bioeconomy and of alternative scenarios for EU's bioeconomy future

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Monitoring the Bioeconomy



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Summary

Bioeconomy is very important for the European transition to circular and low carbon societies however the multiple and interrelated economic sectors involved increase the complexity of metrics and constraint the comparability of the various options. With the new Green Deal, announced in the end of 2019 as Europe's response to climate and environmental-related challenges, the need for improved knowledge and foresight capacities to guide policy and decision making is now more prominent than ever.

One of the research topics in the BioMonitor project, is to quantify the bioeconomy's environmental, economic, and social impacts in the EU and its Member States and perform scenario based quantitative and qualitative assessment to inform future policy making in this domain.

This report presents the baseline (BioMonitor Reference Scenario- BRS) and the alternative scenarios that will be used to analyse the development of the bioeconomy in Europe and give model-based evidence on the potential impacts of policy, technological changes and consumer preferences.

Scenario results will be quantified (using policy relevant bioeconomy indicators from the ones developed in WP1) in WP3 (ex-post) and WP5 (ex-ante) and will be disseminated by infographics in WP9. In this report there are two Appendixes. Appendix 1 provides an overview of the current policy landscape for EU bioeconomy by sector and value chain stage (i.e. land use & biomass production, conversion, distribution, end use). The information will be used as the basis for the work in Tasks 6.3 and 6.4 to understand which policies per value chain stage need to be included in the Biomonitor scenario analysis. Appendix 2 attempts to translate the existing set of directives, standards, policies and strategies that (in)directly relate to the EU bioeconomy into 'model' language. To do so it outlines a non-exhaustive list of drivers that impact policy relevant modelling for the current EU policies.

The deliverable will remain a working document throughout the project duration to ensure input from stakeholders and all relevant updates from WPs 1-5 and any changes or updates of relevant policy are integrated during the project.



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1 Introduction

1.1 Bioeconomy in the wider European policy context

Bioeconomy offers significant opportunities for a transition to sustainable production and demand patterns that at the same time can steer growth that respects the planetary boundaries. Therefore, it is in line with the wider European policy context including:

- The **European Green Deal** (COM(2019) 640 final) is the new sustainable growth strategy that aims to transform every aspect of the European economy, environment and society, including energy use, food use, production and consumption of products. Bioeconomy is included to the integral part of the Commission's strategy to implement the United Nations 2030 Agenda and the Sustainable Development Goals.
- The **Recovery plan for Europe** post Covid-19. European Commission aims to deploy a reinforced EU budget to help repair the immediate economic and social damage brought by the coronavirus pandemic, kickstart the recovery and prepare for a better future for the next generation. **Next Generation EU** with €750 billion as well as targeted reinforcements to the long-term EU budget for 2021-2027 will bring the total financial firepower of the EU budget to €1.85 trillion.
- The economic transition towards a climate-neutral economy as outlined in the **2050 Long-term Strategy** (COM(2018) 773 A Clean Planet for all), in line with the Paris Agreement objective to keep the global temperature increase to well below 2°C and pursue efforts to keep it to 1.5°C, is closely linked to the bioeconomy. On the one hand, it contributes reducing emissions and resource intensity from the food system and other biomass usages. On the other hand, it provides carbon sinks and contributes to the decarbonisation of the industry with clean (bio)technology.
- The new **Circular Economy Action Plan** leads the way to transform the European production and consumption system to reduce its environmental footprint and, among others, create new, circular and bio-based business opportunities.
- With a view to the importance of the agrifood sector in the bioeconomy, the new **Farm to Fork Strategy** and the **Biodiversity Strategy** will be instrumental to support the food security and environmental sustainability objectives of the bioeconomy.
- For the bioeconomy as a dynamic and partly infant industry, the EC's Action Plan on **financing sustainable growth** can be a central tool to re-orientate capital flows towards sustainable investments.

The updated EU Bioeconomy Strategy (European Commission, 2018) aims to develop a sustainable bioeconomy for Europe, strengthening the connection between economy, society and the environment. The update revalidates the five objectives of the 2012 Bioeconomy Strategy:

1. Ensuring food and nutrition security
2. Managing natural resources sustainably
3. Reducing dependence on non-renewable, unsustainable resources whether sourced domestically or from abroad
4. Mitigating and adapting to climate change
5. Strengthening European competitiveness and creating jobs.



While the objectives remain the same, they are accompanied by three new main action areas:

1. Strengthen and scale-up the bio-based sectors, unlock investments and markets
2. Deploy local bioeconomies rapidly across Europe
3. Understand the ecological boundaries of the bioeconomy

To guide policy making, knowledge and foresight capacities are important, as highlighted in the Staff Working Document linked to the updated EU Bioeconomy Strategy, which states the need to "improve the knowledge base (data, information and tacit knowledge) on all areas of the bioeconomy and a forward-looking capacity (modelling, foresight exercises, scenarios), as essential elements for providing the evidence needed to support policy makers and for underpinning policy coherence" (Commission SWD/2018/431).

In this context, the overall objective of the BioMonitor project is to establish a robust and effective framework to develop statistics and modelling tools for the bioeconomy. This framework will enable the quantification of the bioeconomy and its economic, environmental, and social impacts in the EU.

1.2 BioMonitor and WP6

WP6 is the work package that will bring together the policy related analysis based on the BioMonitor Data Platform and the BioMonitor Model Toolbox developed in WPs 1 to 5. This will be done by developing storylines and narratives and use the specific scopes of the models in the BioMonitor Model Toolbox, (AGMEMOD and BioMat, EFI-GTM and EFI-Scen, MAGNET) to analyse their impacts to the development of the bioeconomy in Europe till 2030 and 2050. The analysis will use a set of indicators, that will be selected for their policy relevance from the ones reported in Deliverable D1.1¹.

The aim of this report is to present the baseline, the BioMonitor Reference scenario, as well as storylines and respective narratives of alternative scenarios that will be used in the BioMonitor project to analyse the development of the bioeconomy in Europe.

The project team decided to take scenarios from the Global Energy and Climate Outlook^{2, 3}(GECO) as inspiration for the BioMonitor scenarios. This is considered as best suited to the work in the project since the (EU) Reference scenario is used by multiple Commission services across sectors and therefore ensures both relevance of the BioMonitor scenarios to policy makers but also wider

¹ http://biomonitor.eu/wp-content/uploads/2019/10/BioMonitor_Deliverable_1.1_Update_1.pdf

² <https://ec.europa.eu/jrc/en/publication/baseline-global-energy-and-climate-outlook>. The "Global Energy and Climate Outlook" (GECO) is a recurring publication of the JRC. Based on quantified assessment by the JRC's internal energy-economics teams, GECO provides a global picture of energy markets as they transform over the next decades, under the simultaneous interactions of economic development, technological innovation and climate policies. GECO brings together decades-long expertise in the fields of energy production, energy trade, technological development and energy system transformation, GHG emissions mitigation strategies, economic development and data analysis.

³ <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/global-energy-and-climate-outlook-2019-electrification-low-carbon-transition>



acceptance of the baseline assumptions⁴. Other transition pathways, included in GECO – for example keeping the global temperature increase to 2°C and to 1.5°C - are expected to be consistent with the EU's Green Deal⁵ for mitigation options and low carbon futures, which is regarded as one of the guiding policies for the development of bioeconomy within the timeline of the Biomonitor project. Moreover, the GECO scenarios are updated periodically, which should help to ensure the timeliness of the current project with respect to expected market developments.

Chapter 2 of this report presents the BioMonitor Reference scenario, the storylines and the respective narratives of the alternative scenarios and describes policy relevant questions that will be answered in the Biomonitor impact assessment. Chapter 3 provides an overview of the drivers and indicators for the future development of bioeconomy and outlines their use in modelled scenarios and policies informed so far. Finally, Chapter 4 concludes the deliverable with the foreseen work that will link to the impact assessment.

Appendix I outlines the current policy framework.

Appendix II presents the Biomonitor drivers grouped by their use in current EU policies and value chain stages.

Appendix III presents the type (qualitative, quantitative) and the definition of indicators.

⁴ Latest application of GECO in the context of the bioeconomy, see https://publications.jrc.ec.europa.eu/repository/bitstream/JRC118064/jrc_techreport_bioeconomy2050_online.pdf

⁵ https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en



2 BioMonitor Reference Scenario, storylines and narratives

2.1 Policy relevant questions answered by the scenarios

The scenarios in BioMonitor are designed to inform the ongoing policy relevant discussions for the bioeconomy and its sustainable development in the wider European policy context. The aim of the work is to illustrate how different levels of policy ambition can impact on the economic, environmental and social dimensions of sustainability and to quantify the trade-offs and synergies associated with each of these metrics within different bioeconomy ‘futures’.

The integrated assessment is expected to provide answers for the groups of storylines and narratives on the performance of the bio-based economy and the respective economic (turnover, value added, etc.), environmental (GHG, energy and carbon use, land and water use, etc.) and socio-economic (employment, etc) impacts from external drivers like:

- Climate change
- Land use management and biomass availability
- Economic development
- Technology and innovation
- Consumer preferences and demographic development
- Policy

Intra-trade options will also be explored.

2.2 BioMonitor Reference Scenario

A single baseline or ‘business-as-usual’ scenario for the EU bioeconomy will be analysed in the project, building upon the scope as set in WP1. This scenario will serve as reference for measuring the impacts of alternative scenarios for bioeconomy futures (see section 2.3). The scenario is called the *BioMonitor Reference Scenario* (BRS) and assumes a continuation of current policies, regulations and market trends on the future situation of the bioeconomy production, usage and trade until 2030 with projections to 2050.

The time horizon considered in the BRS reflects current policy and future target setting. Within the policy arena in Europe (especially within energy and climate policy), both 2030 and 2050 serve as a point of reference and this that has also been adopted within the BioMonitor project.

The guiding criterion behind the BRS is to characterise within the BioMonitor modelling platform, a continuity of existing trends and social attitudes in the absence of any drastic course change by society (i.e., in terms of expected macroeconomic growth trends, population, technology change,



climate change, consumption patterns). Moreover, the BRS should encapsulate a series of reasonable biomass-related public policy instruments (i.e., agricultural policy, energy policy, trade policy), whose evolution and design, as far as feasibly possible, reflects current and anticipated developments. The possibility to include to BRS, where possible, a harmonised set of assumptions regarding market developments (i.e., output, trade) for key biobased sectors (e.g., agriculture, bioenergy, forestry) across all models will be investigated. At the current time, a greater degree of certainty on public policy design is available to 2030. Beyond this point (i.e., 2050), some degree of critical thought will be required to decide on 'reasonable assumptions' (i.e., budget limits for policy, reasonable blending rates for bio-based energy inputs etc.).

As mentioned above a key source for the design and implementation of the BRS is the GECO status quo baseline⁶, which is applied in the Global Energy and Climate Outlook (GECO) to 2050, published by the European Commission's Joint Research Centre (Keramidas *et al.*, 2018; Weitzel *et al.*, 2019, Keramidis *et al.*, 2020).⁷ The GECO has also been employed to bioeconomy impact assessment scenarios toward 2050 (M'barek *et al.*, 2019, Philippidis *et al.*, 2020).

Applications of the GECO status quo baseline provide projections for indicators, such as the share of renewable energy sources or levels of energy efficiency, at five-year time intervals up until 2050 for world regions as a whole and for each EU country. In the spirit of the above discussion, the macroeconomic, energy and emissions assumptions for the BRS are taken from the GECO status quo scenario, which assumes that progress in energy markets (i.e., decarbonisation, decoupling of energy usage from energy consumption, shifting of energy carriers toward electrification) is purely driven and justified by the dynamics of market force pressures (i.e., depletion of fossil resources) and anticipated technology change, with no additional climate agreements beyond 2017, nor investment strategies that promote a more responsible and sustainable model of growth. The macroeconomic, population, fossil energy prices and emissions trends, therefore follow 'business as usual' projections in the absence of any unanticipated economic shocks, or radical (inter-) governmental policy prescriptions. Employing additional secondary data sources and assumptions, the scenario is enriched by specific assumptions for energy sectors. The exogenous drivers embedded within the BRS are presented in Chapter 3 (Table 2). This series of drivers may be further refined after discussion with the stakeholders and during model runs.

