Annex to the mandate on the provision of data and analysis on a long-term basis on biomass supply and demand by the JRC

Technical specifications of the work during the first two years

1. INTRODUCTION

This document contains the technical description of the work to be carried out by JRC, as foreseen in the Mandate on the provision of data and analysis on biomass agreed by the Steering Committee. More specifically, the work described herewith is limited to the study to be developed during the first two years of the Mandate, starting from 1st January 2015. The study will address the full scope but is not expected to complete the Mandate, which has a broad and long-term horizon. In order to reach this, the technical specifications will be periodically adapted according to policy needs, to availability of new data etc.; the technical adaptation shall be subject to agreement with the Inter-service Group and will be reported to the Steering Committee.

Revised technical specifications will have to be prepared after the first two years, based on the achievements of the study to date and the updated emerging policy needs.

During the execution of the work, a close dialogue with the Customer DGs will be maintained to ensure coherence with their policy needs and according to the governance structure described in the Mandate. A co-ordination with the Bio-economy Integrated System and Observatory (BISO) will be ensured, to avoid duplication of efforts and exploit potential synergies, as will be illustrated in more detail in this document. Links with similar studies and initiatives carried out in or on other regions of the world will be maintained through the networks where JRC is already participating and other Inter-service Group inputs. If required and feasible, new partnership networks will be developed also with the support of other Commission DGs.

The context for the work is multi-disciplinary and requires a wide range of expertise (e.g. terrestrial and marine ecosystems, remote sensing, modelling, economics…). It crosses different sectors and policies that so far have addressed the biomass assessment from quite diverse, and often contrasting, perspectives. The building of a comprehensive and coherent framework to handle the complexity of the issues addressed requires an unprecedented level of integration across sectors and policies, and calls for state-of-the-art biomass related data, knowledge and modelling tools. The JRC will carry out the study within the institutional Work Programme, thus within the scope of the knowledge, expertise and capacity available and in a close dialogue with involved DGs.

Faced with these challenges, the study must build on solid ground and from the outset, set up robust fundamental results for the follow up. Therefore, it is not expected to answer the realm of all possible questions, but rather to develop a framework that can support policy making with state-of-the-art scientific knowledge, while at the same time providing solid grounds and directions for future progress within the biomass Mandate.

2. GENERAL PROVISION OF THE STUDY

2.1 Boundary conditions and definitions

The study will include a comprehensive review of the existing literature, complemented with novel processing of internal (JRC) and external datasets and with research on assessment and modelling of biomass flows, prices and costs, with the aim to set up an updated knowledge-base on biomass relevant issues to support EU policies.

The following **biomass sources** (biomass types) are considered: forest-based biomass, agriculture biomass, marine biomass, animal matter[1], organic (biogenic) waste. The applicable definition of biomass is given in the Renewable Energy Directive (RED).

The general **categories and uses of biomass** to be covered (and to be further broken down where appropriate) are: food, feed, uses of biomass in agriculture (fertilisers, soil fertility, etc.), bio-energy (electricity, heating, cooling and transport), solid-wood material and products, pulp and paper, fibres, bio-chemicals ((platform chemicals, specialty, oleo-chemicals, enzymes, etc.), bio-materials & bio-polymers (bio-plastics, viscose, composites, etc.) and other bio-based industrial products (pharmaceuticals, cosmetics, food/feed additives, etc.).

The study will address (with different level of detail, depending on data availability):

- Primary products and waste: resulting from harvesting, fishing and collection activities (main production and residues);
- Secondary products and waste: resulting from biomass processing (by-products, co-products and residues from any processing step);
- Tertiary residues (biogenic waste resulting after biomass use).

The spatial domains covered will be EU28 and global, the latter with less spatial detail and specific focus on main biomass and products flows as well as prices and costs.

A baseline scenario will be evaluated, depicting a development trajectory in line with current policies which will be reviewed and, as appropriate, updated from a scientific base point of view if necessary; alternative policy scenarios will be defined based on input from customer DGs (first workshop with customer DGs-JRC to take place in Q2 2015). To support the assessment of prospective scenarios, a transparent, integrated modelling approach will be pursued, setting up a framework based to the possible extent on fully customizable tools and in house (JRC) developments when external tools hamper transparent assessments.

Assessment is referred to both stock and production of biomass which is taking place on land and sea resources that are limited (i.e. finite) and characterised by given productivity. With respect to productivity scientifically robust assumptions about future productivity changes should be taken reflecting both potential productivity increases in areas where currently land productivity is already high but also potential increases in areas where land productivity is currently lagging behind. The study will address potential changes in land productivity as affected by climate change, other changes will be considered in the following years of the Mandate in accordance with future technical specifications pursuant to the Mandate. Different sectors with their respective demand for biomass compete for land resources; such

[1] To be considered for future developments after 2015/16

competition will be analysed and consequent land-use dynamics will be reflected in the modelling framework.

Advances in biomass assessment differ greatly among forest-based, agriculture, fisheries and biogenic waste as regards current data sources, accuracy attainable, spatial and temporal resolution, spatial extent, prevailing assessment approaches[2] (i.e., bio-physical or demand driven). Where possible, efforts will be made to harmonise assessments across sectors and to properly account for the recognised differences when integrating the sectors' results. The assembly of all datasets and the setting up of the overall information flow through the whole study will require considerable efforts. Nevertheless large uncertainties and significant gaps in relevant data still exist for many aspects addressed in the study. The technical specifications of this document provide a framework for the activities, however the level of detail that will be possible to reach in every aspect cannot be anticipated because of the mentioned uncertainties in data quality and the inherent complexity of the challenge.

