Delivery of sustainable supply of non-food biomass to support a "resource-efficient" Bioeconomy in Europe

S2Biom Project Grant Agreement n°608622

D8.5 Ex ante impact assessment

November 2016

About S2Biom project

The S2Biom project - Delivery of sustainable supply of non-food biomass to support a "resource-efficient" Bioeconomy in Europe - supports the sustainable delivery of non-food biomass feedstock at local, regional and pan European level through developing strategies, and roadmaps that will be informed by a "computerized and easy to use" toolset (and respective databases) with updated harmonized datasets at local, regional, national and pan European level for EU28, western Balkans, Turkey and Ukraine. Further information about the project and the partners involved are available under www.s2biom.eu.

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About this document

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Introduction

The S2Biom project supports the sustainable delivery of non-food biomass feedstock at local, regional and pan European level, through development of strategies and roadmaps. The latter will be informed by a “computer-based, user-friendly toolset with updated, harmonized datasets at local, regional, national and pan European level for EU-28, Western Balkans, Moldova, Turkey and Ukraine. Further information about the project and the partners are available online: www.s2biom.eu

This report presents the ex-ante impact assessment of the key findings of the project at pan European and regional levels.

The 'lignocellulosic' resource base for the bioeconomy sectors

Impact: S2Biom has reviewed, refined, updated and validated harmonised data for fifty (50) lignocellulosic biomass types in thirty-seven (37) countries in Europe (EU, Western Balkans, Moldova, Ukraine and Turkey). This information is expected to have high impact in providing useful quantifiable estimates that will inform future policy formation and industrial decisions.

Primary biomass resources in the current bioeconomy are agricultural and forestry/wood resources and are mainly used as follows:

1. Woody biomass from forests is used for paper and pulp and to produce heat and power for the industrial, commercial and residential sectors.
2. Agricultural biomass from oil, sugar and starch crops predominantly produces fuels, biobased chemicals and plastics.
3. Animal manure is digested to produce heat and power for farm use.
4. The biogenic portion of Municipal Solid Waste (MSW) and other waste biomass are consumed to produce heat and power for various sectors.
5. Additional potential biomass resources stem primarily from the development of dedicated lignocellulosic crops, increased use of agricultural residues, and unused or newly developed forestry/wood waste resources, including post-consumer wood.

S2Biom focused on lignocellulosic biomass. Therefore, it has not included 2) and 3) listed above which are of non-lignocellulosic origin. Figure 1 below presents the estimated lignocellulosic biomass potentials per year in 2030.