2.3 Alternative scenarios

The BRS serves as a basis for assessing the impacts of two alternative groups of storylines, each subdivided into two narratives which diverge gradually from the BRS starting from 2020. This means that BioMonitor will look at four scenarios (

Figure 1 Biomonitor storylines and narratives).

⁶ <https://data.europa.eu/euodp/en/data/dataset/energy-modelling>

⁷ A more detailed discussion is available online from Keramididas *et al.*, (2018).



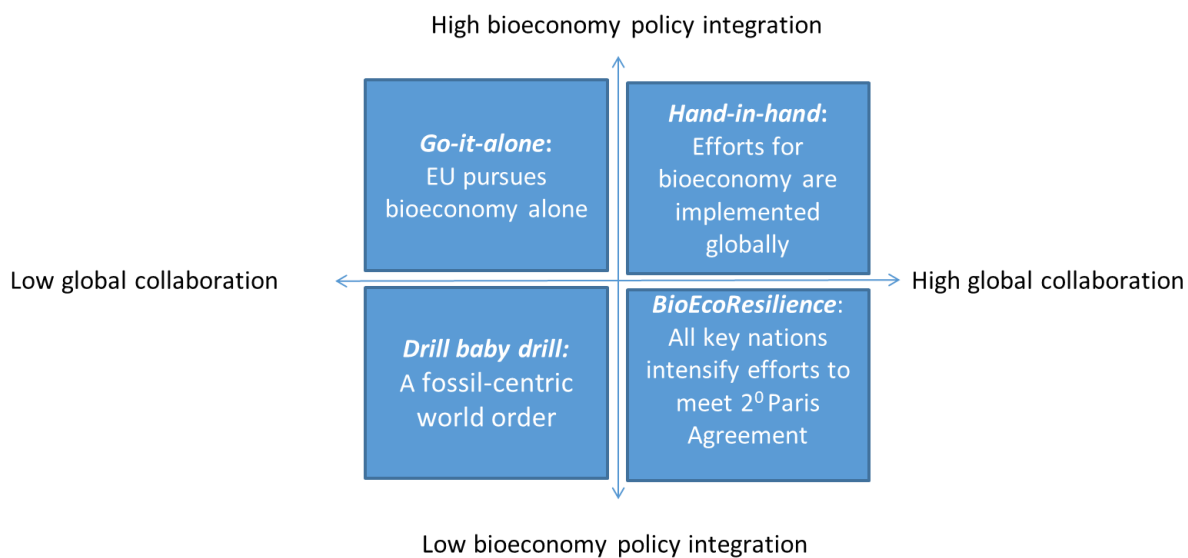


Figure 1 Biomonitor storylines and narratives

Detailed description for each of these storyline groups and narratives is provided below. In Table 2, a series of exogenous drivers are listed (may be further revised) that serve as an illustration of the mechanisms available to modellers for characterising each narrative. The scenarios draw on the GECO scenarios, but also consider elements from other international scenario storylines (e.g. O'Neill et al. 2017, Daigneault et al. 2019).

Storyline 1: Pursuing the BioEconomy

In this storyline, the focus is on the empowerment of bioeconomy as a policy objective for social, economic and environmental change. This is explored through policies designed to promote this collective of activities. The ethos behind the first storyline is to test the responsible limits of 'bio-centric dependence' in terms of its contribution to a more sustainable, circular bioeconomy. This storyline builds on the updated European Union (EU) Bioeconomy Strategy (European Commission, 2018), which emphasises circularity to complement and reinforce the EU's Circular Economy Action Plan (European Commission, 2019). In this storyline, we take a layered approach to the alternate narratives. In the 'Go-it-alone', we examine the EU unilaterally pursuing its greener vision (from a bio economy perspective) while in the "Hand-in-hand", the notion of an active bioeconomy plan is implemented beyond the boundaries of the EU, with the more developed nations taking the lead. A further description of each is provided below.

Narrative 1.1: Go-it-alone



In this narrative, the EU pursues its vision of the sustainable bioeconomy to boost the efficient use of resources by moving to a clean, circular economy and to safeguard biodiversity and cut pollution, without waiting for international commitments.

In this scenario, we consider that all (potentially) bio-based primary and manufacturing sectors contribute to achieving this vision. As such, the EU will introduce an aggressive domestic support policy which encourage significant increases to the demand and supply of biomass from agriculture, forestry and fisheries/aquaculture for industrial and energy applications. This may take the form of domestic procurement policies, revised building codes, requirements on circularity, favourable subsidy schemes on biomass inputs, or agricultural, forestry and other policy adjustments to ensure reliable sources of biomass use in existing and new bio-based value chains. In addition, to further encourage the switch to biobased technologies, domestic market disincentives (i.e., taxes) will be introduced on fossil-based substitutes.

Through education programmes and advertising awareness campaigns, there is a shift toward more responsible consumption patterns (i.e., reductions in food waste, reduced (red) meat consumption within the boundaries of a “healthy diet”, increase of wood in construction, etc.). Overall, this leads to a reduction of product consumption growth and lower resource and energy intensity use. Substitution of fossil-based raw materials with bio-based material is enhanced through revised public procurement, building codes and other measures. There is rapid development of novel bio-based products, while the consumption of fossil-based products reduces. The EU seeks to avoid carbon leakage effects through international trade, e.g. by ensuring that the price of imports reflect more accurately their carbon content or produce deforestation-free products. The modelling team in BioMonitor will seek stakeholders’ opinion to explore policy options that could facilitate the avoidance of carbon leakage effects.

Significant R&D investment efforts are charged into sustainably increasing biomass production and availability from agriculture, forests, and aquaculture, while considering biodiversity and other ecosystem services. Investments will also be made in developing nascent bio-industrial sectors in an attempt to reduce cost disadvantage ratios with conventional fossil technologies, as well as fiscal incentives (i.e., subsidies) to enhance biomass availability from agriculture, forestry and fisheries within the EU. Further, specific policies could be introduced to prescribe the minimum bio-based content in some product categories or ban the use of fossil-based products for some purposes, promoting in this way bio-based industry.

Investments and fiscal incentives (i.e., labour subsidies, biomass subsidies) to these sectors and technologies would have to be met by the public purse, possibly financed by tax hikes on inputs of fossil fuels, or other environmentally harmful processes (the overall effect could be fiscally neutral). Employing trade policy, the EU, to protect its green bio-based vision, would impose higher tariffs on fossil-based equivalents from foreign competitors.

Narrative 1.2: Hand-in-hand

In this narrative, the EU is not acting alone but instead many of the initiatives in ‘Go-alone’ are implemented globally. Thus, the reduction/elimination of tariffs on global trade links for biobased



products ensures a more open market to ease the global transition to a more biobased economy and help all regions to pursue domestic bio-industry and bioenergy policies. For less developed countries to be further implicated in this transition pathway, greater social responsibility on the part of developed regions must be assumed. The costs of technology innovation in nascent bio-based activities would be shouldered by the rich countries, whilst the availability of the resulting bio-based products to poorer countries could be enhanced through the implementation of developed country export subsidies to less developed country markets. Similarly, in tackling food security concerns, competitive less developed and developing countries are provided with much greater market access to developed country agricultural markets, whilst wealthier member states provide export subsidies to those less developed regions where self-sufficiency is considered low. Moreover, as part of a globally more responsible model of biomass consumption, there would be global initiatives to reduce food loss, food waste and establish healthier diets, where reduced demand pressures in developed regions may encourage greater global food affordability through the relieving agricultural market tensions. Carbon leakage effects and indirect land use are avoided as much as possible.

Sensitivity Analysis will include among others i) available residue supply, ii) land availability and iii) fluctuation of fossil fuel prices

Storyline 2: A different world order

The energy-environment nexus forms a cornerstone of any medium- to long-run foresight study. Indeed, within the context of the EU Green Deal, which includes policies to combat climate change, the bioeconomy is expected to play an active role in the transition towards a more sustainable and responsible model of economic growth. On the other hand, in climate policy, the current status is of a fragmented world consisting of different visions and priorities toward planetary responsibility.

The second group of storylines therefore acknowledges the central role of climate and energy market drivers on world development. More specifically, its focus is to contextualise how these additional market forces will impact upon the development of the bioeconomy sectors. Two polar opposite pathways are designed and implemented representing a greener vision and a fossil-centric vision of human development to 2030 and 2050. Employing an array of economic, social and environmental indicators, the aim is to understand the resulting potential opportunities and threats to the bioeconomy sectors.

Narrative 2.1: BioEco-Resilience

This narrative explores the resilience of, and opportunities afforded to, the bioeconomy resulting from a greener world order. It is therefore assumed that all key nations participate in seeking to achieve the 'two degree' target from the Paris Agreement through major reforms of the energy markets and relevant climate policies.

The main drivers for the energy markets would follow the three pillars in the GECO study, namely (i) increases in energy efficiency to decouple economic growth from energy consumption, (ii)



shifting energy carriers toward electrification and (iii) decarbonisation of energy through the adoption of (bio)renewables. These changing energy market trends could be taken from the GECO 'two degree' pathway.⁸ The costs of these investments should somehow be internalised within the model mechanism based on an understanding of rate of return expectations from energy investments. In the same vein, emissions reductions policies based on carbon tax and/or fossil tax increases would also be implemented which are consistent with the GECO two-degree scenario. Significant R&D investment efforts are charged into sustainably increasing biomass production and availability from agriculture, forests and aquaculture. This narrative would preserve the vision of an environmentally conscious society (as in the first storyline) through the preservation and enhancement of our forests, reduction of food waste and food losses along the supply chain.

It is assumed that the bioeconomy will maintain more or less the same policy mechanisms in place that are implemented in narrative 1.2. The assumption is that the level of ambition for the bioeconomy sectors matches that witnessed in the 'hand-in-hand' and this forms a natural complement to the notion of a greener climate friendly (?) world order. It may be the case that additional bioenergy targets may be implemented to complement the deeper transformation in world energy markets (particularly in the case of more sustainable advanced biofuels). Moreover, the same burden sharing, market access and consumer behaviour assumptions as narrative 1.2 are also kept within this scenario.

It is expected that fossil-based industries will be hit and (bio)renewables will flourish. The expected benefits (e.g., rising bio-industry competitiveness through the closing of the cost-disadvantage gap with fossil technologies; environmental indicators) and costs (food security, macroeconomic growth, employment) will be assessed by the models.

Narrative 2.2: Drill baby drill

This world order is a polarised version of narrative 2.1. More specifically, this transition pathway posits a continuation of the linear 'take-make-dispose' model of human development. Thus, it envisages a fossil-centric world order, where all types of public policy support mechanisms of the bioeconomy development inherent within the BRS are removed. The economic and social development in this scenario is coupled with the exploitation of fossil resources and resource- and energy-intensive lifestyles around the world.

Biomass production is enhanced from intensively managed systems with high technological innovations but with limited consideration of environmental issues. While technologies are advancing, there is little progress developing new bio-based products. Demands for packaging material and transportation fuels increase. In addition, an active strategy, on the part of developed regions, to encourage greater extraction of fossil-based resources is underway in the pursuit of regionalised self-interest (to the detriment of the planet). This would take the form of a subsidisation of fossil-based industries in developed and developing countries with available energy reserves, resulting in greater extraction rates/availability of fossil resources (subject to realistic

⁸ A pathway which limits temperature rises to 2 degrees above pre-industrial levels by 2100. This target is still considered as potentially achievable.



expectations). There is little effort to avoid environmental impacts due to a perceived trade-off with economic development.

Inequalities are exacerbated as international institutional strength fades (e.g., in the areas of climate, trade) and regional rivalries emerge (fuelled by populism). On the one hand, developed countries allow emissions to rise even above the BRS through greater exploitation of fossil reserves, whilst policies to reduce emissions (e.g. the EU's Effort Sharing Decision and Emissions Trading System) are abandoned. With the absence of co-responsibility, the developing and less developed countries also abandon targeted emissions reductions. In the sphere of trade policy, developed countries pursue insular and retaliatory trade policies through protective rises in tariffs.

Moreover, strategic partnerships with energy-rich countries are enhanced as developed country net-importers of fossil energy seek to optimize access to supplies, at the expense of the poorer nations. This transfer of fossil supplies could be represented through developed country subsidies on fossil imports from energy-rich partners. This will in turn have implications on fossil prices. Food continues to be wasted, and even at an increasing rate in the fast growing, middle income countries, as they adopt 'westernised' food consumption habits exhibited by wealthier nation states. The changing food consumption patterns enhance the demand for animal products, resulting in continued deforestation patterns.