2.2 Transparency and Involvement of Stakeholders

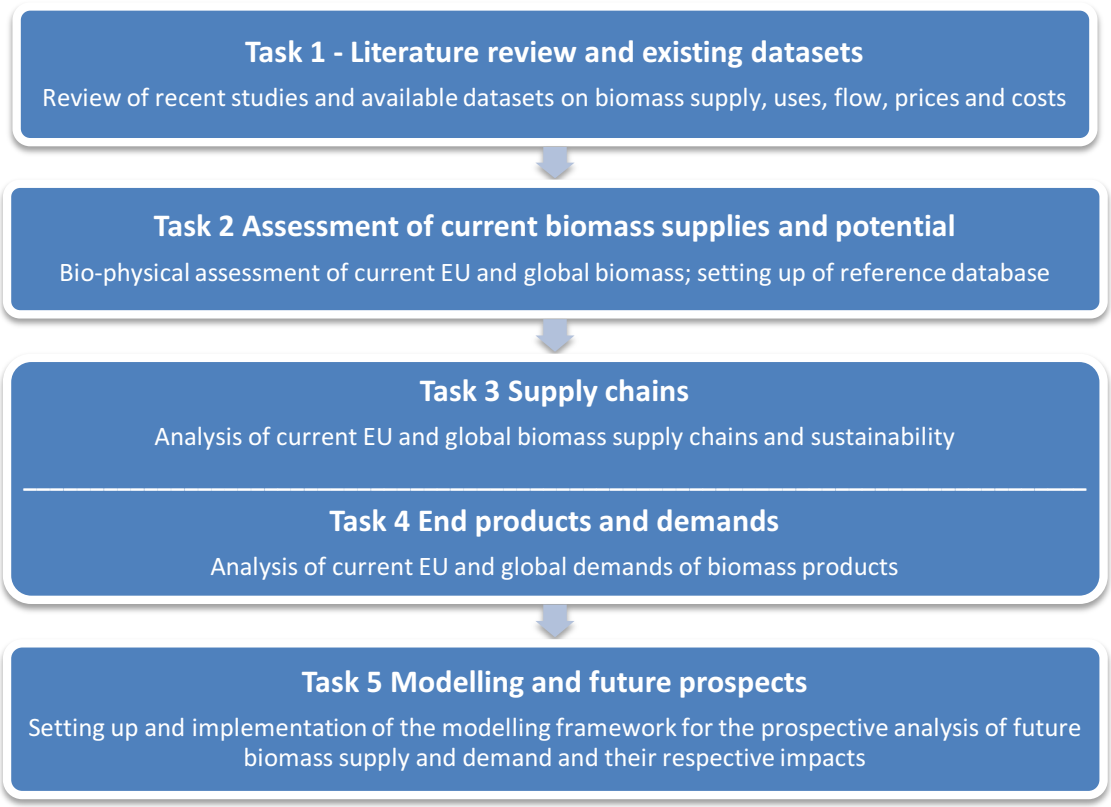
Pursuant to Article 4.3 of the Mandate, the JRC will execute this study in a transparent mode and engage in an open dialogue with the scientific community and stakeholders.
Regarding the engagement with the scientific community, the JRC, following its customary way or working, will adhere to generally acknowledged scientific standards, collaborate with scientific partner institutions and, where appropriate, ensure peer-review of outputs and deliverables.
Regarding the dialogue with stakeholders, the customer DGs will examine ways to consult relevant stakeholders, including appropriate parts of civil society, in particular via the organisation of general or sectorial workshops, in accordance with the provisions of Article 6.2 of the Mandate. The first workshop(s) with stakeholders should take place in Brussels in 2015.

2.3 Tasks

The study will be broken down into 5 interlinked tasks. Tasks are arranged in a logical sequence, however a significant part of the related activities will be executed in parallel.

Task 1 will constitute reviews of literature and existing datasets, Tasks 2 to 4 are aimed at characterising the current status and recent trends of biomass supply, uses, flow, costs and prices. They will allow to analyse the supply-demand interactions, the potential impacts, synergies and competitions and to set up the relevant EU and global databases in preparation of the modelling work of Task 5 that will address the future projections.

[2] An example illustrating this challenge is a comparison between forests and marine natural renewable resources: while trees can be monitored directly e.g. through satellites, fish are not accessible to such direct assessment approaches and therefore biomass estimates do heavily rely on projection, estimation and modelling.



3. DESCRIPTION OF TASKS

Task 1. Review and existing datasets

Subtask 1.1 Review

Review of existing work. This should include projects supported by the EU (e.g. FP7 projects such as BEE, S2Biom) or commissioned by different DGs, Cost Actions (e.g. USEWOOD), ERANets, documents from the industry associations, peer-reviewed scientific papers. Supporting DGs will provide JRC with a list of projects and studies and all the related deliverables. JRC will guarantee protection of confidentiality and protection of data, in accordance with the relevant Grant agreements (as provided by supporting DGs) and Commission rules. The additional material collected will be organised, stored and made available at the Bio-economy Integrated System and Observatory (BISO) interactive website.

The aim of the review will be to support the activities of the study through the analysis of results of past and ongoing studies on biomass supply and demand. This will be done by systematically organising and critically analysing the current knowledge, identifying gaps and outlining strategies to address them.

A number of studies have attempted to assess the potential of biomass for energy and industrial (chemical; material; other) purposes, with varying scope as regards types of biomass, uses of biomass, time periods covered (present and/or future), type of potential, whether the focus is on demand or resources, and geographical scope. A broad division of studies assesses whether they are **resource-based** studies - focusing on the resource base - or

demand-driven assessments, dealing with the different uses of biomass for food, feed, industrial (chemical/material/other) and energy purposes.
The literature review will provide an overview of existing studies. A synthesis will be conducted, identifying gaps in the current knowledge base.

The review will primarily deal with studies on global, regional (e.g., EU, Asia-pacific, North America) and country levels. Hence, studies limited to sub-country regions will not be dealt with. The literature review will be mostly focused on studies published in the last ten years, as the datasets underlying older studies would be outdated.

Biomass assessment studies will be categorised according to (i) **geographical** scope: global, regional or country, (ii) **type** of biomass (for wood-based biomass: roundwood, logging residues, industrial residues, etc.; for agricultural biomass: grain crops, sugar crops, oil crops, crop residues, crop processing residues, etc.; for biogenic wastes: waste oil and greases, animal manures, MSW, food waste, textiles wastes, landfill gas, fisheries waste and residues, etc.; for industrial crops: woody crops, perennial grasses, fibre crops, rubber, specialty crops, etc.) (iii) **focus**: resources or demand/uses thereof, (iv) for studies dealing with **demand/use**: which products (type of food, feed, industrial (chemical; material; other) or energy feedstock) have been covered (v) **time** frame: present or future, (vi) type of **potential**; theoretical, technical, economic or implementation and (vii) how **sustainability** is defined. An important distinction has to be made here: whereas the potential for forest-based biomass and agricultural residues concerns the potential harvest level – given a sustainability criterion that varies depending on type of potential – the potential for agricultural crops concerns the entire production.

A synthesis will be provided, detailing conclusions that can be drawn as regards assessment for respective geographical units. A table summarising the findings - as to types of potentials assessed, whether the assessments are based on factual data or modelling output, geographical scope, type of biomass, uses thereof (i.e., type of products), and time horizons - will be provided. Gaps in the knowledge base (concerning geographical scope, type of biomass covered, use/demand (products) scope, etc.) will be identified, and how to address them will be indicated. In this context, the risk of deterioration of EU national and aggregate forest-related data, especially those drawn from the annual JFSQ (Joint Forest Sector Questionnaire), due to the long-term erosion of resources, is already noted as an issue to be addressed urgently, including at a high administrative level.