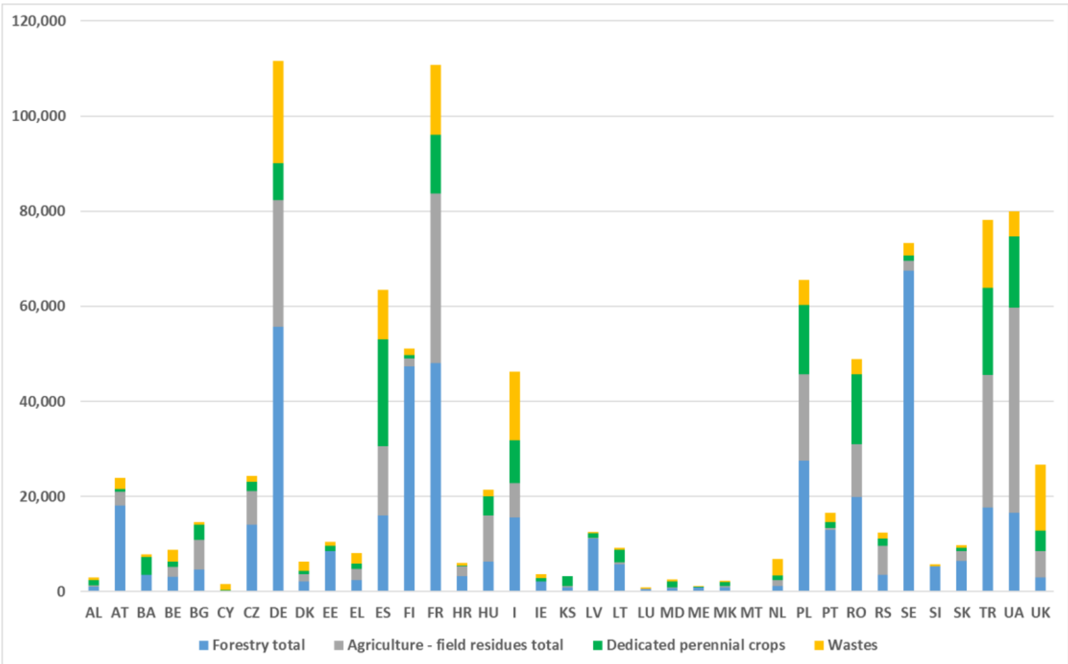

Figure 1 S2Biom estimated lignocellulosic biomass potentials (,000 dry tonnes) per year in 2030

Regions in Europe with high biomass occurrence

Impact: S2Biom provided disaggregated information for lignocellulosic biomass supply in European regions. Data are available in both viewing and downloadable forms in the project website (www.s2biom.eu). This information is expected to have high impact on providing clarity for biomass occurrence in European regions, both in terms of types and estimated annual sustainable quantities.

S2Biom improved data and scientific evidence on the assessment of lignocellulosic biomass potentials at regional level in Europe (EU, Western Balkans, Moldova, Ukraine and Turkey). The following sections present maps which illustrate regions with high biomass occurrence from agriculture, forest and biowastes.

Agricultural biomass analysed in S2Biom includes straw, stubbles, woody pruning & orchards residues, grassland cuttings not used for feed purposes, biomass from road side verges, by-products and residues from food and fruit processing industry.

Figure 2 below presents the results from the S2Biom open access tool for the total potential in 2030 from cereals straw in European regions. All agricultural biomass types analysed in S2Biom can be viewed in the tool.

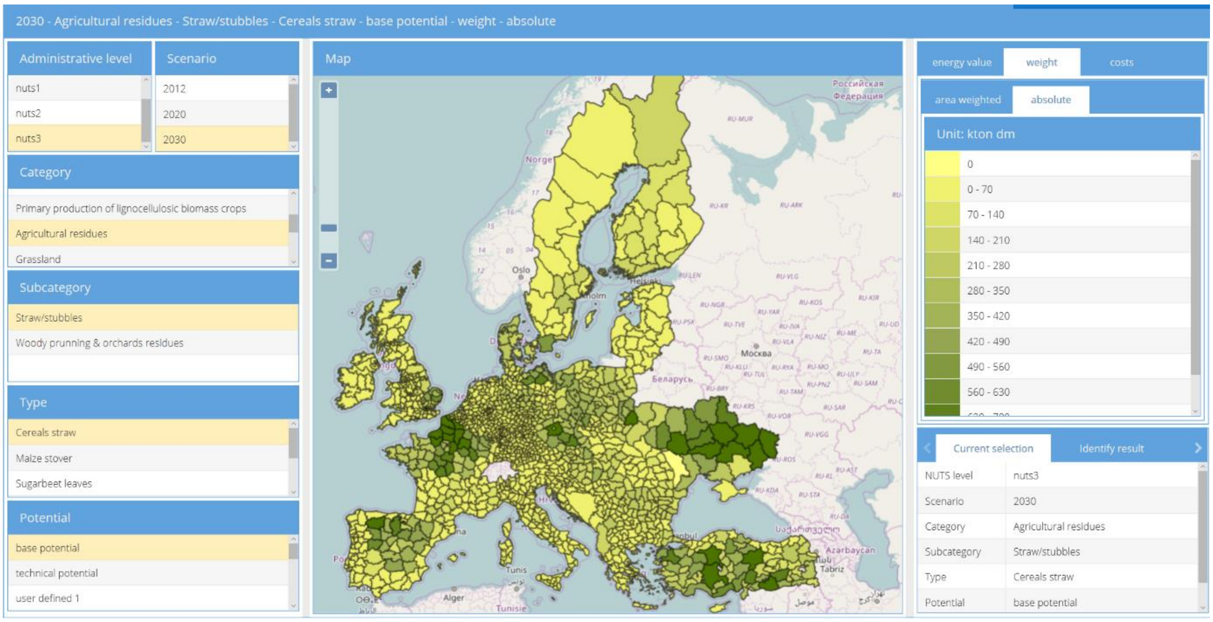

Figure 2 Total annual potential in (in ,000 tonnes dry matter) from cereals straw in European regions