Sensitivity Analysis will include among others i) available fossil reserves, or extraction rates and ii) fossil fuel prices.



3 Drivers and indicators for modelling bioeconomy futures

3.1 Driving forces in scenarios

The bioeconomy is driven by a number of forces and includes multiple sectors. Deliverable 1.1 of the Biomonitor project (Framework for measuring size and development of bioeconomy with a list and detailed description of bioeconomy indicators, measures, and data requirements) sets the background for the scope and definitions of bioeconomy as well as the driving factors behind its development. These are especially relevant for the BioMonitor Model Toolbox and Scenario analysis in WP6 as well as the indicators to be considered for monitoring the bioeconomy.

The groups of storylines and narratives in WP6 will ensure that the driving forces reported in D1.1 are captured appropriately both for the baseline and the alternative scenarios. Table 2 below provides an initial overview of the exogenous drivers that shape the BRS and possibilities for the storylines.

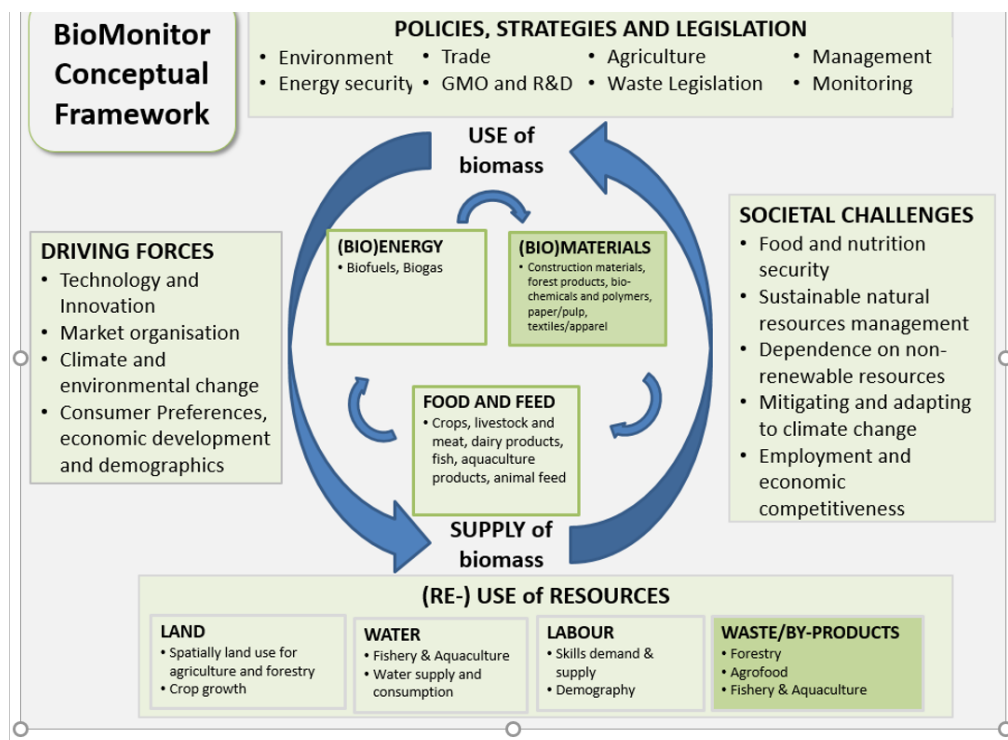


Figure 2 BioMonitor conceptual framework: overview of the relations within the bioeconomy. (Adapted from SAT-BBE, 2015)

Table 1: Drivers and model assumptions that shape the BRS and its possibilities for shocks for the storylines.

Driver category	Model assumptions	Possibilities for storylines	Model using the information	Source of information
Land use and management	Land productivity*	Exogenous BRS land productivity shocks. In the storylines, it might be possible to examine deviations in expected yield or productivity changes of crops and forests, as well as plantation forests	AGMEMOD: yield/ha of cereals, oilseeds, root crops, apple areas	Yield trends, estimated from historical data
	Biomass availability: This is a combination of land use (natural resource availability) and land productivity (technology/climate related).	For the BRS, arising from the relevant model drivers and possible linkages between models within the BioMonitor platform, expected projections in forestry supplies to support wood-based products and residues would be harmonised across the relevant models. To reflect the spirit of the alternate storylines, plausible projections of the availability of biomass (all types of biomass, including forest, agricultural, waste, aquatic biomass, etc.) might be revised upward (i.e., Go-alone, hand-in-hand, BioEco-resilience), based on realistic expectations. The rise in available forestry resources could be accompanied and targeted by rising subsidy support.	Magnet, EFI-GTM AGMEMOD: crops, oilseeds, root crops, fruits & vegetables land used for food and feed production AGMEMOD: Fish biomass stock BioMAT: availability of starch, plant oil, industrial sugars (incl. residues) for biobased material use	EFISCEN, literature, IMAGE model of land usage (Daiglou <i>et al.</i> , 2015)
	Wood demand and land management practices	Forest management practices (Europe), development of plantation forest area	EFISCEN, EFI-GTM, MAGNET	
	Land use regulations	Restrictions on land use changes, including deforestation / leakage effects	EFI-GTM	
Economic growth	Real macroeconomic growth/technology change	Country specific productivity growth is calculated to target assumed macroeconomic (GDP) rates of growth. In the alternate storylines, at the margin, real growth can deviate with the implementation of additional policies/investments which carry additional social and economic benefits and costs.	EFI-GTM, MAGNET AGMEMOD, BioMAT	Keramidas <i>et al.</i> (2018) AGLINK projections
Technology change	Agricultural production technology trends*	Anticipated outlook for agricultural production trends within the EU based on official forecasts. In the BRS, these production trends are targeted by technology change shifters that remain unchanged in the alternate storylines.	MAGNET AGMEMOD for agro-food production developments. Note that this is not an exogenous driver but an endogenous outcome	
	Nascent biotechnologies*	In the BRS, reasonable technology change developments in nascent bio-industrial processes may be available from bottoms-up specialist technology models, expert opinion, or even through model assumptions calibrated to the GECO baseline. Again, to factor in the cost of said R&D investments to economic development, a reasonable understanding of the rates of return is key. Alternate storylines can explore higher technology change assumptions (and associated R&D costs), although again, these anticipated changes will either require specialist model input, expert opinion, or model assumptions and calibration.	MAGNET BioMAT	Calibration, expert opinion, bottom-up modelling. Markal (energy model) is such a bottom-up model from which MAGNET took conversion factors (technology learning curves) a couple of years ago. Note that we don't have access or experience to MARKAL



Driver category	Model assumptions	Possibilities for storylines	Model using the information	Source of information
Energy	Energy input to industry	Calibrated input-output technology shifters to mimic energy balance trends by energy type and usage. To factor in the cost of energy investments to economic development, some generalizable understanding of the rates of return on energy efficiency investments would be desirable.	MAGNET	Keramidas et al. (2018)
	Energy in final demand	Final energy demand shifters to mimic anticipated changes in energy consumption with (if deemed important) the accompaniment of final energy demand tax structure changes. Alternate storylines may explore more responsible energy demand (possibly with accompanying tax changes).	MAGNET	Keramidas et al. (2018)
	Global fossil fuel prices	Changes in world average fossil fuel prices for oil, coal and gas. A sensitivity analysis of fossil fuel price expectations is possible.	Magnet, EFI-GTM BioMAT	Keramidas et al. (2018)
	Biomass for energy demand	Biomass needed (distinguished by feedstock types) for energy	EFI-GTM	Literature (POLES)
Conversion capacity	Fossil industry* Development of fossil-based industry is in principle a model outcome	In the BRS, the development of the fossil-based industries is an outcome of the model solution, based on changes in market prices, substitution effects in production and relative rates of real income growth. In the alternate storylines, it is possible to explore different market incentives on this collective to fit different narratives.		
	Feed efficiency*	Exogenous BRS anticipated changes for biomass in animal feed efficiency (through technology change or farm management efficiencies) could be included to improve an understanding of biomass availability across competing uses. In the alternate storylines (subject to data availability), one could examine alternate feed efficiency rates.	MAGNET AGMEMOD	Conversion factors that come from a) BioTic, RoadToBio and other FP/H2020 project; b) Andrzej?; c) JRC/BTG?
Policy mechanisms and reforms	Carbon Tax	Global increase in the carbon tax on relevant economic activities by time period. Possible exploration of alternate increases in carbon prices under more ambitious green policies can be considered in alternate scenarios.	MAGNET, EFI-GTM BioMat (only indirectly, based on expected price changes in Magnet)	Keramidas et al. (2018)
	Set aside area for biodiversity protection	Area set aside for biodiversity	EFISCEN, EFI-GTM AGMEMOD for agricultural land	EFA rates (EC)
	Biofuel mandates*	Exogenous mandates on first-generation and advanced-generation biofuels by region. In the storylines, these mandated blending requirements may be adjusted upward for (more sustainable) advanced generation biofuels.	MAGNET AGMEMOD, BioMAT (only indirectly, based on expected price changes in Magnet)	EU policy documents (REDII), expert opinion.
	Bio-based materials support*	Policy interventions could promote or shut down the production of specific fossil-based or bio-based products. In BioMonitor Reference Scenario (BRS?) no specific policy intervention is foreseen. For scenarios they are imaginable and could entail ban on use of specific products or targets on their production/use.	EFI-GTM, MAGNET AGMEMOD, BioMAT	



Driver category	Model assumptions	Possibilities for storylines	Model using the information	Source of information
	EU Agricultural Policy* (for BioMonitor that current CAP remains the reference, and we can play with budget envelopes in the scenarios).	A plausible EU agricultural policy baseline with detailed information and model implementation on budget limits for first (decoupled/coupled) and second pillar policy instruments. When exploring alternate storylines, a deviation in budget allocations could be contemplated.	MAGNET AGMEMOD, BioMAT	In MAGNET we use the CATS (Clearance Audit Trail System) database from DG Agri to introduce support payments and extrapolation.
	Bilateral and regional trade agreements*	With an emphasis on the EU, ratified and expected trade agreements will be implemented. In addition, the BRS might include third-country trade agreements between large country players on biomass markets. In the alternate storylines, further manipulation of applied tariff rates can capture greater trade openness/closedness.	MAGNET Trade measures will influence world prices. AGMEMOD/ BioMAT can use the changing world prices as exogenous drivers (so trade agreements can be indirectly imposed)	GTAP database (Aguar et al., 2019).
	Capital stock*	On a country basis, changes in the total available stock of capital, either by assumption of a fixed capital-output ratio, or if possible, through a more complex mechanism related to relative rates of return. In the alternate storylines, at the margin, capital stock growth can deviate with the implementation of additional policies/investments.	MAGNET	Assumption
	Labour force*	Changes in the total labour force for the regions/countries under consideration. Possible exploration of changing labour force rates in function of the skill type, or, as consistent with economic theory, an assumption of a fixed long-run employment rate. In the alternate storylines, at the margin, labour force changes can deviate with the implementation of additional policies/investments.	MAGNET	Assumption
Demographic development	Population	Exogenous rates of population change. With no clear link between bioeconomy developments and population change, at the current stage, it is not envisaged that the alternate storylines will include different rates of population change. If deemed important, it may be possible to include variation through sensitivity analysis.	Magnet, EFI-GTM AGMEMOD, BioMAT	Keramidas et al. (2018)
Consumer preferences	Attitudes to food consumption*	In the BRS, the model outcomes determine status quo attitudes to food consumption, based on the prices and income patterns arising from the model baseline. In the alternate storylines, exogenous demand shifts for changing food consumption patterns can be implemented and, if deemed appropriate, linked to tax/subsidy incentives.	MAGNET AGMEMOD, BioMAT	LANCET-EAT diet recommendations (healthy eating). Food waste and food loss estimates (FAO).
	Attitudes to and consumption of bio-based products*	In the BRS, the model outcomes determine status quo attitudes to consumption of bio-based products/biobased materials, based on the prices and income patterns arising from the model baseline. In the alternate storylines, exogenous demand shifts favouring the consumption of bio-based materials (reflecting for example awareness about negative external effects of fossil-based materials) can be implemented and, if deemed appropriate, linked to tax/subsidy incentives or other policy interventions (e.g. bans on use of some fossil-based products).	Magnet, EFI-GTM AGMEMOD, BioMAT	Literature, assumptions

* Not taken from the GECO baseline, but borrowed from a suitable alternative data source or calculated through modelling assumptions.