Subtask 1.2 Glossary

A glossary of reference terminology will be created in Task 1.2. The terminology with be extracted from the definitions collected in the review, further analysed, discussed and agreed within the Inter-service Group.

Subtask 1.3 datasets review

Review and compilation of available global and European relevant datasets, on current and projected biomass uses, flow, prices and costs assessments. Initial set up of a knowledge management base to streamline the use of selected datasets in the biomass mandate in collaboration and synergy with BISO[3].

[3] BISO will make data already collected and stored available for the study and will host in its databases the additional data collected and organized within this study.

The aim of the dataset review will be to select for the study as comprehensive and reliable data as possible. The review will address origin, scope, overlap, parameters, quality, series and detail of available datasets.

The following datasets will be initially considered for analysis (not necessarily used when inappropriate by providing the reasons and consequences for the work described) and eventually complemented with new emerging datasets when available:

Forest-based: National Forest Inventories (NFIs), FOREST EUROPE, FAO Forest Resource Assessment (FRA), Joint Forest Sector Questionnaire (UNECE/FAO, Eurostat, ITTO), Joint Wood Energy Enquiry (UNECE/FAO, Eurostat), NREAPs (National Renewable Energy Action Plans), inventories and projections undertaken in the framework of UNFCCC/Kyoto protocol, industry data (various associations), national fuel wood surveys (e.g. those co-financed by Eurostat), JRC datasets derived from remote sensing surveys or from the European Forest Data Centre (EFDAC).

Agriculture and livestock: EUROSTAT, DataM, AGRI short term outlook, EC agrifood outlook, FAO/OECD global outlook, SERI global material flows, FAOSTAT, IGC (International Grain Council) data, national statistics, LULC data, M3 dataset, NREAPs (National Renewable Energy Action Plans), GAEZ (Global Agro Ecological Zoning) maps, FAO PLOS, industry data (various associations).

Marine biomass: ICES (International Council for the Exploration of the Sea) stock assessment database, GFCM (General Fisheries Commission for the Mediterranean) stock assessment files, STECF (Scientific, Technical and Economic Committee for Fisheries) stock assessment files, scientific surveys' data (geo-located), FAO Fisheries and Aquaculture Databases, EUROSTAT, EUMOFA, industry data (various associations).

Biomass from municipal waste: EUROSTAT data/statistics on municipal solid waste and food waste, FAOSTAT database, NREAPs (National Renewable Energy Action Plans), E-PRTR (European Pollutant Release and Transfer Register) data on waste, EEA (European Environmental Agency) waste management data/statistics for Member States, JRC Life Cycle Indicators project., industry data (various associations).

Task 1 deliverables
D1.1 Glossary of terms and reference definitions for the biomass study.
Preliminary version due in M3
Final version due in M6

D1.2 Review of studies and datasets on biomass supply potentials, uses, flow, costs and prices assessment.
Preliminary version due in M6
Final version due in M12

Task 2. Assessment of current biomass supply and potential

Task 2 will carry out a state of the art bio-physical assessment of current biomass supply and potential, both in the EU and worldwide, taking into account the conclusions from task 1, and will serve as a reference to build the baseline for the modelling, therefore it is an intermediate step for the following Tasks 3, 4 and 5 (where biomass potentials will be projected for 2020 and 2030 horizons). The main question addressed in this task will be how much biomass is

growing and how much we are producing now from the different biomass sources and what is the potential given the current land use and fishing.

The assessment will start compiling the available datasets that will be further elaborated and processed in Task 2 for the scope of the study. The assessment will be carried out separately for each of the biomass sources, further broken down by supply categories (i.e. raw material obtainable), including the assessment of biomass potentials from municipal solid waste.

For each biomass type, JRC will need to review available sources and related applied methodologies to derive processed datasets with different levels of complexity and uncertainty. All potential data sources identified in Task 1 will be initially considered for the assessment. Statistical data with different aggregation levels (from macro-region to country and sub-country levels) will be complemented with spatially explicit datasets when available.

The assessment carried out in Task 2 will be focused on current biomass supply and existing biomass potentials (namely theoretical and technical potentials). Theoretical and technical potentials by definition require long-term, non-declining amount of biomass, however they do not explicitly encompass sustainability.

Because of their important policy implications, specific sustainability constraints to be added should be formulated in close dialogue with all Customer DGs and taken into account in the assessment only at the modelling stage (Task 5). New layers of "sustainable" biomass potentials would be generated from this process.

Methods to derive the technical potential and apply sustainability criteria can be different according to the spatial aggregation level of the available data. Remote sensing and derived spatially explicit data will also be used to complement available data and potentially fill data gaps regarding Europe.

When feasible, spatially explicit assessments will be carried out. For example, by using spatially explicit data on biomass from land use, combined with factors affecting the technical potential, such as terrain and transport networks.

Results will go into a dedicated database based on administrative units or geographical coordinates depending on the level of detail achieved per biomass category and spatial domain (i.e., European or global).

Task 2 Deliverables

D2.1 Databases on current biomass supply and technical potentials per biomass type, at different geographical scales and aggregation levels in Europe and world-wide.
Preliminary version due in M12
Final version due in M24

D2.2 Report on current forest-based, agriculture, marine (fish and algae) biomass supply, as well as biogenic waste biomass (e.g. municipal waste) and technical potentials in Europe and world-wide: results, methodologies, derived datasets and identified gaps, inconsistencies and uncertainties, including possible approaches on how to close them.
Preliminary version due in M12
Final version due in M24

Task 3. Supply chains

Task 3 deals with the current supply chains. The full production pathway including cascade uses will be considered where possible, with related impacts and sustainability assessments. Cost-supply curves of different biomass categories will be derived from existing datasets, literature review and *ad hoc* development work. The objective of the task is therefore to analyse the supply chains of the products, assessing the production costs to the extent that this is possible and the environmental impact of the production pathways. The approach followed to address the assessment of the supply will differ among sectors in accordance to the JRC WP 2015/16. Differences in approaches will be transparently described.

