

BioMonitor Tools for Policy Makers and Industries: Analysing and Implementing Bioeconomy Strategies

Abstract

BioMonitor is creating a toolbox with models and other quantitative methods to facilitate the understanding of how the EU's bioeconomy operates and influences future sustainability goals, such as meeting emissions reduction targets, decarbonising EU energy markets, producing safe and healthy food, and creating sustainable income and employment. The BioMonitor Model Toolbox will capture assumed trends for economic performance, demographics, consumer preferences, technology and innovation, climate and environment. Our toolbox also takes into account how producers, consumers, and policy makers behave. Their actions influence the bioeconomy and its ability to reach sustainability goals. The effects of public and private initiatives on the development of the bioeconomy are expressed in terms of economic, social, and environmental indicators.

The BioMonitor Model Toolbox aims to examine the impacts of different trends and policy options and to assist policy makers in deciding what needs to be done to empower the emerging bioeconomy.

Key points

Analyse alternative policy options for achieving sustainability goals

Provide future outlooks for innovative bio-based product markets

Identify market and non-market synergies and trade-offs based on different transition pathways

Introduction

The European Green Deal and related strategies on the Bioeconomy, Circular Economy and Farm to Fork aim to establish a resilient and sustainable Europe. Different models are widely used for assessing the potential impacts of these strategies (Wesseler and von Braun, 2017; Lovrić et al., 2020).

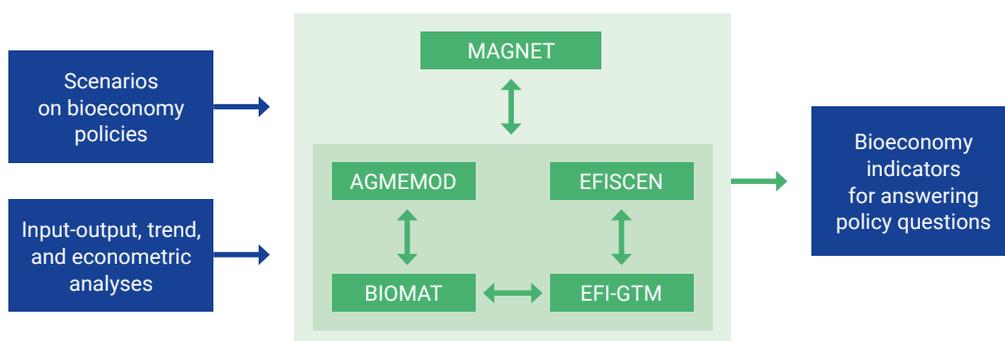
The BioMonitor project uses several models that provide insights into industries and governments in two ways. Firstly, models can identify those policies or best practices that yield consistent, cohesive, and long-term pathways with desirable consequences across multiple objectives. Secondly, models can quantify indicators that summarise market prospects across multiple sectors and commodities within the bioeconomy in accordance with different future scenarios.

One of the key actions that BioMonitor seeks to address is to close the know-

ledge gaps in current versions of these models. The BioMonitor Model Toolbox contains a suite of analysis techniques and five simulation models (AGMEMOD, BIOMAT, EFISCEN, EFI-GTM and MAGNET) that are combined to cover multiple aspects of the bioeconomy. These models will be improved in BioMonitor by including emerging bio-based activities and products, encompassing construction materials, textiles, plastics, chemicals and pharmaceuticals.

One challenge is to better capture the link between emerging and traditional bioeconomy sectors (Lovrić et al., 2020). BioMonitor models will quantify the developments of multiple bio-based materials and commodity markets and improve the link of those with traditional bioeconomy sectors. This allows for more detailed ex-ante analyses of the aforementioned EU policy strategies (Kardung et al., 2021).

Figure no.1 - BioMonitor Model Toolbox



The scenarios on bioeconomy policies (derived from EU strategies) in conjunction with quantitative methods (input-output, time series and panel data analyses) provide prior information to the BioMonitor Model Toolbox (green boxes). The arrows indicate the interrelationships between the models in the toolbox. Each model quantifies a variety of indicators that complement each other, as shown in Table 1. When used together, the models can provide more detailed responses to policy questions raised in the scenarios (see, [Policy brief #1](#)).