3.2 Examples of scenario applications and models used

Table 3 below provides an initial outline of the modelling capacities within BioMonitor, scenario examples that show how each model has been used in the past and respective policies informed.

Table 2: Drivers and policies applied in previous scenarios, and models used

Drivers	Model	Scenario examples that show how each model has been used in the past	Policies informed
Economic growth in GDP (Technology & innovation; markets)	MAGNET	long term projections describing changes in the economy and patterns of investment consistent with changes in capital stock over time	NER300 programme, Horizon 2020, Sustainable Process Industry through Resource and Energy Efficiency (SPIRE), BRIDGE 2020
	AGMEMOD	impact of accelerated technological development from payments on agricultural production growth (Chantreuil, F. 2013)	CAP Pillar I - Direct Payments, NER300 programme, Horizon 2020, Sustainable Process Industry through Resource and Energy Efficiency (SPIRE), BRIDGE 2020
Trade (Market organisation)	MAGNET/	The effect of agricultural trade liberalisation on emissions from land-use and food security (Rutten, M. et al 2013; Verburg, R. et al 2009)	iLUC Directive (EU) 2015/1513, LULUCF-Land use land-use change and Forestry (Dec. 529/2013/EU)
	CAPRI	Impact of set aside and intervention prices on sector-based domestic demand and net exports (Heckelei & Britz, 2001); impact of trade liberalisation (tariffs, export subsidies and tariff quotas) on farm production value (Mittenzwei et al, 2007)	Habitat Directive 92/43/EEC, Natura 2000, Bird Directive 2009/147/EC, CAP Pillar I - Direct Payments, CAP Pillar II – Rural Development
	EFI-GTM	Impact of LULUCF forest reference levels on forestry production and trade (Kallio et al. 2018) Impacts of policy measures to prevent import of illegal wood and wood products (Moiseyev et al. 2011).	EU Forest Strategy, REDD+, FLEGT, LULUCF Regulation (2018)
Agricultural productivity (Technology & innovation; Markets)	MAGNET	The role of technological progress based on human capital investments, labour augmenting and natural resource expansion (Woltjer, G. et al 2014) in labor market impacts on land use (Helming, J. & Tabeau, A. 2018)	NER300 programme, Horizon 2020, Sustainable Process Industry through Resource and Energy Efficiency (SPIRE), BRIDGE 2020
	AGMEMOD	Impact of accelerated technological development from payments on agricultural production growth (Chantreuil, F. 2013)	CAP Pillar I - Direct Payments, NER300 programme, Horizon 2020, Sustainable Process Industry through Resource and Energy Efficiency (SPIRE), BRIDGE 2020
	CAPRI	Income distributional impact of different direct payment systems (Gocht et al, 2011); impact of research and development on productivity (Jansson, T. et al 2008)	CAP Pillar I - Direct Payments, NER300 programme, Horizon 2020, Sustainable Process Industry through Resource and Energy Efficiency (SPIRE), BRIDGE 2020
Food demand (Markets; consumer preferences)	MAGNET	Calculating average nutrition indicators through flow of primary agri-food commodities of the global economy (Rutten et al., 2013)	Nitrates Directive, Directive for sustainable use of pesticides
	CAPRI	Integrating complex interrelations between population growth and technological change, policies and competing markets to assess climate change impacts on agriculture, including effects on demand for agricultural products (Frank, S. et al 2014)	iLUC Directive (EU) 2015/1513, EU Bioeconomy strategy (COM(2018) 673)
Raw material demand (Markets; consumer preferences)	MAGNET	Long term projections of consumption by households, including dietary patterns through the adjustment of income elasticities as GDP per capita changes over time	iLUC Directive (EU) 2015/1513
	CAPRI	Increasing feedstock demand on land use, land demand and prices (Britz, W. & Delzeit, R. 2013)	iLUC Directive (EU) 2015/1513, LULUCF-Land use land-use change and Forestry (Dec. 529/2013/EU)



Drivers	Model	Scenario examples that show how each model has been used in the past	Policies informed
	EFI-GTM	Impact of forest stock set-aside and intensifying use of wood for bioenergy on demand and harvests of local wood (Kallio et al 2019)	EU Forest Strategy, Forest based sector technology platform (FTP), Joint technology initiative for bio-based industries (BBI-JTI), SET plan: Action 8: Renewable Fuels and Bioenergy
Raw material supply	EFI-GTM	Potential availability of primary and secondary forest biomass (Moiseyev et al. 2014)	
	EFISCEN	Potential availability of primary forest biomass (Verkerk et al. 2007- 2015; 2019)	
	EFISCEN	Net annual increment changes of European forests from climate change (temperature and precipitation changes) (Nabuurs et al, 2002)	
Climate & environmental change	CAPRI/MAGNET	impact of removing biofuel targets on agricultural area (Adenauer & Britz, 2012)	Habitat Directive 92/43/EEC), Natura 2000, Bird Directive 2009/147/EC, EU Forest Strategy
	AGMEMOD	projection of biofuel crops based on yield changes and area allocation with scenario drivers such as population growth, world prices, innovation, trade agreements...etc. (Salamon et al, 2017)	
Bioenergy (Policy, Markets)	CAPRI	simulate the impacts of biofuel policies (consumer tax exemptions, quota obligations, import tariffs) on food production and prices, use of by-products, pressure on marginal land and share of imported biofuels (Blanco et al, 2012; Adenauer & Britz, 2012)	Renewable energy directive (Dir, 2009/EC/28), iLUC Directive (EU) 2015/1513, EU Bioeconomy strategy (COM(2018) 673)
	MAGNET	land use change and emissions of biofuels use in the EU (Smeets, E. et al, 2014; Kavallari, K. & Tabeau, A. 2014, Philippidis et al., 2016)	Renewable energy directive (Dir, 2009/EC/28), EU Bioeconomy strategy (COM(2018) 673)
	EFI-GTM	Impact of increased globalization or economic growth on energy wood prices, imports and reallocation of wood from competing uses (Moiseyev et al, 2011)	European Technology and Innovation Platform on Bioenergy (ETIP Bioenergy),
	EFISCEN	Potential availability of primary forest biomass (Verkerk et al. 2011; 2019)	Renewable energy directive (Dir, 2009/EC/28), Sustainability requirements (COM(2010)11)
	MAGNET	long term and short term effects of different timings of reforms and policies on farm income and employment	European Technology and Innovation Platform on Bioenergy (ETIP Bioenergy), REDD+
	CAPRI	impact of set aside, premiums and intervention prices on sector-specific production, including NPK balances, feeding requirements, and trade (Heckelei & Britz, 2001, Was et al, 2014); effects of decoupling and liberalisation on resource mobility and available agricultural land (Mittenzwei, K. et al, 2007)	European Standards EN16214 CEN/TC 383 Sustainably produced biomass for energy applications
	AGMEMOD	Impact of equalizing direct payments in EU (Erjavec et al, 2011); reaction of agri-food markets to combining policy-led budgetary support with effects of market prices, taking into account different effects from payments (Chantreuil et al, 2013)	CAP Pillar I - Direct Payments, CAP Pillar II – Rural Development, EU Forest Strategy, European Regional Development Fund, European Regions Research and Innovation Network, Green public procurement (COM(2008)400)
Biomass allocation	MAGNET	Medium to long-term scenario projections of biomass allocation across bio-based activities (Van Meijl et al., 2018, Philippidis et al., 2019).	CAP Policy, Trade Policy, BioEnergy Policy
CAP (Policy, Markets)	CAPRI	effects of policy reforms on agricultural provision of food security (Mittenzwei, K. et al 2007); effects of labour and capital on farmers’ decisions	CAP Pillar I - Direct Payments, CAP Pillar II – Rural Development, EU Forest Strategy, European Regional Development Fund, European Regions Research and Innovation Network, Green public procurement (COM(2008)400)
Producer behaviour and food supply (consumer preferences)	MAGNET	Examining the impacts of CAP budget changes on trade, welfare and CAP budget distribution (Boulangier and Philippidis, 2015).	CAP Pillar I - Direct Payments, CAP Pillar II – Rural Development
	AGMEMOD	Effects of policy on agricultural supply and demand of food (DG-Agri outlook, 2019); impact of grow in vegetarians on demand for meat (Jongeneel, et al, 2019)	CAP Pillar I - Direct Payments, CAP Pillar II – Rural Development
	CAPRI	effects of policy reforms on agricultural provision of food security (Mittenzwei, K. et al 2007); effects of labour and capital on farmers’ decisions	CAP Pillar I - Direct Payments, CAP Pillar II – Rural Development



Drivers	Model	Scenario examples that show how each model has been used in the past	Policies informed
	AGMEMOD	Impact of population growth on self-sufficiency rate in EU.	CAP Pillar I - Direct Payments, CAP Pillar II – Rural Development
Demography (Population)	CAPRI	integrating complex interrelations between population growth and technological change, policies and competing markets to assess climate change impacts on agriculture, including effects on demand for agricultural products (Frank, S. et al 2014)	Green public procurement (COM(2008)400)
			European Standards EN16214 CEN/TC 383 Sustainably produced biomass for energy applications
Sustainable pathways, SDGs	MAGNET	Analysis of how climate change mitigation scenarios to address the world's most pressing long-term challenge, are delivering on a broad range of social, economic and biophysical indicators related to the SDGs. (M'barek, R. et al 2019; Philippidis, G. et al 2020)	Long-term vision of the EU (climate-neutral by 2050)



4 Conclusions

This report describes the baseline (BioMonitor Reference Scenario, BRS) and the alternative scenarios that Biomonitor will employ to perform quantitative and qualitative assessment for the development of European bioeconomy to 2030 and 2050. It presents the storylines and the respective narratives and describes policy relevant questions that will be answered by the scenarios in the Biomonitor impact assessment. Furthermore, it provides an overview of the drivers, model assumptions and indicators for the future development of bioeconomy and outlines their use in modelled scenarios and policies informed so far.

The report also outlines how and which (group of) models would be able to capture the key technology, conversion factors, consumer preference trends and policy mechanisms that could influence the future of the bioeconomy in EU. The complementary appendices provide insight to possibilities to concretize the scenario narratives towards model inputs and outputs, and how to change/shock the models per scenario.

The deliverable will remain a working document to ensure input from stakeholders and all relevant updates from WPs 1-5 and any changes or updates of relevant policy are integrated during the project.

This will ensure the validity and added value of the scenarios in terms of relevance with the Biomonitor indicators (WP1/ D1.1; D1.2), foreseen datasets like the Biomonitor Data Platform (WP3/ D3.1) and compatibility with the models that will be included in the project (WP4, D4.1) and the input output structure of the Biomonitor Model Toolbox (WP5).