A dedicated methodology for environmental impact assessment will be developed for bioenergy and other uses, including industrial ones, based on a life-cycle perspective.
A broad range of environmental aspects will be considered (without any normalisation), including – if applicable – timing of carbon emissions and sequestration (e.g. carbon storage, biogenic CO_2), other climate forcers (e.g. surface albedo change, near-term climate forcers) and displacement and substitution effects. The methodology will assess the environmental performances of biomass-based systems by means of relevant and applicable midpoint impact categories. These categories cover e.g. climate change, ozone depletion, human toxicity, ecosystem toxicity, land use, and depletion of mineral/biotic resources (Annex 2 provides the complete list of impact categories considered).

The environmental components of sustainability of the production pathways will take into consideration appropriate inputs, including the methodologies in existing EU legislation and policy documents (e.g. RED for biofuels, the 2010 Commission Report on the sustainability of solid and gaseous biomass for heat and electricity and the 2014 Staff Working Document on the same issue[4]).

Task 3 develops along four subtasks. Sector-specific research areas will be developed, aiming at filling existing knowledge and data gaps, since large difference among sectors exist in this respect.

<u>Subtask 3.1 Forest-based biomass</u>

- Development of EU and global balance sheet of forest-based biomass supply and demand (Wood Resource Balance tool accounting for all uses and sources of woody biomass). All current sources and uses of woody biomass in EU countries and world regions, including the cascade uses, will be described and quantified. The double counting inherent in wood resource balances will be rationalised against the supply values generated in task 2 and use values in task 4.
- Analysis of environmental impacts (through analysis of all the identified pathways), and time-dependent climate impacts of the use of forest-based biomass for energy purposes. The analysis will also include assessing alternative uses of biomass.
- Cost analysis to support the modelling task (building of cost supply curves).

<u>Subtask 3.2 Agricultural biomass</u>

[4] See SWD(2014) 259 final and COM(2010)11

- Update of EU and global balance sheets of agricultural biomass supply and demand (production, consumption, prices, stocks and trades) for food, feed, energy production and industrial (chemical/material/other) uses.
- Specific focus on the supply from agricultural biomass arable crops, processed arable products (sugar, vegetable oils, protein meals, starch, biodiesel and ethanol), meat and dairy.
- Definition of the cost component for the modelling task.
- Analysis of environmental impacts

Subtask 3.3 marine biomass (algae, fisheries and aquaculture)

- Supply chains and demand for algae production and derived goods
- Supply chains and demand for fisheries and aquaculture (including imports, exports and internal consumption).
- Analysis of environmental impacts[5]
- Cost analysis[5].

Subtask 3.4 Biomass from wastes and residues

- Review of potential sources of biomass from wastes and residues, with an assessment of their quantity / quality, current status, uses and trends. This work will include in particular the following feed stocks:
    - municipal solid waste (including food waste)
    - agricultural, forest-based and fisheries residues
    - industrial residues
- Analysis of environmental and economic impacts, time-dependent impact on global climate, , direct and indirect effects of diverting wastes and residues to bioenergy and industrial uses (displacement effects) and removing them from original environment (removal effects).
- Biogas potentials and analysis of the opportunities provided by co-digestion of different production pathways from residues and agricultural feedstock (e.g. manure + agriculture residues and crops. Economics of GHG emissions and mitigation potentials of biogas production from agricultural crops (e.g. maize, sorghum) and residues (e.g. manure).
- Costs analysis of bioenergy (including biofuels and biogas) from waste and residues, through an assessment of capital and operational costs (CAPEX and OPEX) annualized over the average life-time of plants. Evaluation of payback time for the investments and of costs for GHG savings.

Task 3 Deliverables

D3.1 Supply chains for forest-based, agriculture and marine biomass in EU and world-wide
D3.2 Analysis of biomass supply from wastes and residues
D3.3 Methodologies to assess the sustainability of biomass supply chains

Preliminary versions due in M12
Final versions due in M24

[5] To be considered for future developments after 2015/16.

Task 4. End products and demands

Task 4 deals with the analysis of current demands for end products from biomass, flows, demand trends, price formation and demand curves. Competition and synergies among different uses will also be addressed in this task. The task will imply desktop and econometric analysis of datasets and literature reviewed in Task 1.

The following uses of biomass will be analysed: food, feed, bio-materials (fibres, , solid-wood material and products, pulp and paper, bio-chemicals and other bio-based industrial products) and bio-energy (electricity, heat and transports).

Subtask 4.1 Demand trends and prices

It is important to note that the level of detail and the quality attainable is highly uncertain, and often it has to be indirectly derived from apparent consumption.

Given this caveat, for each of the uses addressed (broken down in subcategories where appropriate and feasible) the analysis of demand trends and prices will be attempted using econometrics techniques. The use categories initially addressed, and depending on the resources more or less in depth analysed, will be:

- food
- feed
- fibres
- solid-wood material and products
- pulp and paper
- biomaterials & biopolymers (bio-plastics, viscose, composites, etc.)
- bio-chemicals (platform chemicals, specialty, oleo-chemicals, enzymes, etc.)
- other bio-based industrial products (pharmaceutical, cosmetics, food/feed additives, etc.)
- bioenergy
    - electricity
    - heat and cooling (including CHP)
    - transports

The level of detail reached for the single categories will also depend on the definition of the JRC WP 2015/16.

The following additional sectorial analysis will accompany the assessment of the demand:

- Current use of wood resources by the forest-based sector (forest-based industries, bioenergy based on wood, other bio-based industries using wood i.e. textile companies), including both primary and secondary sources of woody biomass.
- Current status and evolution of the bio-based industry sector (chemicals, materials, others) including quantitative analysis of agricultural biomass use, its share (input) in a selected set of bio-based products (output) and its origin.
- Current status and future evolution of the EU bioenergy sector (in the three final uses of heat, power and transports), including quantitative analysis of use of domestic and imported forest-based and agriculture biomass, and synergies with the biomaterial sector.

- Review the potential uses of algae as sources of biomass for food, fibres, high value products (e.g. oils and chemicals and pharmaceutical, bioactive compounds, colorants) and biofuels.
- Direct uses of fish products and cascading uses (waste for feed, feed for aquaculture and terrestrial farms); new (emerging) products.
- Assessment of bioenergy components of European countries energy mixes from the data of National Renewable Energy Action Plans and bi-annual progress reports.

Subtask 4.2 Competitions and synergies

Subtask 4.2 will address competitions and synergies among sectors and biomass uses in a qualitative way; these issues will also be addressed in the modelling exercise as depicted under Task 5.