Table no.1 - Models in the BioMonitor Toolbox

	Value chains	Indicators	Geographical location	Timeframe
Input-Output, econometric, trend analysis	Bioeconomy sectors, bio-based products	Socio-economic, environmental	Case based; country based data	Case based
AGMEMOD	Agro-food products markets; biofuels	Economic	EU member states, Balkan countries, East-African countries, Ukraine, Russia	2030, 2050
BIOMAT	Bio-based product markets	Techno-economic	EU member states	2030, 2050
EFISCEN	Forest resources	Environmental	EU member states, other European countries	2030, 2050
EFI-GTM	Forest and wood-based products and markets	Economic	EU member states, world regions	2030, 2050
MAGNET	Bioeconomy sectors; overall economy	Socio-economic, environmental	EU member states; 141 world regions	2030, 2050

The BioMonitor toolbox models provide different perspectives on emerging bio-based value chains, spatial coverage, and the timeframe. The year 2030 is considered to be a medium-length time frame, while 2050 refers to a long-term projection. Results are summarised by using a set of indicators for monitoring the bioeconomy (Kardung et al., 2021).

Quantitative methods

BioMonitor covers a suite of approaches to close gaps in newly collected data. Entropy and other techniques are used to fill data gaps. Statistical techniques (e.g. econometric and multi-variate analyses) are applied to estimate structural model drivers including conversion factors, relative costs, substitution elasticities, and supply and demand elasticities for the new bio-based materials. This infor-

mation is then fed into the simulation models to provide a better analysis of the economic, social, and environmental impacts of policy interventions related to the bioeconomy.

BIOMAT (BIO-based MATerials) and AGMEMOD (AGriculture MEmber State MODelling)

The BIOMAT model is a multi-regional partial equilibrium model of innovative

bio-based products markets. BIOMAT applies the same framework as AGMEMOD, accounting for the supply, import, export, use, and price of innovative bio-based materials in EU member states.

With its dedicated network of experts, AGMEMOD provides outlooks and impact analysis for agri-food markets (Salamon et al., 2017; Chantreuil et al., 2012; <https://agmemod.eu/>). It is envisaged that expertise in BIOMAT will also benefit from this network.

BIOMAT uses projections on industrial biomass from AGMEMOD and EFI-GTM as a starting point for developing bio-based product value chains. Industrial biomass enters two subsequent processing stages: bio-based platform products such as technical starch, industrial sugars and plant oils (1st stage in value chain) and semi-final products such as bio-based polymers, bio-based lubricants, bio-based solvents, biofuels and paper (2nd stage in value chain).

BIOMAT aims to produce ex-ante business-as-usual market prospects for innovative bio-based products in the EU and its members up to 2030. Simulations are conducted to evaluate measures and policies of the bioeconomy of interest to different stakeholders.

EFISCEN (European Forest Information SCENario) model

EFISCEN is an environmental model that projects the development of European forest resources for up to 50 or 60 years based on different policy and management scenarios from the regional to the European scale (Verkerk et al., 2017; 2019; Nabuurs et al., 2018; <https://efi.int/knowledge/models/efiscen>). The model uses detailed information on current forest structure, common forest management practices, climate change impact, and the wood needed from European forests.

EFISCEN provides information on the development of Europe's forests (tree species, area, growing stock, biomass, growth, age structure), as well as key information on the potential availability of woody biomass (roundwood, logging residues) for material

and energy use, roundwood production, and multiple sustainability indicators and ecosystem services. EFISCEN is typically linked with EFI-GTM to assess how much wood is needed to meet the changing demand for forest industry products and for energy and its impact on important bioeconomy indicators, such as carbon storage and biodiversity.

EFISCEN provides key information on policies related to biomass availability to supply the bioeconomy with raw materials, and on Land Use, Land Use Change, and Forestry (LULUCF) issues and targets.

EFI-GTM (European Forest Institute – Global Trade Model)

EFI-GTM is a multi-region, multi-periodic, partial equilibrium model for the forest sector in EU member states and other global regions (Moiseyev et al., 2014). It depicts a value chain consisting of wood supply, forest industries (sawmilling, wood-based panels, pulp and paper industries) and production of wood-based energy and biofuels, demand for forest industry products and woody biomass for energy, and international trade in wood and forest products.