5 References

- Adenäuer, M. & Britz, W. (2012). A Land Demand And Supply System With Endogenous Land Prices in the CAPRI Agricultural Sector Model. Institut für Lebensmittel- und Ressourcenökonomik, Universität Bonn. GEWISOLA
- Blanco, M., Adenäuer, M., Shrestha, S., Becker, A. (2012). Methodology to assess EU Biofuel Policies: The CAPRI Approach. JRC Working Papers JRC80037, Joint Research Centre (Seville site).
- Boulangier, P. and Philippidis, G. (2015) The EU Budget Battle: Assessing the trade and welfare impacts of CAP budgetary reform, *Food Policy*, 51, 119-130
- Britz, W. & Delzeit, R. (2013). The impact of German biogas production on European and global agricultural markets, land use and the environment. *Energy Policy*, 62, 1268-1275. <https://doi.org/10.1016/j.enpol.2013.06.123>
- Chantreuil, F., Salputra, G., & Erjavec, E. (2013). Market Analysis of Direct Payment Options for New EU Member States Using the AGMEMOD Partial Equilibrium Modelling Tool. *Outlook on Agriculture*, 42(1), 33–40. <https://doi.org/10.5367/oa.2013.0111>
- Daioglou, V., Stehfest, E., Wicke, B., Faaij, A., et al., 2015. Projections of the availability and cost of residues from agriculture and forestry. *GCB Bioenergy*. <https://doi.org/10.1111/gcbb.12285>
- Daigneault, A., Johnston, C., Korosuo, A., Baker, J.S., Forsell, N., Prestemon, J.P., Abt, R.C., 2019. Developing Detailed Shared Socioeconomic Pathway (SSP) Narratives for the Global Forest Sector. *Journal of Forest Economics* 34, 7-45.
- Erjavec E. et al. (2012) The CAP Beyond 2013. In: Chantreuil F., Hanrahan K., van Leeuwen M. (eds) *The Future of EU Agricultural Markets by AGMEMOD*. Springer, Dordrecht
- European Commission, 2018. A sustainable bioeconomy for Europe: Strengthening the connection between economy, society and the environment. In: *Updated Bioeconomy Strategy*: COM/2018/673 Final, Available at. <https://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy>.
- European Commission, 2019. Reflection paper towards a sustainable Europe by 2030. In: Com(2019)22, Available at. https://ec.europa.eu/commission/publications/reflection-paper-towards-sustainable-europe-2030_en
- Frank, S., Witzke, H., Zimmermann, A., Havlík, P., Ciaian, P. (2014). Climate Change Impacts on European Agriculture: A Multi Model Perspective. Paper prepared for presentation at the EAAE 2014 Congress 'Agri-Food and Rural Innovations for Healthier Societies', August 26 to 29, 2014 Ljubljana, Slovenia.
- Gocht, A., Britz, W., Ciaian, P., Gomez y Paloma, S. (2011) EU-wide Distributional Effects of EU Direct Payments Harmonization analyzed with CAPRI. Paper prepared for presentation at the EAAE 2011 Congress Change and Uncertainty Challenges for Agriculture, Food and Natural Resources, August 30 to September 2, 2011 ETH Zurich, Zurich, Switzerland.
- Heckelei, T. & Britz, W. (2001). Concept and Explorative Application of an EU-wide, Regional Agricultural Sector Model (CAPRI-Project).
- Helming, J. & Tabeau, A. (2018). The economic, environmental and agricultural land use effects in the European Union of agricultural labour subsidies under the Common Agricultural Policy. *Regional Environmental Change* 18, 763–773. doi:10.1007/s10113-016-1095-z.
- Jansson, T., Bakker, M. M., Le Mouél, P., Schirmann-Duclos, D., Verhoog, D., Verkerk P.J. (2008). Dynamic impacts of a financial reform of the CAP on regional land use, income and overall growth. 12th Congress of the European Association of Agricultural Economists – EAAE.



- Kallio, A.M.I., Solberg, B., Käär, L., Päivinen, R., 2018. Economic impacts of setting reference levels for the forest carbon sinks in the EU on the European forest sector. *Forest Policy and Economics* 92, 193-201.
- Kavallari K. & Tabeau, A. (2014). Land use changes of biofuel use in the EU: An uncertainty analysis. *Journal of Operational Research*, 14 (2), 261-281
- Keramidas, K., Tchung-Ming, S., Diaz-Vazquez, A.R., Weitzel, M., et al., 2018. Global energy and climate outlook 2018: Sectoral mitigation options towards a low-emissions economy – global context to the eu strategy for long-term greenhouse gas emissions reduction. Publications Office of the European Union, Luxembourg.
- Maarit Kallio, A. I., Moiseyev, A., Solberg, B. (2006). Economic impacts of increased forest conservation in Europe: a forest sector model analysis. *Environmental Science & Policy*, 9 (5), 457-465, <https://doi.org/10.1016/j.envsci.2006.03.002>.
- M'barek, R.; Philippidis, G.; Ronzon, T. Alternative Global Transition Pathways to 2050: Prospects for the Bioeconomy - An application of the MAGNET model with SDG insights, EUR 29862, Luxembourg: Publications Office of the European Union, 2019, ISBN 978-92-76-11335-5, doi:10.2760/594847,JRC118064.
https://publications.jrc.ec.europa.eu/repository/bitstream/JRC118064/jrc_techreport_bioeconomy2050_online.pdf
- Mittenzwei, K., Fjellstad, W., Dramstad, W., Flaten, O., Gjertsen, A. K., Loureiro, M., Prestegard, S. S. (2007). Opportunities and limitations in assessing the multifunctionality of agriculture within the CAPRI model. *Ecological Indicators*, 7(4), 827-838, Weitzel, M., Vandyck, T., Keramidas, K., Amann, M., Capros, P., del Elzen, M., Franck, S., Tchung-Ming, S., Diaz Vasquez, A., Saveyn, B. (2019) Model Based Assessments for Long Term Climate Strategies, *Nature Climate Change*, 9, 343-347. <https://doi.org/10.1016/j.ecolind.2006.10.002>
- Moiseyev, A., Solberg, B., Kallio, A. M. I., Lindner, M. (2011). An economic analysis of the potential contribution of forest biomass to the EU RES target and its implications for the EU forest industries. *Journal of Forest Economics*, 17 (2), 197-213, <https://doi.org/10.1016/j.jfe.2011.02.010>.
- Moiseyev, A., Solberg, B., Kallio, A.M.I., 2014. The impact of subsidies and carbon pricing on the wood biomass use for energy in the EU. *Energy* 76, 161-167.
- Moiseyev, A., Solberg, B., Michie, B., Kallio, A.M.I., Modeling the impacts of policy measures to prevent import of illegal wood and wood products. *Forest Policy and Economics* 12, 24-30.
- Verkerk, P.J., Anttila, P., Eggers, J., Lindner, M., Asikainen, A., 2011. The realisable potential supply of woody biomass from forests in the European Union. *Forest Ecology and Management* 261, 2007-2015.
- Nabuurs, G. J., Päivinen, R., Schanz, H. (2001). Sustainable management regimes for Europe's forests – a projection with EFISCEN until 2050. *Forest Policy and Economics*, 3 (3-4), 155-173. [https://doi.org/10.1016/S1389-9341\(01\)00058-2](https://doi.org/10.1016/S1389-9341(01)00058-2)
- Nabuurs, G. J., Pussinen, A., Karjalainen, T., Erhard, M., Kramer, K. (2002). Stemwood volume increment changes in European forests due to climate change—a simulation study with the EFISCEN model. *Global Change Biology*, 8 (4), 304-316. <https://doi.org/10.1046/j.1354-1013.2001.00470.x>
- O'Neill, B.C., Kriegler, E., Ebi, K.L., Kemp-Benedict, E., Riahi, K., Rothman, D.S., van Ruijven, B.J., van Vuuren, D.P., Birkmann, J., Kok, K., Levy, M., Solecki, W., 2017. The roads ahead: Narratives for



- shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change* 42, 169-180. DOI: <https://doi.org/10.1016/j.gloenvcha.2015.01.004>.
- Philippidis, G., M'Barek, R., & Ferrari, E. (2016). Is 'Bio-Based' Activity a Panacea for Sustainable Competitive Growth? *Energies*, 9(10), [806]. <https://doi.org/10.3390/en9100806>
- Philippidis, G.; Bartelings, H.; Helming, J.; M'barek, R.; Smeets, E.; Van Meijl, H. The Good, the Bad and the Uncertain: Bioenergy Use in the European Union. *Energies* 2018, 11, 2703. <https://doi.org/10.3390/en11102703>
- Philippidis, G., Bartelings, H., Helming, J., M'barek, R., Ronzon, T., Smeets, E., Van Meijl, H. and Shutes, L., The MAGNET model framework for assessing policy coherence and SDGs: Application to the bioeconomy, EUR 29188 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-81792-2, doi:10.2760/560977, JRC111508. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC111508/technical_report_bioeconomy_magnet_final.pdf
- Philippidis, G., Bartelings, H., Edward, S.; Sailing into Uncharted Waters: Plotting a Course for EU Bio-Based Sectors. *Ecological Economics* 147 (2018) 410–421; <https://www.sciencedirect.com/science/article/pii/S0921800916308941?via%3Dihub>
- Philippidis, G., Bartelings, H., Helming, J., M'barek, R., Smeets E. & van Meijl, H. (2019) Levelling the playing field for EU biomass usage, *Economic Systems Research*, 31:2, 158-177, DOI: 10.1080/09535314.2018.1564020
- Philippidis G., Martina Sartori, Emanuele Ferrari, Robert M'Barek. Waste not, want not: A bio-economic impact assessment of household food waste reductions in the EU. *Resources, Conservation and Recycling* Volume 146, July 2019, Pages 514-522. <https://www.sciencedirect.com/science/article/pii/S0921344919301788>
- Philippidis G., Heleen Bartelings, John Helming, Robert M'barek, Edward Smeets & Hans van Meijl (2019) Levelling the playing field for EU biomass usage, *Economic Systems Research*, DOI: 10.1080/09535314.2018.1564020
- Pindozi, S., Cervelli, E., Recchi, P. F., Capolupo, A., & Boccia, L. (2017). Predicting land use change on a broad area: Dyna-CLUE model application to the Litorale Domizio-Agro Aversano (Campania, South Italy). *Journal of Agricultural Engineering*, 48(1s), 27-35. <https://doi.org/10.4081/jae.2017.657>
- Rutten M., Nowicki P., Bogaardt M.-J., Aramyan L., (2013). Reducing Food Waste by Household and in Retail in the EU: a Prioritisation Using Economic, Land Use and Food Security Impacts. LEI Wagenigen UR. <https://edepot.wur.nl/290135>
- Salamon, P., Banse, M., Barreiro-Hurlé, J., Chaloupka, O., Donnellan, T., Erjavec, E., Fellmann, T., Hanrahan, K., Hass, M., Jongeneel, R., Laquai, V., van Leeuwen, M., Molnár, A., Pechrová, M., Salputra, G., Baltussen, W., Efken, J., Hélaine, S., Jungehülsing, J., von Ledebur, O., Rac, I., Santini F. (2017). Unveiling diversity in agricultural markets projections: from EU to Member States. A medium-term outlook with the AGMEMOD model. JRC Technical Report, Publications Office of the European Union, Luxembourg, ISBN 978-92-79-77335-8, doi:10.2760/363389.
- Schelhaas, M., Hengeveld, G., Moriondo, M., Reinds, G. J., Kundzewicz, Z. W., ter Maat, H., Bindi, M. (2010). Assessing risk and adaptation options to fires and windstorms in European forestry. *Mitigation and Adaptation Strategies for Global Change*, 15 (7), 681-701.
- Sieber, S., Amjath-Babu, T. S., Jansson, T., Müller, K., Tscherning, K., Graef, F., Pohle, D., Helming, K., Rudloff, B., Saravia-Matus, B. S., Gomez y Paloma, S. (2013). Sustainability impact assessment using integrated meta-modelling: Simulating the reduction of direct support under the EU



- common agricultural policy (CAP). *Land Use Policy*, 33, 235-245, <https://doi.org/10.1016/j.landusepol.2013.01.002>.
- Smeets, E., Tabeau, A., van Berkum, S., van Meijl, H., Woltjer, G., Moorad, J. (2014). The impact of the rebound effect of first generation biofuels on greenhouse gas emissions in the EU. *Sustainable and Renewable Energy Reviews*, 38, 393-403.
- Solberg, B., Moiseyev, A., Kallio, A. M. I. (2003). Economic impacts of accelerating forest growth in Europe. *Forest Policy and Economics*, 5 (2), 157-171, [https://doi.org/10.1016/S1389-9341\(03\)00022-4](https://doi.org/10.1016/S1389-9341(03)00022-4).
- Van Meijl, H., Tsiropoulos, I., Bartelings, H., Hoefnagels, R., Smeets, E., Tabeau A., and Faaij, A. (2018) On the Macro-Economic Impact of Bioenergy and Biochemicals – Introducing Advanced Bioeconomy Sectors into an Economic Modelling Framework with a Case Study for the Netherlands. *Biomass and Bioenergy*, 108, 381–397.
- Verburg, P. & Overmars, K. P. (2009). Combining top-down and bottom-up dynamics in land use modeling: exploring the future of abandoned farmlands in Europe with the Dyna-CLUE model. *Landscape Ecology*, 24: 1167. <https://doi.org/10.1007/s10980-009-9355-7>
- Verkerk, P.J., Fitzgerald, J.B., Datta, P., Dees, M., Hengeveld, G.M., Lindner, M., Zudin, S., 2019. Spatial distribution of the potential forest biomass availability in Europe. *Forest Ecosystems* 6, 5. DOI: 10.1186/s40663-019-0163-5.
- Wąs, A., Zawalińska, K., Britz, W. (2014). Impact of ‘greening’ the Common Agricultural Policy: evidence from selected countries based on CAPRI model. From organized session “Assessing multiple dimensions of CAP environmental measures” at the EAAE 2014 Congress ‘Agri-Food and Rural Innovations for Healthier Societies’, August 26 to 29, 2014, Ljubljana, Slovenia.
- Weitzel, M., Vandyck, T., Keramidas, K., Amann, M., Capros, P., del Elzen, M., Franck, S., Tchung-Ming, S., Diaz Vasquez, A., Saveyn, B. (2019) Model Based Assessments for Long Term Climate Strategies, *Nature Climate Change*, 9, 343-347.
- Woltjer, G.B. & Kuiper, M. (2014). The MAGNET Model: Module description. Wageningen, LEI Wageningen UR (University & Research centre), LEI Report 14-057.