Namely focusing on:
- Competition, trade-offs and synergies regarding biomass for different uses (alternative services and commodities obtained from the same source such as for example energy/material use or food/energy or food/material or food/feed)
- Competing land uses, including indirect land use change (ILUC) emissions estimates and related impacts for all biomass uses. Calculation of ILUC impacts for new demands (e.g. energy crops, short rotation forests and coppices etc.) and residues. The ILUC-related part of the analysis will be indicated.
- Substitution for non-renewable feedstock and related impacts
- Synergies and limitations of biomass in the cascade uses and flows

The subtask will imply the analytical scrutiny of products and uses using different approaches to highlight and when possible quantify competitions and synergies. As an example of analytical tool, the construction of common products/uses matrices will be attempted[6]. Results of the analysis will be potentially reflected as constraints or calibration parameters in the modelling framework.

Task 4 Deliverables

D4.1 Databases on biomass uses and flows, at different geographical scales and aggregation levels in Europe and world-wide.
Preliminary version due in M12
Final version due in M24

D4.2 Report on biomass uses, flows, competitions and synergies in Europe and world-wide: results, methodologies, derived datasets and identified gaps, inconsistencies and uncertainties.

[6] As another example of a tool to investigate synergies and competition on commodities, a balance sheet approach can be pursued. To give an illustration for the forest-based sector, by-products of the sawmill industry (wood chips and sawdust) are important raw materials for further processing. They can be used for the production of commodities like wood pulp, wood pellets, or particle board; constituting an example of synergy (both the sawmill industry, the users of these by-products, and society (through efficient use of resources) benefit from this cascading). In their turn, the three uses of secondary sources of woody biomass provide an example of competition. The balance sheet is a useful instrument for keeping track of these material flows highlighting competions and synergies. This approach can be complemented with an analysis of price and cost trends.

Preliminary version due in M12
Final version due in M24

Task 5. Modelling and future prospects

Interaction of supply and demand, as well as the integration and prospects of different sectors with their potential synergies and competitions will be addressed in a coherent framework in Task 5.

The prospective analysis of biomass supply and demand and their respective impacts will be carried out for short-term (2020) and medium-term (2030) perspectives. It will be furthermore evaluated the possibility to extend projections to the 2050 horizon, namely incorporating for this long-term perspective the impact of climate change on net primary productivity.

The envisaged integrated modelling framework will be built on a core of stand-alone models currently in use at JRC and on their further development and linkages. The suite of models to interlink in the integrated assessment modelling framework can be anticipated in general terms but cannot be fully defined ex-ante in view of the inherent challenges to tackle (e.g., consistency across different spatial and temporal scales, domains, assumptions, accuracies etc.). Details are provided as annex of this document.

There is no simple solution that enables a consistent analysis of biomass potentials and impacts respecting within sufficiently realistic boundaries the inherent complexity of individual sectors, and at the same time sufficiently comprehensive and integrated to fully account for their interactions, competition and synergies. Alternative approaches will be considered and explored in this respect, within the limits of the output defined in the JRC WP 2015/16.

One approach will aim to integrate sectorial models in a coherent framework (Figure 1). Partial equilibrium (PE) or sectorial models permit detailed and sector specific parameterisation and are able to sufficiently capture the complexity of individual sectors. PE models can be run in parallel and can be then integrated with an additive approach, namely applying a balance sheet to compare total biomass supply and demand. The main challenge for this combined sectorial model approach is the harmonisation of assumptions across sectors, which is the work needed to correctly set up the integrated assessment. Cross-sectorial interactions will be accounted for by explicitly including, in the modelling framework, a land use modelling platform such as LUISA.

LUISA, developed at JRC, resolves the competition between sectors for land resources; it has already been linked with the agriculture and forestry sectors in the context of AFO-CC (AA between JRC and DG CLIMA that ended in 2014) and has been applied in different projects. It is also used by several EC services to build a baseline scenario for policy relevant impact assessment procedures, in connection with sectorial socio-economic models, to assess policy impacts with possible overlaps – not only conflicts but also mutual benefits and cumulated effects - between sectorial developments and sectorial policies.

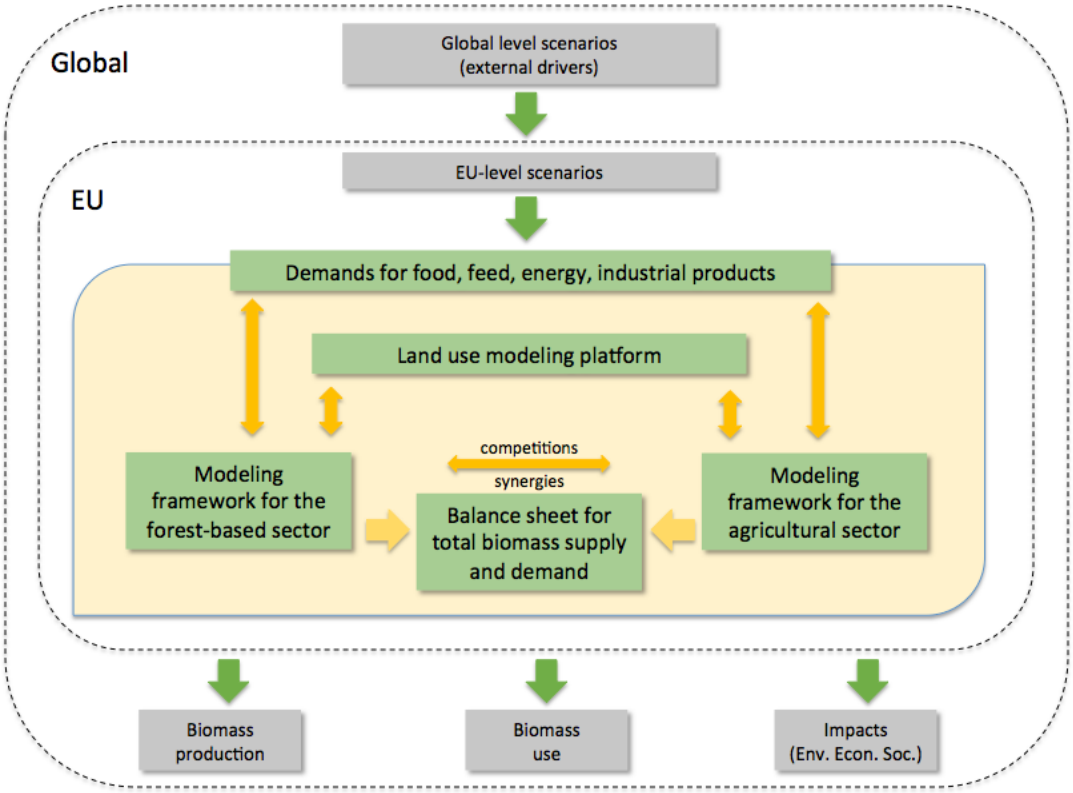


Figure 1. Modelling approach integrating sectorial models. Demands are partially exogenous or, as in the case of energy, derived through modelling[7].