Regions with biomass potentials can be found in France, Germany, Poland, Romania, Spain, Ukraine and Turkey.

Forest biomass analysed in S2Biom includes:

i. primary forestry production from thinnings & final fellings, stem and crown biomass from early thinnings,
ii. logging residues and stumps from final fellings,
iii. secondary residues from wood industries (sawmill and other wood processing).

Figure 3 below presents the results from the S2Biom open access tool for the total potential in 2030 from logging residues from final fellings originating from broadleaf trees in European regions. All forest biomass types analysed in S2Biom can be viewed in the tool.

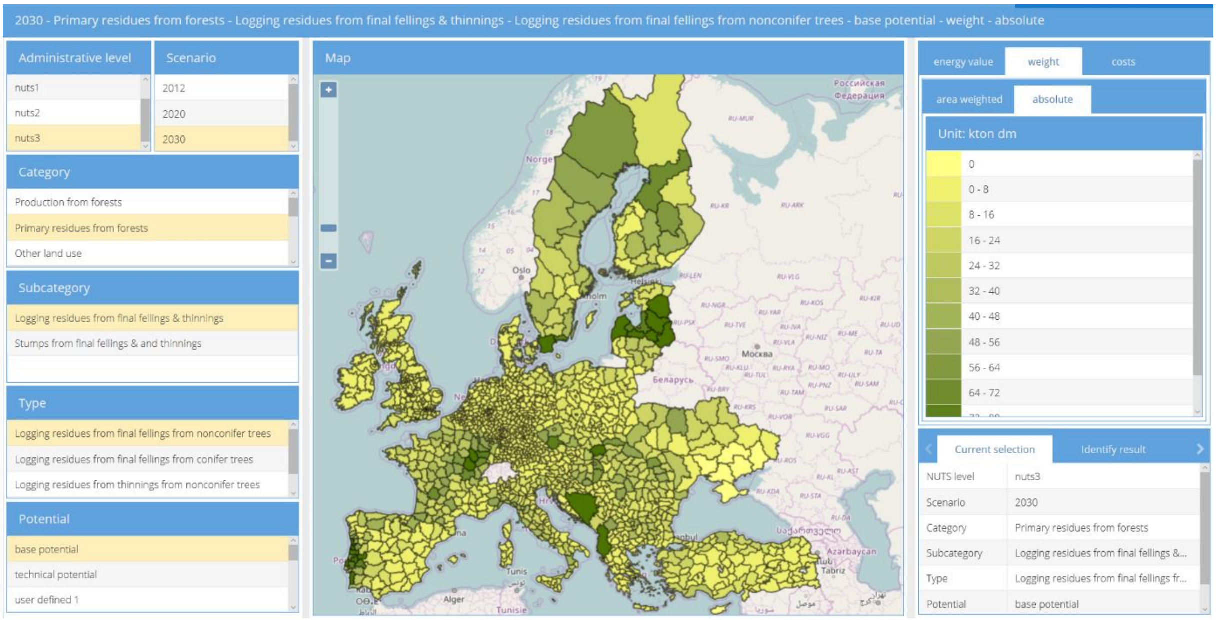

Figure 3 Total annual potential in 2030 (in ,000 tonnes dry matter) from logging residues from final fellings originating from broadleaf trees in European regions

Regions with biomass potentials are in Austria, Bosnia & Herzegovina, Finland, France, Italy, Portugal, Germany, Poland, Romania, Sweden, UK.