Appendix 1: Current policy landscape in EU

This Appendix provides an overview of the current policy landscape for EU bioeconomy by sector and value chain stage (i.e. land use & biomass production, conversion, distribution, end use). The information will be used as the basis for the work in Tasks 6.3 and 6.4 to understand which policies per value chain stage need to be included in the Biomonitor scenarios.



Table : Overview of policies across sectors that regulate land use and biomass production and are relevant to the bioeconomy

Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Agriculture	The Future CAP (2021-2027) CAP Pillar I: Direct Payments and CAP Pillar II –Rural Development	Adopted in 2013 updated in 2020	To support and encourage producers to ensure viable food production, sustainable management of natural resources, climate action and territorial development. Specific objective: Promote employment, growth, social inclusion and local development in rural areas, including bio-economy and sustainable forestry.	Cross Compliance, Standards of good agricultural and environmental condition (GAECS).	Mandatory greening measures financed by EAFRD and EAGF : Financial support to fund Bioeconomy activities. 10 billion EUR (Horizon Europe) will support research and innovation in food, agriculture, rural development and the Bioeconomy. LIFE programme for Env and Climate to promote energy-efficiency and clean energy.	Voluntary mechanisms for rural development activities
Agriculture / Forest/Energy	European Standards CEN/TC 383 Sustainably produced biomass for energy applications	Adopted in 2012	It creates standard in terminology, conformity assessment, biodiversity and environmental aspects and calculation methods of GHG emissions from sustainably produced biomass for energy applications.	Standards based on sustainability principles, criteria and indicators for biomass energy applications		
Forestry	LULUCF Regulation (EU) 2018/841 (Land use and forestry regulation) 2021-2030	Adopted in 2014/ Updated in 2018	To reduce GHG emissions from LULUCF. Regulation implements the agreement between EU leaders by binding commitment for each MS to ensure GHG emissions from land are compensated by equivalent CO2 removal from atmosphere	Binding targets for inclusion of GHG emissions and removals of CO2 in all sectors by MSs.	Accounting rules and governance for forest management as it is the main source of biomass.	
Forestry	EU's FLEGT (Forest Law Enforcement, Governance and Trade) Action Plan	Adopted in 2003	To prevent illegal logging and the trade of timber products			Voluntary partnership agreements (VPAs)
Forestry	EU Timber Regulation (EUTR)	Adopted in 2013	To prevent illegal logging and the trade of timber products	FSC (Forest Stewardship Council) Certification to enforce Forest Law		
Forestry	EU Forest Strategy 2014-2020	Adopted in 2013	The Strategy promotes a forward-looking forest-based sector, the sustainable and resource-efficient mobilisation and use of forest biomass, the development of the Bioeconomy, access to domestic and international markets, and enhanced R&I.	Forest Management Plans (FMPs) are instruments to deliver multiple good and services under the principle of SFM.	LIFE+ supports nature conservation, climate change adaptation, information and protection need. REDD+	Strategy (Communication). European Forests 2020 -common strategy of 47 signatories. It is non-legally binding forest targets; supports MRV of the forest ecosystem services as information for policy making
Forestry	REDD+		To reduce emission through sustainable forest management and carbon stocks development		Financial market mechanisms to create value from carbon stocks in forests. Result-based actions receives supports provided for full implementation of REDD+; Green Climate Fund	National Strategy and Action Plan; MRV (Monitoring, Reporting and Verification) System ; Information sharing; Assessment of Forest Reference Level



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Waste	Circular Economy Package -COM Closing the loop -An EU Action plan for the Circular Economy	Adopted in 2020	To main global competitiveness through transition to use of natural resource efficiently, promote circularity in material, reduce negative impacts one environment and contribute in climate change mitigation. One of the key strategies is promotion of bio-based sector through implementation of Bioeconomy Strategy and Action Plan.			Communication.
Waste	Waste Incineration Directive 2000/76/EC	Adopted in 2000	To prevent and reduce negative impacts of incineration and co-incineration of waste in environment	Emission limit and permits on pollutants PM, NOx, SO2, HCL, HF, heavy metals etc from incineration plants. Wastewater from treatment of waste gases is also controlled under the Directive		Public consultation, access to information and participation in the permitting procedure.
Waste	Sewage Sludge Directive (86/278/EEC); Urban wastewater treatment Directive (91/271/EEC)	Adopted in 1986	To encourage the use of treated sewage sludge in agriculture and regulate it to prevent harmful effects on soil, vegetation, animals, and man.	Directive specifies- Rules for the sampling and analysis of sludges and soils. Requirements for records keeping; Limit values for concentrations of heavy metals in sewage sludge intended for agricultural use and in sludge-treated soils.		
Waste	Waste Framework Directive (2008/98/EC) updated COM 2015/0595	Adopted in 1975	To establish framework to handle waste in community to reduce environmental impacts and increase economic value of waste. Waste Hierarchy to facilitate the separate collection and treatment of bio-waste to reduce GHG emission originating from landfills.	Compliance -obligation to set up separate collection. Reinforces targets for diversion of biodegradable waste from landfills as set in landfill Directive. Penalties for people responsible for waste management if they did not meet the targets -waste producers, holders, Enforcement of standards.	MSs should introduce financial incentives to apply waste hierarchy. Raw Materials Initiatives to recycle valuable materials and channel back into the economy. brokers, dealers, collectors, transporters for noncompliance.	Waste prevention programmes. Reporting by MSs should be uniform and reporting of targets should be based on the input to the final recycling process. Recycling rates can be reported based on output of recycling centres.



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Waste	Landfill Directive (1999/31/EC) updated COM/2015/0594	Adopted in 2001 updated in 2015	To protect and improve the quality of environment, human health and rational utilisation of natural resources to promote circular economy. Establish long term path for waste management and recycling	Legislative -sets targets for reduction of waste. Ban on separately collected waste to be landfilled.	Economic instrument to discourage landfilling	Harmonised calculation methods for improved calculation of recycling rates
Waste	Directive 94/62/EC on packaging and packaging waste	Adopted in 1994 updated in 2015	To provide environmental protection and harmonised measures for management of packaging waste to avoid distortion and restriction of competition. Promotes innovation in waste management practices- reduce GHG emission; sustainable growth and job creation; better environment.	Recycling Targets Directive provides a list of items which fits under the criteria of packaging to increase the recovery and recycling of packaging waste		
Waste	Animal by-products and derived products not intended for human consumption Regulation EC No 1069/2009	Adopted in 2005 updated in 2009	To protect human and environmental health. Potential to be used as biomass feedstock for biogas	Regulatory measures for - approval for establishment of plants, the implementation of parameters for transformation into biogas or compost, hazard analysis and critical control points (HACCP) principles.		
All sectors	New Industrial Strategy for Europe 2020	Adopted in 2020	To promote European industry's global competitiveness, climate-neutral by 2050 and shape digital future of Europe			Strategy (Communication)- Promotes biotechnology, biopharmaceutical industry
All sectors	Research and Innovation Strategies for Smart Specialisation (RIS3)	2014-2020	To support smart growth and knowledge-based economy in EU with a broad view of innovation.	Framework for building national strategies and establish synergies with other funding programmes like ESIF, Horizon Europe 2021-2027, ERDF		



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Energy	2030 Climate and Energy Framework	Adopted in 2014 and revised in 2018	To improve energy efficiency to reduce GHG emissions, sustainable use of land and forest and address ILUC impacts because of biomass use for various bio-based industries.	Regulatory: EU 2030 targets for GHG emission reductions, share of renewable energy and energy efficiency	SET Plan for investments in R&D	
Energy	Renewable energy directive (Dir. 2009/EC/28) updated RED II 2018/2001/EU	Adopted in 2001 updated in 2018	Promotes sustainable biomass use for bioenergy production	Compliance: RED II sets sustainability criteria and GHG emission criteria for bioliquids used in transport. Sets criteria for low ILUC-risk and high ILUC-risk biomass feedstock		
Energy	Kyoto Protocol	Adopted in 1997 updated in 2012	To reduce GHG emission in accordance with agreed targets	Targets and commitments for GHG reduction	Market mechanism - tradable emission permits, Clean development mechanisms (CDM) and Joint Implementation (Emission reduction units ERUs)	Land management practices for carbon Sequestration in agricultural soils.
Energy	Paris Agreement	Adopted in 2016	To reduce GHG emission by 40% by 2030 compared to 1990 and limit global warming and strengthen ability to adapt to climate change impacts	Requirements for regular reporting on emissions and implementation efforts	Financial supports	Provided framework of 1.5 degree limit on temperature rise for countries to develop Nationally Determined Contribution NDCs Capacity building and technological building framework.
Energy	ILUC Directive 2018/2001	Adopted in 2019	To reduce GHG emissions from land conversion for biofuel production	Certification of low and high ILUC		
Energy	Roadmap to Resource Efficient Europe COM 2011/571	Adopted in 2011	To promote resource efficient and sustainable growth of Europe	proposes ways to increase resource productivity, decoupling of resource use and economic growth through structural and technological change by 2050		Communication provides framework for structural and technological change needed up to 2050.



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Natural resources (Air)	Industrial Emissions Directive (IED)2010/75/EU	Adopted in 2010	To establish principles to control industrial activities.	MSS should ensure the compliance with the Directive-permits, standards, binding rules, emission limit values, best available techniques etc. Combustion plants and livestock rearing annual emissions are aggregated and inventory are made available to the Commission every 3 years. Special provisions for waste incineration plants.		
Natural resources (Air)	Clean Air Policy Package/New Clean Air Programme for Europe	Adopted in 2013	To improve air quality by regulating PM, NOx, NH3 and SO2 and prevent eutrophication of protected ecosystems, acidification of forest ecosystems	Targets to regulate the air quality limit values limit values for PM, NO2, SO2. Reporting and monitoring of national emission inventories. Air pollution control programmes to be adopted and implemented by all MSs and reduce emissions of NH3 and PM2.5 from agriculture.		Strategy (Communication)
Natural resources (Air)	Integrated pollution prevention and control (IPPC) (96/61/EC) Directive	Adopted in 1996	To regulate emissions to air, land and soil from industrial sites.	Directive provides emission limit values, quality standards, best available techniques which can be adopted by MSs		
Natural resources (Biodiversity)	EU 2020 Biodiversity Strategy	2011 /Updated in 2020	To support the conservation of biodiversity and their natural habitat through land designations, minimise ecological costs of biomass harvesting and maintain the balance in ecosystem services	Biodiversity targets- 4 key targets with a path to attain 2050 vision.	LIFE Programme is a funding source for nature and biodiversity. ESIF, CAO, Cohesion policy funds, European Maritime and Fisheries Fund all have biodiversity concept integrated in their aims and objectives. So more funding will require more integration of policies from Ag and Forest sectors.	Strategy -includes framework for a decade to achieve 6 objectives. 2050 vision.