An alternative approach will seek to build a Systems Analysis Framework which is intended as a comprehensive integrated system (Figure 2). Computable General Equilibrium (CGE) models such as MAGNET which is currently in use at JRC will be an option to attempt. MAGNET provides a holistic and prospective view that accounts for cross-sectorial interactions, offers internally consistent and globally comprehensive analysis of impacts, taking into account uncertain exogenous factors (GDP growth, population, technology) and policies to create scenarios and compare impacts on macro-economic, environmental and social dimensions. Despite such advantages, the holistic approach of CGEs implies a level of sectorial aggregation which does not allow to fully capture the complexity of individual sectors. Research and Innovation policies, with their potential effect on technical progress can be included as drivers in the model. Important assumptions will have to be accepted in this respect.

[7] Models initially considered for the future biomass demands from the energy sector will be JRC-EU-TIMES and POLES, the latter already applied in linking agriculture and forest-based sectors within the AFO-CC project, the former being subject of the JRC Exploratory Project EREBILAND to test a regional analysis system of energy demand and consumption. Additional details are given in Annex 1.

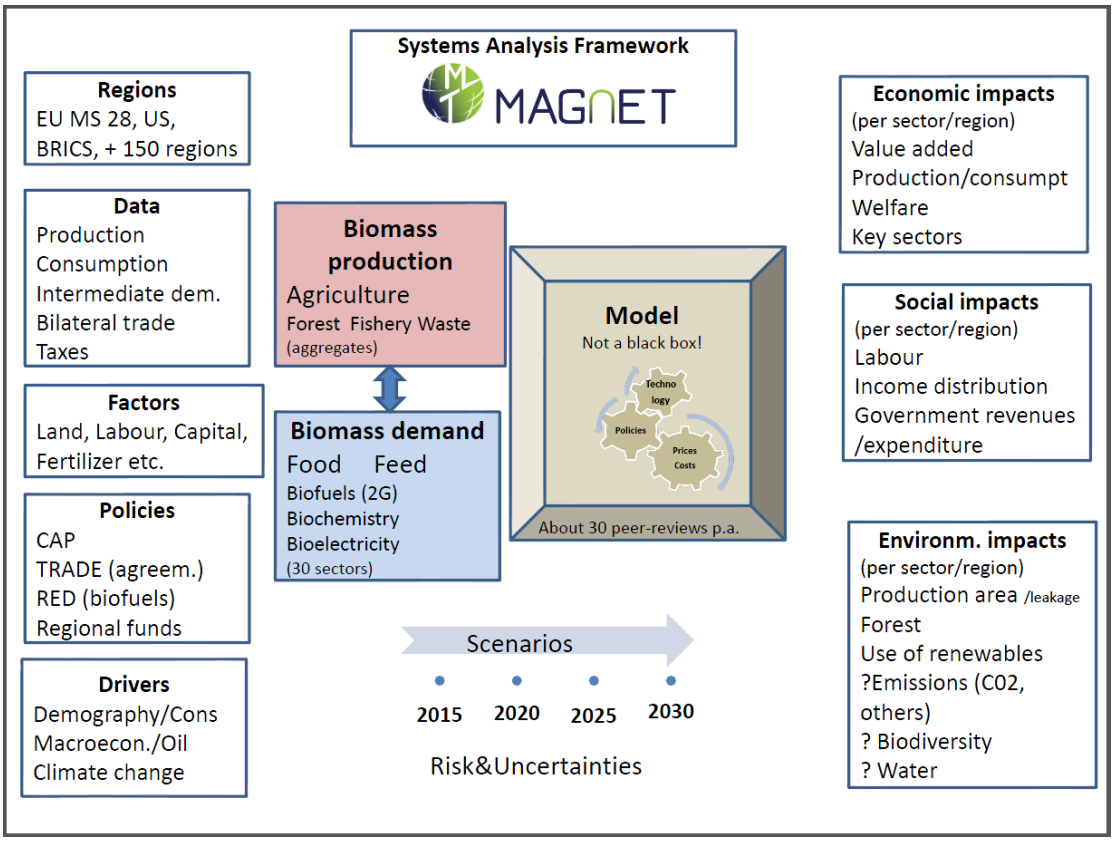


Figure 2. Schematic representation of the systems analysis modelling approach

Typical caveats in terms of mathematical simplifications, assumptions related to behavioural parameters and handling of uncertainties and sensitivities hold for all the models available and will be carefully indicated and assessed within the deliverables. Moreover and as agreed in the mandate, all employed assumptions, data sources including their uncertainties, LCA-approach related uncertainties including the sensitivities of performed models and limitations, including their data inputs, are reported up-front in a clear and transparent manner, allowing the decision maker to easily understand the background and basic fundaments of the work performed. Additionally, data and methods used need to be described at the very beginning of the report, allowing for the reader to comprehend and interpret the results.

Scenarios, depicting development trajectories and related socio-economic drivers for the models, will be selected through dialogue with customers DGs as defined in the JRC WP 2015/16. The baseline scenario will be based upon the EU 2030 Climate and Energy package baseline with any necessary review based upon scientific evidence in particular regarding material use. Learning from experience (e.g. Thematic Strategy for Air Pollution (TSAP) & revision of the National Emission Ceiling Directive (NECD)), when performing the baseline setting and agreement on which scenarios should be run by the model(s), it is suggested to form an expert group that will look into both of these activities.

This expert group can consist of different stakeholders including industries, NGOs, Member States, academia and the Commission, noting that the Commission must have agreed its position before in an Inter-service Group meeting. In accordance with the provisions of Article 6.2 of the Mandate, the customer DGs will examine ways to form the expert group and organise the relevant meetings. Given the complexity of this discussion (by the way similar to

the air quality topic), it is to be noted that a number of meetings (say three or four) will be needed especially for the scenarios agreement given the results obtained for the baseline setting and the previous scenarios results.

Task 5 Deliverables

D5.1 Definition and preliminary implementation of Baseline. Definition of alternative scenarios. Prospective analysis of biomass supply and demand and their respective impacts with short-term (2020) and medium-term (2030) perspectives, together with an appraisal of the possibility to extend projections to 2050. It will include the identification of gaps of this study and possible solutions.

Preliminary results (sectorial models) due in M12
Final results with integrated sectorial models due in M18
Final results (includes system analysis) due in M24

Annex 1 – Modelling framework

Annex 1 provides additional technical details on models and approaches that will be investigated in the study.