EFI-GTM depicts 30 forest industry and energy sector products, five roundwood and three forest chips, four recycled paper grades, and the main by-products such as sawmill chips, sawdust, and black liquor. BioMonitor updates the existing wood product markets and enhances EFI-GTM with emerging wood products such as man-made fibres for textile applications and engineered wood products (CLT, glulam) for construction as well as wood-based chemicals, plastics and packaging. **EFI-GTM provides ex-ante long term impact assessments for global forest product markets, covering both conventional and innovative products up to 2050 under various policy scenarios.**

MAGNET (Modular Applied GeNeral Equilibrium Tool)

MAGNET is an ex-ante, recursive, dynamic, multi-region, multi-sector computable

general equilibrium simulation model (Van Meijl et al., 2018; Philippidis et al., 2020; <https://www.magnet-model.org/>). With economy-wide coverage, it characterises market prospects across world regions for medium- to long-term time frames. In addition to standard market performance indicators, it also provides a list of non-market social and environmental measures. The model is developed by the MAGNET consortium. MAGNET represents traditional bioeconomy sectors (crops, livestock, processed food, fishing, forestry, textiles, wood, and paper products), as well as sources of biomass supply (residues, plantations and pellets) and demand (biofuels, bioelectricity, and bio-based chemical activities). BioMonitor will integrate economic details for bio-based versus fossil-based pathways of chemicals (NACE C20), pharmaceuticals (NACE C21), and plastics (NACE C22). Moreover, further developments are envisaged to capture the concept of circularity through the calculation of resource footprints.

MAGNET can quantify socio-economic impacts of bioeconomy developments in the EU and its member states as well as the resulting feedback or “second round” effects that arise. It can address bioeconomy-related questions using its dedicated modules for CAP, biofuels, natural resources, or emissions.

Establishing a sound data monitoring system

The impact on climate, biodiversity, employment, and economic growth from substituting fossil-based with bio-based products are difficult to understand and analyse due to the current lack of reliable and harmonised data. Such challenges are also driven by changes in policy, consumer behaviour, technological advancement, climate change, and other factors (Wesseler and von Braun, 2017).

As a result, the BioMonitor project is developing a sound monitoring system that builds on new data collection and imputation methods to gain important historical insights into the past performance of the

EU bioeconomy. Furthermore, models in the BioMonitor Toolbox will use the new data for improving the forward-looking analyses.

Establishing a sound model analysis system

Simulation models are useful tools for projecting the development of the bioeconomy over the medium and long term. The results can be used for a broader impact analysis and as input for monitoring bioeconomy indicators. The simulation models can help policy makers, stakeholders, and the public at large to understand the complex interactions between market forces, public policies, and biophysical constraints inherent in the different transitional pathways. By identifying the resulting synergies and trade-offs that arise from these interactions, models provide a comparable evidence-based platform upon which different transition strategies towards a bioeconomy can be assessed.

A set of economic and biophysical models has been selected for the BioMonitor Model Toolbox. BioMonitor will enhance these models with further data on emerging bio-based sectors and materials and extend the currently available list of indicators to encompass sustainability aspects of the bioeconomy ([Table 2](#)).

Models for assessing bioeconomic scenarios

The BioMonitor Model Toolbox will analyse alternative policy options that meet future sustainability goals. These are designed to assist in decision-making on the part of policy makers and stakeholders. To this end, the following steps are envisaged. Firstly, reasonable reference projections of European bioeconomy market developments by 2030 and 2050 will be produced based on current trends and policies. Secondly, alternative future transition pathways of human development will be linked to broad storylines or narratives.

Table no.2 - Indicators in the BioMonitor project covered by the BioMonitor Model Toolbox

	AGMEMOD	BIOMAT	EFI-GTM	EFISCEN	MAGNET
<p>■ Driving forces of the bioeconomy for which assumed future trends constitute prior information for the models</p> <p>■ Indicators calculated by the model</p>					
1. Food and nutrition security					
Availability of food	■				■
Access to food	■				■
Utilization	■				■
Stability					■
2. Sustainable natural resource management					
Sustainable threshold levels for bioec. technology					■
Biodiversity				■	
Land cover	■	■		■	■
Primary biomass production	■	■	■	■	■
Sustainable resource use		■		■	
3. Dependence on non-renewable resources					
Bioenergy replacing non-renewable energy					■
Biomaterial replacing non-renewable sources	■	■			■
Biomass self-sufficiency rate	■	■	■	■	■
Material use efficiency		■	■		
Certified bio-based products					
4. Mitigating and adapting to climate change					
Greenhouse gas emission			■	■	■
Climate footprint					■
Climate change adaption				■	■
5. Employment and economic competitiveness					
Innovation	■	■	■	■	■
Investments	■	■	■	■	■
Value added					■
Production/consumption of non-food/feed bio-based products	■	■	■		■
Import/export of bioeconomy raw materials	■	■	■		■
Employment					■
Policies	■	■	■	■	■

These will then be integrated into the models to measure the potential impact of policy, technological, or behavioural options on sustainability indicators compared to the reference projection (Panoutsou et al., 2020). A real option approach will be employed

to capture uncertainties and irreversibilities (Wesseler and von Braun, 2017). This process will allow models to quantify the value of possible strategic actions and policy outcomes within plausible future scenarios as expressed by stakeholders.