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Natural resources (Biodiversity)	Habitat Directive 92/43/EEC	Adopted in 1992	Conservation of natural habitats of flora and fauna	Member states shall contribute to create Natura 2000 network which shall include the special protection areas classified by the Member States pursuant to Bird Directive	Natura 2000 network ensures that threatened species and habitats under Birds and Habitats Directive are protected.	
Natural resources (Biodiversity)	Bird Directive 79/409/EEC updated Directive 2009/147/EC	Adopted in 1979 updated in 2009	To protect the species of birds in EU territory	Member states needs to identify the special protection areas for conservation of species listed in Annex I of the Directive.		
Natural resources (Soil)	Soil Thematic Strategy COM (2012)46	Adopted in 2006 and updated in 2012	To protect soil and use it sustainably	Limits the introduction of toxic substance to soil.	Reduction of soil contamination risk by funding mechanisms for remediation	Commission supported the activities like -awareness raising on soil protection, distribution of Soil Atlas of Europe.
Natural resources (Soil)	Standards for soil improvers (CEN-TC223)	Adopted in 1999 and updated 2013	To protect soil by standardizing materials (soil improvers) used in agricultural soil	Standards (binding)		Voluntary products labels and guidelines.
Natural resources (Water)	Nitrates Directive	Adopted in 1991 and updated	To protect ground and water surfaces by promoting good farming practices	National monitoring and reporting. Compulsory establishment of action programmes to be implemented by MSs in designated Nitrate Vulnerable Zones (NVZs)		Voluntary codes of good agricultural practice
Natural resources (Soil)	EU Circular Economy Fertilising Products Regulation (EU 2019/1009)	Adopted in 2019	To promote the use of recycled nutrients (organic) to increase nutrient efficiency under the principles of circular economy.	Regulation provides framework for regulation of fertilising products		



Natural resources (Soil)	Directive for sustainable use of pesticides 2009/128/EC	Adopted in 2009 updated in 2019 Directive 2019/782	To achieve sustainable use of pesticides in EU and use non-chemical alternatives (organic farming) to protect human-health and environment.	Directive lays down principles for MSs to promote Integrated Pest Management (IPM). Under updated Directive 2019/782 Harmonised Risk Indicators to be adopted by MSs to implement a union level statistical data collection.		
Natural resources (Water)	Water Framework Directive 2000/60/EC	Adopted in 2000 and transposed to national legislation in 2003.	To promote the sustainable use of water resource	Directive proposed a Common Implementation Strategy (CIS) and established a list of priority substances for chemical analysis and monitoring of water.		Improvement of information exchange between MSs under Information Exchange Platform (CIRCABC)



Table: Overview of policies across sectors that regulate conversion and end use and are relevant to the bioeconomy

Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Biobased Industry	EU REACH 317/2014	Adopted in 2006 updated in 2014	To protect human and environmental health from the chemicals used in the industry. To promote free circulation of substances in the internal market to promote industrial competitiveness and innovation.	Registration, Evaluation, Restrictions and Authorisations and information requirements for substance that flow in the supply chain. Compliance: registration of chemicals in central database, evaluation of hazardous chemicals.		
Biobased Industry	Standardisation committee Standards for Biobased products (CEN TC411)	Adopted in 2011	To develop standards for bio-based products	Horizontal standards for bio-based products produced by CEN/TC 411: CEN/TR 16721, CEN/TS 16640, CEN/TS 16766, EN 16575, EN 16751, EN 16760, EN 16785-1		
Biobased Industry	Standardisation for Bio-lubricants (Liquid petroleum products) CEN/TC 19	Adopted in 2011	To standardize bio-lubricants based on their biodegradability and impact on GHG emissions, raw material consumption rates, test and measurement methods and LCA procedures.	Standardize bio-lubricants with criteria and requirements EN 16897/2016		
Biobased Industry	Standardisation for Biopolymers and Bioplastics CEN/TC 249	Adopted in 2007	To standardize biopolymers and bioplastics	Sets standards to regulate bio-based carbon content and characterise biopolymers and bioplastics. European Standards EN 14995 (non-packaging plastics), EN 13432 (packaging plastics) requirements for composting and biodegradation. Requirements-packaging material to meet for industrial scale composting.		
Biobased Industry	Standardisation for products made from algae CEN/TC 454	Adopted in 2018	To standardize bio-based products from algae	Standards for algae as feedstock for bio-based and determine quality standards for for algae-based products. Terms and Definitions EN 17399:2020		
Energy	European Norm Sustainability criteria for biofuels and bioliquids: EN16214		To verify sustainability criteria for biofuels and bioliquids			Voluntary Standards



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Energy	European Norm Petrol: EN228		To develop standard for petrol fuel.	Binding Standards		
Energy	Standards for solid biofuels (CEN/TC335)		Standards to regulate solid biofuels to ensure quality of the raw material supply, production and delivery to end-user.			
Energy	Standards for Solid Recovered Fuels (SRF) (CEN-TC343)		Standards to regulate fuels prepared from non-hazardous waste for energy in waste-incineration and co-incineration plants.			Voluntary standards
Energy	prEN16723 - Natural gas and biomethane	Adopted 2016	To standardise specifications for natural gas and biomethane.	Bindings standards, requirement for biomethane at the entry point of natural gas networks		Share information about test methods.
Research and Innovation	EU Innovation Action Plan		To promote eco-innovation in technologies, business processes and organisational change to address challenges of resource scarcity, air, water and soil pollution, water efficiency and to promote growth and jobs. The EcoAP support progress towards goal of sustainable development by reducing impacts on environment, increasing resilience to environmental pressures or using natural resources more efficiently and responsibly.		European Business Awards for the Environment (EBAE) to encourage SMEs. Horizon 2020, LIFE Programme, Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME) funding programmes are all coming to their end of the cycle.	Reinforces initiatives such as EMAS, EU Ecolabel, Environmental technology verification programme (EU- ETV)- Voluntary verification tool. Green Action Plans for SMEs.
Research and Innovation	Entrepreneurship and Innovation operational programme (EIP)		To support eco-innovation activities in SMEs and facilitate commercialisation of innovative production processes products and services to reduce environmental impacts and to promote an efficient and responsible use of resources and encourage the competitiveness of European enterprises.			



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Research and Innovation	Environmental Technologies Action Plan (ETAP)	Launched in 2004	To improve European competitiveness by supporting environmental technologies from research stage to market stage.		Cohesion Funds, LIFE, Structural Funds, Competitiveness and Innovation Programme (CIP), Market based instruments. Green Public Procurement. Environmental technology verification programme (EU- ETV)- Voluntary verification tool to increase consumers' confidence in new environmental technologies	Performance targets. Awareness and Training programmes
Research and Innovation	LIFE+		Promotes eco-innovation and environmental technologies		Financial support	
Research and Innovation	SET-Plan	Launched in 2007	To accelerate innovation in cutting edge European Low Carbon Technologies in energy sector			
Research and Innovation	ERDF, ESIF, S3		Promotes environmentally friendly products and production processes in SMEs.			
Natural Resources	Sustainable Consumption and Production Action Plan (SCP-AP)		Outlines integrated approach to sustainable production and consumption patterns to enhance environmental performance of products and encourage consumers for uptake.			
Natural Resources	European Pollutant Release and Transfer Register (E-PRTR)	Adopted in 2006	To establish public access of information on pollutants releases to air, water and land and transfer of water and pollutants to waste-water.	Kieve Protocol is first legally binding international instrument on pollutant release and transfer registers.		
Biobased Industry	Medium Combustion Plant Directive (MCPD) EU 2015/2193	Adopted in 2015	To reduce the harmful substances emissions from industries, improve their energy efficiency to control air quality in cost effective manner.	Emissions limits value (ELVs) depending on the size of the plants and fuel uses. It applies to all operators and owners of combustion plant rated between 1 MW and 50 MW thermal input. ELVs are different for plants <5MW and >5MW. Reporting requirements with minimum administrative burden		Provides information and encourages exchange among stakeholders on the advanced techniques available to lower emissions.



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Energy	Eco-design Requirement of solid fuel boilers Regulation (EU) 2015/1189	Adopted in 2015	To establish eco-design requirements for solid fuel boilers to improve energy efficiency by reducing energy consumption and emissions.	Requirements, Compliance with eco-design requirements.		
Energy	Energy Labelling of Solid Fuel Boilers EU 2015/1187		To promote energy efficiency in solid fuel (biomass) boilers (only woody biomass and exemption of non-woody biomass boilers)	Labelling requirements		
Energy	Energy Efficiency Directive EU 2018/2002 amending EU (Dir. 2012/27/EU)	Adopted in 2012 updated in 2018	To promote energy saving by encouraging uptake of innovative technologies, by improving energy efficiency measures, by reducing consumption.	Target for energy efficiency. Energy Labelling. Rules on metering, transparent allocation of cost of heating. Monitoring energy efficiency.	Incentives for producers and manufacturers to use low carbon and innovative technologies. Investment support.	Guidance notes for member states to transpose the Directive into national law.
Energy	Eco-design Directive 2009/125/EC	Adopted in 2009	To regulate the minimum eco-design requirements for energy-using products, such as boilers, water heaters, computers, televisions or industrial fans to reduce their environmental impact and ensure movement of these products through fair competition and international trade.	Compulsory eco-design requirements for energy-using products		Voluntary benchmarks of environmental performance,
Energy	Energy Labelling Framework Regulation (EU) 2017/136	Adopted 2017	To provide consumers with labels indicating the energy consumption of energy-related products (household appliances, such as washing machines, dishwashers, ovens or air-conditioning appliances) Manufacturers and retailers will go beyond minimum standards because eco-labelling is an voluntary label which puts environmental friendly or green label on products and services	Market surveillance and control of products to ensure labelling.		



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Biobased Industry	EU Eco Label	Adopted in 1992	To encourage high environmental standards of products and services throughout their life-cycle. To encourage producers to generate less waste and GHG during manufacturing process.			
Natural resources	The EU Eco-Management and Audit Scheme (EMAS)	Adopted in 1993	To improve environmental performance of companies to track progress towards targets reducing GHG emissions and waste, promoting efficient use of energy and water and to incorporate environmental guidelines in procurement procedures.			Voluntary audit and certification system
Natural resources (Air)	Industrial Emissions Directive (IED)2010/75/EU	Adopted in 2010	To establish principles to regulate GHG emissions (4), pollutants, particulate matters from industrial activities.	Zero tolerance for pollutants and Polluters pay principles. Permits, standards, binding rules, emission limit values, best available techniques etc for members states to comply.		Inventory on emissions to be reported regularly
Natural resources (Air)	Clean Air Policy	Adopted in 2013	To improve air quality by regulating PM, NOx, NH3 and SO2 and prevent eutrophication of protected ecosystems, acidification of forest ecosystems	Targets to regulate the air quality limit values limit values for PM, NO2, SO2. Reporting and monitoring of national emission inventories. Air pollution control programmes to be adopted and implemented by all MSs and reduce emissions of NH3 and PM2.5 from agriculture.		Strategy (Communication)
Transport	Emission performance standards for new passenger cars (Reg 443/2009)	adopted in 2009	To develop emissions standards for cars registered in European Union to reduce GHG emissions. The Regulation aims to create incentives for car industry to invest in new technologies and promote eco-innovations.	Binding EU wide targets for passenger cars provides certainty and flexibility to meet the targets of GHG reductions. Monitoring and reporting on emissions.		



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Transport	Clean Vehicles Directive (Dir. 2009/33/EC)	adopted in 2009 updated 2017	To promote clean mobility solutions in public and procurement tenders and raise demand for deployment of clean vehicles. To stimulate the market for clean and energy-efficient vehicles		Financial incentives for vehicles with eco-innovation system, electric and hybrid vehicles	
Transport	Alternative Fuel Strategy COM (2013)17	Adopted in 2013	To encourage development and uptake of vehicles with low environmental impact. To substitute energy source in all modes of transport	Vehicle registration and circulation tax systems, energy taxation	Incentives to increase market demand for vehicle with high environmental performance.	
Transport	Alternative fuels infrastructure (Dir. 2014/94/EU)	Adopted in 2014	To deploy alternative fuels and distribution infrastructure.	Technical specification standards for recharging points, hydrogen and natural gas refuelling stations. Customer experience standards - geographic location data of alternative fuels infrastructure made public, intelligent metering systems and ad-hoc access.		
Transport	EU Regulation 595/2009 on Heavy duty vehicles standards	Adopted in 2009 updated in 2018	To reduce GHG emissions and fuel consumption	Regulatory (Codes and standards) for motor vehicles and engines with respect to emissions from vehicles.	Incentives for zero or low-emission vehicles	Information access about the vehicle repair to SMEs. On-board diagnostic systems and their interaction with other vehicle systems.
Transport	EU regulation EU 2017/2400 CO2 emissions and fuel consumption of heavy-duty	Adopted in 2017	To enforce emission standards to reduce air pollution and GHG emissions.	CO2 reduction targets. Obligation to determine and declare for certification of CO2 emission and fuel consumption of new vehicles. Standard and Certified values. Vehicle energy consumption calculator tool (VETCO)	https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/628268/EP_RS_BRI(2018)628268_EN.pdf	
Transport	EU Regulation 692/2008 on light vehicles standards	Adopted in 2008	To enforce emission limits for light-duty vehicles to improve energy efficiency.	Regulatory (Codes and standards) for emissions from vehicles.		