Modelling framework for the forest-based sector

The bio-economy modelling framework for the forest-based sector that is envisaged to be applied in the study is currently under development at JRC and comprises (i) a forest resource assessment model, (ii) an economic model of the forest-based sector, and (iii) an accounting tool for the comparison between potential future supply and expected future demand of wood, the Wood Resource Balance (WRB).

As for forest assessment model, the Carbon Budget Model (CBM) is currently operational. CBM is an inventory-based, yield-data driven model that can provide a technical potential of woody biomass from forests at EU and MS levels. Hence, CBM can provide harvestable volumes of stemwood, other wood components (i.e., tops and branches) and snags (i.e., standing dead trees or branches). Natural disturbance events such as storms and fires can be simulated. Under development within a collaborative effort between JRC and national forest inventories (NFIs) is another forest resource assessment model, the European Forestry Dynamics Model (EFDM). EFDM is an area-based state transition model, meaning that forest areas are transiting between elements of a set of fixed states. EFDM is being developed so as to provide technical potential of woody biomass, i.e., harvestable volume of stemwood (sub-divided into sawlogs and pulp/energy-wood). By linking to CBM, the development of carbon stocks on country level can also be modelled. EFDM will have the possibility to consider forest management in greater detail, taking stock of the heterogeneity of forest owners.

The Global Forest Trade Model (GFTM) is a partial equilibrium model of the global forest-based sector being developed at JRC, providing projections of production, consumption and trade of wood-based products (sawlogs, pulp logs, sawnwood, wood-based panels, wood pulp and paper, wood-pellets. The focus is on Europe, where countries are modelled individually, while some countries outside Europe are aggregated into sub-regions (using FAOSTAT groupings).

The WRB is an accounting tool for keeping track of all uses and sources of woody biomass. Thus the WRB is used to map all sources and uses of woody biomass for a given spatial unit (country, larger world sub-region) The WRB is particularly adapt for illustrating the cascade uses of wood.

In the integrated setting of these stand-alone models, starting from the forest in a given geographical unit in the EU the forest resource assessment model, in an initial run, provides the maximal sustainable (in the sense of a non-diminishing stock) potential supply of woody biomass, given legal and policy constraints (e.g., Natura2000 sites). This is used as a constraint for the production of wood-based products in the GFTM. GFTM, considering international trade, reaches equilibrium and, together with the energy sector model, provide the 'real demand' for woody-biomass. This harvesting demand is fed back to the forest resource assessment model, for response analysis as regards the development of the forest resource, for updating of the potential. The final supply of woody biomass is ingested by the WRB, along with forest industry by-products on the 'sources side' and the use of wood for wood-products and pellets on the 'uses side'. By applying this framework, linking supply and demand the framework can be considered as supplying the economic potential of forest biomass.

Modelling framework for the agricultural sector

The agricultural sector from an (economic) supply-demand perspective is covered by the integrated Modelling Platform for Agro-economic Commodity and Policy Analysis (iMAP), an operational policy support-oriented platform at JRC that disposes of a number of partial equilibrium (PE) and Computable General Equilibrium (CGE) models.

The PE models in iMAP focus on the agricultural sector. Increasingly, they also comprise other selected sectors (vegetable oil processing, dairies, biofuel processing, feed concentrate industry) with strong ties to primary agriculture or to the wider economy (e.g. competition for land). The core PE models of iMAP are AGLINK-COSIMO and CAPRI, although other models (such as AGMEMOD) or tools are used to complement or address questions that cannot be treated with these models.

A key outcome, involving joint efforts of DG AGRI and the JRC is the annual outlook on the medium-term (10 years ahead) developments in agricultural markets and income in the EU. This outlook (or 'baseline') is elaborated on the basis of specific policy and macroeconomic assumptions and presents a coherent set of market and sector income prospects. It cannot be considered a forecast, but a description of what may happen under the assumptions above mentioned.

- AGLINK-COSIMO: recursive-dynamic, partial equilibrium, supply demand model of world agriculture. The model covers annual supply, demand and prices for the main agricultural commodities produced, consumed and traded in each of the regions it covers. A key feature is the stochastic (uncertainty) analysis.
- CAPRI: global agro-economic model, which iteratively links a supply module, focusing on the EU (NUTS2 level) with a global multi-commodity market module; about 50 agricultural primary and processed products for the EU, from regional level to global scale including input and output coefficients. Baselines are prepared for the next 10 years ahead (calibrated to AGLINK), as well as for 2030 for different policy applications as defined in the JRC WP 2015/16.

Modelling framework for marine biomass

Based on the outcome of previous tasks, the JRC will assess the feasibility of using fisheries biologic and bio-economic modelling approaches for the biomass study.

In relation to seafood market models, there exist already modelling approaches incorporating fish (products) into supply and demand models (an example is the IMPACT model[8]).

Energy sector models

Models initially considered for future biomass demands from the energy sector will be JRC-EU-TIMES and POLES

The JRC-EU-TIMES is a linear optimisation bottom-up technology-rich energy system model designed for analysing the role of energy technologies and their innovation for meeting Europe's energy and climate change related policy objectives. It models technology market uptake and their interaction with the energy infrastructure including storage options in an energy systems perspective. It is a relevant tool to support impact assessment studies in the energy policy field that require quantitative modelling at an energy system level with a high technology detail. The scope of the model extends beyond purely energy oriented issues, to the representation of environmental emissions, and perhaps materials, related to the energy

[8] Rosegrant, M.W. and the IMPACT Development Team. 2012. International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT): Model Description. International Food Policy Research Institute (IFPRI), Washington, D.C. http://www.ifpri.org/book-751/ourwork/program/impact-model

system. In addition, the model is suited to the analysis of energy and environmental policies, which may be represented with accuracy thanks to the explicitness of the representation of technologies and fuels in all sectors.
The JRC-EU-TIMES model represents the EU28 energy system plus Norway, Switzerland, Iceland and the Balkan countries from 2005 to 2050, where each member state is one region. The model considers both the supply and demand sides and includes the following seven sectors: primary energy supply; electricity generation; industry; residential; commercial; agriculture; and transport.