Authors

Myrna van Leeuwen
Wageningen Economic Research
Myrna.vanLeeuwen@wur.nl

Hans Verkerk
European Forest Institute
Hans.Verkerk@efi.int

George Philippidis
Centre for Agrofood and
Technology Research (CITA)
gphilippidis@aragon.es

Viktoriya Sturm
Thuenen Institute
viktoriya.sturm@thuenen.de

Contacts

Learn more about
BioMonitor project:
www.biomonitor.eu
info@biomonitor.eu



This project has received
funding from the European
Union's Horizon 2020
research and innovation
programme under grant
agreement N°773297.

Bibliography

- Chantreuil F, Hanharan K., and van Leeuwen, M. (eds) (2012) AGMEMOD; the future of EU Agricultural markets by AGMEMOD. Springer.
- Kardung, M., Cingiz, K., Costenoble, O., Delahaye, R.; van Leeuwen, M., M'Barek, R., van Meijl, H., Piotrowski, S., et al. (2021) Development of the Circular Bioeconomy: Drivers and Indicators. *Sustainability* (2021), 13, 413. <https://doi.org/10.3390/su13010413>.
- Lovrić, M., Verkerk, H., Hassegawa, M., Cramm, M., Varacca, A., Sckokai, P., van Leeuwen, M., Salamon, P., Sturm, V., Vracholi, M., M'Barek, R., Philippidis, G. (2020) Requirements and priorities for improved bioeconomy modelling. BioMonitor deliverable report 4.2.
- 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* 01/2014 76:161-167.
- Nabuurs, G.-J., Arets, E.J.M.M., Schelhaas, M.-J. (2018) Understanding the implications of the EU-LULUCF regulation for the wood supply from EU forests to the EU. *Carbon Balance and Management* 13, 18. DOI: 10.1186/s13021-018-0107-3.
- Panoutsou, C., Arrekl, O., Christensen, T., Singh, A., Verkerk, H., Philippidis, G., van Leeuwen, M., Sturm, V., M'barek, R. and Wesseler, J. (2020) Report on description of baseline scenario for EU bioeconomy and of alternative scenarios for EU's bioeconomy future. Deliverable 6.1. BioMonitor project.
- Philippidis, G., Shutes, L., M'barek, R., Ronzon, T., Tabeau, A., van Meijl, H. (2020) Snakes and Ladders: World development pathways' synergies and trade-offs through the lens of the Sustainable Development Goals, *Journal of Cleaner Production*, v267, <https://doi.org/10.1016/j.jclepro.2020.122147>
- Salamon, P., Banse, M., Efen, J., van Leeuwen, M., Jongeneel, R., Baltussen, W., Hanrahan, K.F. (2017) Livestock and meat markets. In: Salputra, G., Salamon, P., Jongeneel, R., van Leeuwen, M., Banse, M., (eds) Unveiling diversity in agricultural markets projections: from EU to member states: a medium-term outlook with the AGMEMOD model. Luxembourg: Commission of the European Communities, pp 34-43 <http://publications.jrc.ec.europa.eu/repository/handle/JRC109115>
- Van Meijl, H., Tsiropoulos, I., Bartelings, H., Hoefnagels, R., Smeets, E., Tabeau, A., 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.
- Verkerk, P.J., Schelhaas, M.J., Immonen, V., Hengeveld, G., Kiljunen, J., Lindner, M., Nabuurs, G.J., Suominen, T., Zudin, S. (2017) Manual for the European Forest Information Scenario model. Version 4.2.0. EFI Technical Report 99. European Forest Institute, Joensuu, 49.
- 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
- Wesseler, J. and von Braun, J. (2017) Measuring the Bioeconomy: Economics and Policies. *Annual Review of Resource Economics*. Vol. 9: 275-298