Bio wastes

Biowastes analysed in S2Biom are defined as “biodegradable garden and park waste, food and kitchen waste from households, restaurants, catering and retail premises and comparable waste from food processing plants” (Waste Framework Directive (2008/98/EC).

Figure 4 below presents the results from the S2Biom tool for the total potential in 2030 from separately collected biowastes in European regions. Biowastes and postconsumer wood types analysed in S2Biom can be viewed in the tool.

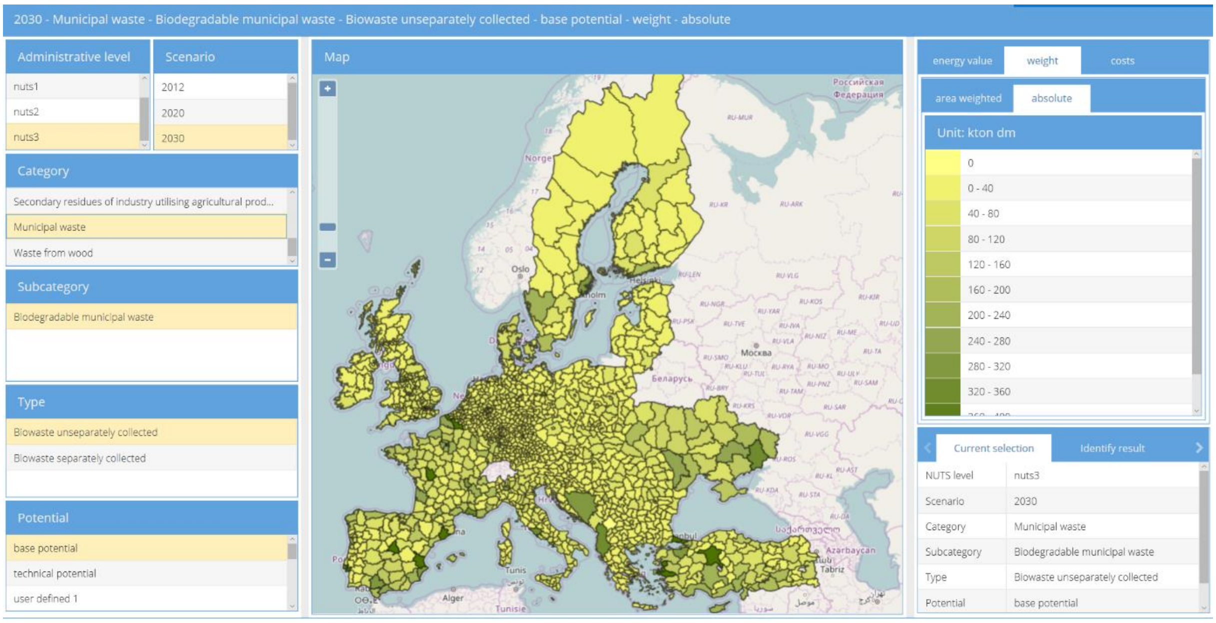

Figure 4 Total annual potential in 2030 (in ,000 tonnes dry matter) from separately collected biowastes in European regions

Detailed information can be found in the S2Biom deliverables:

D1.1 Roadmap for regional end-users on how to collect, process, store and maintain biomass supply data.

D1.8 Atlas with regional (NUTS2/3) cost supply biomass potentials for EU; Western Balkans, Ukraine, Turkey and Moldova.

http://www.s2biom.eu/en/publications-reports/s2biom.html

Market growth, drivers and constraints

Impact: S2Biom performed a detailed market review for future biomass demand for several Product to Market Combinations[1] (PMCs). This information is expected to improve clarity on which sectors of energy, fuel, biobased materials and chemicals are expected to demand the major shares of European lignocellulosic biomass supply.

To understand to what extent, the additional demand for biomass from chemicals and materials could be sufficiently significant to influence lignocellulosic biomass prices and induce scarcity and competition issues with energy applications, it is important to estimate the future demand for biobased products and bioenergy. Several European studies in the past focused mainly on bioenergy and biofuels (Refuel, Biomass Futures, Biomass Policies).