The POLES (Prospective Outlook for the Long term Energy System) model is a global sectorial simulation model for the development of long-term (2050) energy supply and demand scenarios for the different regions of the world.
The development of the model and of the corresponding scenario studies intends to fulfil five main objectives: detailed world energy system scenarios, strategic areas for emission control policies, analysis of technologies development, assessment of Marginal Abatement Costs for CO2 emissions and simulation of emission trading systems, and impacts on international markets and price feedback. The dynamics of the model are based on a recursive (year by year) simulation process of energy demand and supply with lagged adjustments to prices and a feedback loop through international energy prices. The model is developed within the framework of a hierarchical structure of interconnected modules at the international, regional and national level. It contains technologically-detailed modules for energy-intensive sectors, including power generation, production of iron and steel, aluminium and cement, as well as modal transportation sectors.

System analysis framework
Computable General Equilibrium (CGE) models such as MAGNET, developed and used at JRC (iMAP), can be an option to analyse the supply and demand of the different bioeconomy sectors in the EU embedded in a global context.

MAGNET provides a holistic and prospective view (2020/30, 2050 technically possible) that accounts for cross-sectorial interactions and competition, offers internally consistent and globally comprehensive (up to 130 countries, 57 sectors) analysis of (among others) impacts on food security, resource use, labour markets and GDP.

Under a current initiative at JRC-IPTS, the model is being extended to incorporate a selection of additional bio-based sectors (2nd generation biofuels, bioelectricity and biochemical) as part of a broader drive toward understanding potentially increasing bioeconomic activity within the macroeconomy.

Scenarios are created taking into account uncertain exogenous factors (GDP growth, population, technology) and policies (trade, agriculture, bioenergy etc.) and allow the comparison of impacts on macro-economic, environmental and social dimensions.

The analysis addresses trade-offs between sectors (e.g. resource competition for food vs. material vs. energetic use), between policies and between regions (e.g. leakage effects).

Despite such advantages, the holistic approach of CGEs implies a level of sectorial aggregation which does not allow one to fully capture the complexity of individual sectors. Also, the explicit representation of quantities for biophysical flows is limited, although with supplementary data sources, they can be calculated.

A specific challenge (for all model types) is the modelling of land use. In MAGNET the competition for land is characterised through land supply curves describing the relationship between average real agricultural land rent and the area of land in a country that is used for agriculture (and forestry).

The model reports several indicators per sector/country/year on
i) Economic growth, jobs, bilateral trade flows, income and welfare
ii) Food and energy security (e.g. self-sufficiency in food consumption, consumer price level, share of bio-energy in total energy production)
iii) Resource use (e.g. land use, yields, share of bio-based products in total use, trade footprint, CO2 equivalents)

Annex 2 – List of default impact categories included in the methodology for sustainability assessment of biomass supply chains

Impact Category	Impact Assessment Model	Impact Category indicators	Source
Climate Change	Bern model - Global Warming Potentials (GWP) over a 100 year time horizon.	kg CO_2 equivalent	Intergovernmental Panel on Climate Change, 2007
Ozone Depletion	EDIP model based on the ODPs of the World Meteorological Organization (WMO) over an infinite time horizon.	kg CFC-11 equivalent	WMO, 1999
Ecotoxicity for aquatic fresh water	USEtox model	CTUe (Comparative Toxic Unit for ecosystems)	Rosenbaum et al., 2008
Human Toxicity - cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Human Toxicity – non-cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Particulate Matter/Respiratory Inorganics	RiskPoll model	kg PM2.5 equivalent	Humbert, 2007
Ionising Radiation – human health effects	Human Health effect model	kg U^{235} equivalent (to air)	Dreicer et al., 1995
Photochemical Ozone Formation	LOTOS-EUROS model	kg NMVOC equivalent	Van Zelm et al., 2008 as applied in ReCiPe
Acidification	Accumulated Exceedance model	mol H+ eq	Seppälä et al.,2006;
Eutrophication – terrestrial	Accumulated Exceedance model	mol N eq	Seppälä et al.,2006;
Eutrophication – aquatic	EUTREND model	fresh water: kg P equivalent marine: kg N equivalent	Struijs et al., 2009 as implemented in ReCiPe
Resource Depletion – water	Swiss Ecoscarcity model	m^3 water use related to local scarcity of water	Frischknecht et al., 2008
Resource Depletion – mineral, fossil	CML2002 model	kg antimony (Sb) equivalent	van Oers et al., 2002
Land Use	Soil Organic Matter (SOM) model	Kg (deficit)	Milà i Canals et al., 2007

CFC-11 = Trichlorofluoromethane, also called freon-11 or R-11, is a chlorofluorocarbon.
CTU = Comparative Toxic Unit
PM2.5 = Particulate Matter with a diameter of 2.5 μm or less.
NMVOC = Non-Methane Volatile Organic Compounds
Sb = Antimony
U = Uranium

Annex 3 - Time-Table of Deliverables

Deliverable number	Deliverable	Preliminary version due in	Intermediary version due in	Final Version due in
Task 1. Review and existing datasets				
D1.1	Glossary of terms and reference definitions for the biomass study	M3		M6
D1.2	Review of studies and datasets on biomass supply potentials, uses, flow, costs and prices assessment	M6		M12
Task 2. Assessment of current biomass supply and potential				
D2.1	Databases on current biomass supply and technical potentials per biomass type, at different geographical scales and aggregation levels in Europe and world-wide	M12		M24
D2.2	Report on current forest, agriculture, marine (fish and algae) biomass supply, as well as biogenic waste biomass (e.g. municipal waste) and technical potentials in Europe and world-wide: results, methodologies, derived datasets and identified gaps, inconsistencies and uncertainties, including possible approaches on how to close them	M12		M24

Deliverable number	Deliverable	Preliminary version due in	Intermediary version due in	Final Version due in
Task 3. Supply chains				
D3.1	Supply chains for forest-based, agriculture and marine biomass in EU and world-wide	M12		M24
D3.2	Analysis of biomass supply from wastes and residues	M12		M24
D3.3	Methodologies to assess the sustainability of biomass supply chains	M12		M24
Task 4. End products and demands				
D4.1	Databases on biomass uses and flows, at different geographical scales and aggregation levels in Europe and world-wide	M12		M24
D4.2	Report on biomass uses, flows, competitions and synergies in Europe and world-wide: results, methodologies, derived datasets and identified gaps, inconsistencies and uncertainties	M12		M24
Task 5. Modelling and future prospects				
D5.1	Definition and preliminary implementation of Baseline. Definition of alternative scenarios. Prospective analysis of biomass supply and demand and their respective impacts with short-term (2020) and medium-term (2030) perspectives, together with an appraisal of the possibility to extend projections to 2050. It will include the identification of gaps of this study and possible solutions	M12 (sectorial models)	M18 (Final results with integrated sectorial models)	M24 (including system analysis)