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Transport	EU Regulation (EU) 2018/956 monitoring and reporting of CO2 emissions from and fuel consumption of new heavy-duty vehicles	Adopted in 2018	To set up a system for monitoring and reporting of GHG emissions and fuel consumption	Requirement to monitor and report data related to emissions and fuel consumption of heavy-duty vehicles.		
Transport/Energy	European Strategy for low emission mobility	Adopted in 2016	To improve transport system efficiency by using digital technologies and smart road charging; encourages the use of low-emission alternative energy for transport and outlines measures for moving towards zero-emission vehicles.			
Transport	Monitoring, reporting and verification (MRV) of CO2 from maritime transport -EU Regulation 2015/757	Adopted in 2009 updated in 2015	To regulate emission from maritime sector in a cost-effective manner.	Data collection and reporting (amount and emission factor of fuel consumed) as defined by EC. Verification. Applicable for ships more than 5000 gross tonnage calling at any EU ports.		
Natural resources	EU emissions trading system (EU ETS) EU 2018/410)- Phase 4	Adopted in 2018	To reduce GHG emissions cost-effectively and to combat climate change.	Caps; Monitoring and reporting regulation (MRR); Accreditation and Verification Regulation (AVR)	Carbon market mechanisms- receive or buy emission allowances. Investment funds-Innovation fund and Modernisation fund	
Natural resources	Effort sharing targets for member states 2021-2030	Adopted in 2018	To reduce GHG emission emissions by translating commitment to targets on principles of fairness, cost-effectiveness and environmental integrity.	Efforts Sharing Decision (ESD) sets national targets for sectors -transport, building, agriculture, waste and non ETS industry.		



Sectors	Policies	Adopted year/ Revised year	Overall aim/objective relevant to Bioeconomy	Type of instrument: Regulatory	Type of instrument: Financial	Type of instrument: Soft measures
Natural resources	Green public procurement (COM(2008)400)	Adopted in 2008 last updated in 2020	To incentivise green technologies and products to reduce environmental impacts. To avoid distortion of single market and to reduce administrative burden by creating common criteria.			Voluntary EU GPP criteria; Information on Public Procurement for a Circular Economy (2017)
Energy/Biobased Industry	Just Transition Mechanisms The EU Emissions Trading System Innovation Fund,		To support large-scale innovative projects to support clean products and decarbonise energy intensive sectors, create jobs, provide technical assistance and investment in renewable energy sources			
Climate Change/Energy	European Green Deal		To support this transition and make EU climate-neutral by 2050 and one of the focus action area is to help European industries to become global leaders in adopting clean products and technologies			
Energy	Energy Taxation Directive (ETD) Dir. 2003/96/EC	Adopted in 2003	To establish harmonised tax on energy products (heating fuel, motor fuel) and electricity to avoid distortions of trade and competition between energy sources and consumers and supplier. It also aims to maintain competitiveness of EU companies and create jobs.		Energy taxes are imposed based on energy used (heat, electricity, fuel) and serve the purpose of internalising negative environmental impacts that arise from fossil fuel-based power generation	
Energy	Clean Energy for All European Package	Adopted in 2019	To facilitate transition from fossil fuels towards cleaner energy. RED II is part of the package and aims to keep EU as global leader in renewable.	All Member States are required to prepare National Energy and Climate Action Plans (NECPs) for 2021-2030 to outline how they will meet 2030 targets for renewable energy and energy efficiency.		



Energy	EU Energy Union Strategy COM/2015080	Adopted in 2015	To integrate EU energy market, to increase energy efficiency and to reduce dependency on imports, reduce GHG emissions and lead global efforts on climate change	Energy Union provides the framework of 5 energy union dimensions - integrated internal market, energy efficiency, energy security, decarbonising economy, and research, innovation and competitiveness		
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Appendix 2: Drivers impacting policy relevant modelling for biobased value chains

This Appendix attempts to translate the existing set of directives, standards, policies and strategies that (in)directly relate to the EU bioeconomy into 'model' language. To do so it outlines a non-exhaustive list of drivers that impact policy relevant modelling for the current EU policies.



Table 3 Drivers that impact relevant variables in modelling current EU policies

Policy	Variables influenced	Land stock and structure	Technology level/change	Energy need	Conversion capacity	Policy mechanisms and reforms
iLUC Directive (EU) 2015/1513		X				
Renewable energy directive (Dir. 2009/EC/28)				x		x
Alternative fuels infrastructure (Dir. 2014/94/EU)			x		x	x
Clean Vehicles Directive (Dir. 2009/33/EC)			x		x	x
Ecodesign Directive (Dir. 2009/125/EC)			x		x	
Effort sharing targets for member states (binding targets)						x
Emission performance standards for new passenger cars (Reg 443/2009)			x			x
EN ISO 17225 Standards for solid biofuels (CEN/TC335)					x	x
Energy Efficiency Directive (Dir. 2012/27/EU)			x	x	x	
Energy Performance of Buildings Directive (Dir. 2010/31/EU)				x		x
EU emissions trading system (EU ETS)			x			
European Standards EN16214 CEN/TC 383 Sustainably produced biomass for energy applications	X					
Fuel quality directive (Dir. 2009/30/EC)					x	
prEN16723 - Natural gas and biomethane				x		
Renewable energy directive (Dir, 2009/EC/28)						x
Solid fuel boilers and solid fuel local space heaters			x			x
Sustainability requirements (COM(2010)11)						x
2030 Framework for climate and energy	x	x	x	x	x	x
EU Bioeconomy strategy (COM(2018) 673)	x	x	x	x		x
EU Timber Regulation						
European Technology and Innovation Platform on Bioenergy (ETIP Bioenergy)				x	x	x
European Technology Platform for Sustainable Chemistry (SusChem)			x			
Forest based sector technology platform (FTP)	x	x				x
LULUCF-Land use land-use change and Forestry (Dec. 529/2013/EU)	x					x
Roadmap to a Resource Efficient Europe	x	x	x	x	x	x
S3 Platform			x		x	x
SCAR Network						x
Horizon 2020			x			x
Joint technology initiative for bio-based industries (BBI-JTI)			x			x
BRIDGE 2020			x		x	
NER300 programme			x			
SET plan: Action 8: Renewable Fuels and Bioenergy			x	x		
Sustainable Process Industry through Resource and Energy Efficiency (SPIRE)			x	x		



Table 4 Environmental drivers used to assess policy impacts in EU policies

Variables influenced Policy	Land use	Nutrient levels	Life cycle GHG	Carbon stocks	Inputs	Harvest/litter	Pollutants/contaminants	Water use	Ecosystem services/productivity
iLUC Directive (EU) 2015/1513	x			x					
Natura 2000									x
Nitrates Directive		x	x		x	x			
Directive for sustainable use of pesticides					x		x		
Standards for soil improvers (CEN-TC223)				x	x				
Soil Thematic Strategy –soil protection COM(2006) 231				x	x				
EU timber Regulation (Reg 995/2010)						x			
Bird Directive 2009/147/EC									x
Habitat Directive 92/43/EEC)	x								x
European Standards EN16214 CEN/TC 383 Sustainably produced biomass for energy applications	x		x						x
Landfill Directive (1999/31/EC) 2030	x								
Sewage Sludge Directive (86/278/EEC)							x		
Standardisation on surface active agents (CEN-TC276)							x		
Standards for biobased products (CEN-TC411)							x		
Animal by-products regulation	x						x		
Bird Directive 2009/147/EC									x
CAP Pillar I: Direct Payments	x			x					
CAP Pillar II –Rural Development									x
CEN/TC 308 – Characterization of sludges							x		
Clean Vehicles Directive (Dir. 2009/33/EC)			x				x		
Effort sharing targets for member states (binding targets)									
Emission performance standards for new passenger cars (Reg 443/2009)			x				x		
EN ISO 17225 Standards for solid biofuels (CEN/TC335)			x						
Energy Efficiency Directive (Dir. 2012/27/EU)						x		x	
EU Council Directive 2015/652			x						
EU emissions trading system (EU ETS)			x	x					



EU Monitoring, reporting and verification (MRV) Regulation 2015/757			x						
EU timber Regulation (Reg 995/2010)						x			
European Standards EN16214 CEN/TC 383 Sustainably produced biomass for energy applications	x		x			x			x
Fuel quality directive (Dir. 2009/30/EC)			x						
Green public procurement (COM(2008)400)	x		x			x			
Habitat Directive (Dir. 92/43/EEC)	x								x
Industrial Emissions Directive							x		
REACH (Reg. 1907/2006)							x		
Sewage Sludge Directive (86/278/EEC)							x		
Soil protection (COM(2006)231)		x		x					
Soil Thematic Strategy –soil protection COM(2006) 231		x		x					
Standards for fertilizers and liming materials (CEN-TC260)		x							
Standards for soil improvers (CEN-TC223)		x		x					
EU Forest Strategy									
2030 Framework for climate and energy	x		x	x		x		x	x
EU 2020 Biodiversity Strategy COM(2011)									x
EU Timber Regulation						x			
European Technology and Innovation Platform on Bioenergy (ETIP Bioenergy)	x								
Forest based sector technology platform (FTP)	x			x					
LULUCF-Land use land-use change and Forestry (Dec. 529/2013/EU)	x		x	x					x
Roadmap to a Resource Efficient Europe	x	x	x	x	x	x		x	x
SCAR Network	x	x	x		x	x		x	x
Energy Taxation Directive (Dir. 2003/96/EC)									
NER300 programme			x	x					
SET plan: Action 8: Renewable Fuels and Bioenergy			x						
REDD+	x			x					



Table 5 Economic drivers used to assess policy impacts in EU policies

Policy	Variables influenced	Biomass production and availability	Energy carriers/production supply	Trade	GDP
EU timber Regulation (Reg 995/2010)				x	
Standards for biobased products (CEN-TC411)		x			
Alternative fuels infrastructure (Dir. 2014/94/EU)		x	x		
Clean Vehicles Directive (Dir. 2009/33/EC)		x			
EN ISO 17225 Standards for solid biofuels (CEN/TC335)		x	x		
Energy Efficiency Directive (Dir. 2012/27/EU)			x		
EU emissions trading system (EU ETS)					
Renewable energy directive (Dir, 2009/EC/28)		x	x	x	
Sustainability requirements (COM(2010)11)				x	
2030 Framework for climate and energy		x	x	x	x
EU 2020 Biodiversity Strategy COM(2011)					
EU Bioeconomy strategy (COM(2018) 673)		x		x	x
European Technology and Innovation Platform on Bioenergy (ETIP Bioenergy)		x	x		
Forest based sector technology platform (FTP)		x		x	
LULUCF-Land use land-use change and Forestry (Dec. 529/2013/EU)		x			
Roadmap to a Resource Efficient Europe		x	x		
Horizon 2020				x	x
Joint technology initiative for bio-based industries (BBI-JTI)					
BRIDGE 2020				x	
Energy Taxation Directive (Dir. 2003/96/EC)					



Table 6 Social drives used to assess policy impacts in EU policies

Policy	Variables influenced	Demand/consumption	Employment	Welfare	Food security
EU timber Regulation (Reg 995/2010)		x			
CAP Pillar II –Rural Development			x		
Sustainability requirements (COM(2010)11)		x			
2030 Framework for climate and energy		x			
EU Bioeconomy strategy (COM(2018) 673)		x	x		X
Forest based sector technology platform (FTP)		x	x		
Roadmap to a Resource Efficient Europe					X
S3 Platform					
SCAR Network					X
Horizon 2020					X
BRIDGE 2020		x			
Energy Taxation Directive (Dir. 2003/96/EC)		x			