Work within S2Biom has added value to current research and extended the integrated cross- sector model based analysis to selected biochemicals and bio-based products.

The focus was directed towards sectors that can create significant biomass demand, i.e. bioenergy and relatively bulky chemicals markets. Specialties and fine chemicals can have high added value and can therefore be most relevant for a biorefinery business case, but their production will not induce bulky amounts of biomass demand. However, the demand for biomass for other products can have an impact on feedstock price and as such have an indirect impact on the development of these markets.

Table 3 below presents the market to product combinations analysed by S2Biom cross sector modelling.

Table 1 Market to product combinations (PMCs) analysed in S2Biom

	Product	Market
1	Heat	District heating
2	Electricity	Power market
3	Advanced Biofuels	Transport fuel
4	C6 sugars	C6 chemistry: polymers & plastics, others
5	C5 sugars	C5 chemistry: polymers & plastics, others

[1] Originally, three more PMCs were identified: lignin, bioethanol and mixed alcohols. Current bioplastic routes only use the cellulose and hemicellulose parts of the lignocellulosic feedstock. Lignin is a more complex resource for which less biochemical pathways are available today. It is expected, that lignin up to 2030 would mainly be used as a source of bioenergy. Bioethanol has been considered as a #biofuel within the third PMC, and as a biochemical in the dehydration reaction to produce bio-ethylene (PMC 10). The process of mixed alcohol production is still at the early stage of development. No data is found for the conversion efficiency of this process. The process is mostly developed in the USA (NREL), where the major focus lies on renewable alternatives for fossil-based gasoline. An alternative to this process in Europe is ethanol production via biochemical conversion of lignocellulosic biomass.

	Product	Market
6	Bio-methane	Grid, transport
7	BTX	Petrochemical industry
8	Methanol	Transport, chemical industry
9	Hydrogen	Transport, (petro)chemical industry
10	Ethylene	(petro)chemical industry

Modelling work in S2Biom focused on an integrated assessment of lignocellulosic biomass chains, for energy as well as chemicals and materials. By doing this it provided answers to questions related to the future costs of biobased options, competition and synergies between energy and chemical-material applications, and overall system implications of the development of a full-blown biobased sector.

For this, the ECN model for integrated assessment of biomass chains RESolve-Biomass[2] was further expanded and used. This model has been developed and further improved in an array of EU projects, from the VIEWLS project (2003-2005) through REFUEL (2006-2008), Elobio (2007-2010) and Biomass Futures (2009-2012) to Biomass Policies (2013-2016).

Market growth

A recent study by the Biobased Industries Consortium and the nova institute[3] (2016), based on Eurostat numbers, shows that biofuels and bioenergy together account for 15% of the turnover of the EU bio-based economy. The largest shares in turnover are made up for by the sectors paper and paper products (30%) and forest-based industry ((27%). The total turnover of the bio-based industries was 600 billion EUR in 2013. The pulp and paper sector, the wood products and furniture, and the bioenergy sectors are mainly forestry based, while the smaller biofuels sector today in Europe is mainly biodiesel.

The bioethanol production is slowly moving from sugar based to lignocellulose based (the so-called second generation). Many chemical building blocks and bioplastics today are “sugar based” (fermentation), and will only partially be produced from lignocellulosic biomass in the future.

[2] RESolve-Biomass determines the least-cost configuration of the entire bioenergy production chain, given demand projections for biofuels, bio-electricity, bioheat and biochemicals[2], biomass potentials and technological progress (Lensink et al, 2007; Lensink & Londo, 2010). By doing so the model mimics the competition among these four sectors for the same resources. The RESolve-biomass model includes raw feedstock production, processing, transport and distribution. One of the most important features of the RESolve-biomass model is the ability to link the national production chains, allowing for international trade. By allowing trade, the future cost of bioenergy and biochemicals can be approached in a much more realistic way than when each country is evaluated separately.

[3] http://biconsortium.eu/sites/biconsortium.eu/files/news-image/16-03-02-Bioeconomy-in-figures.pdf

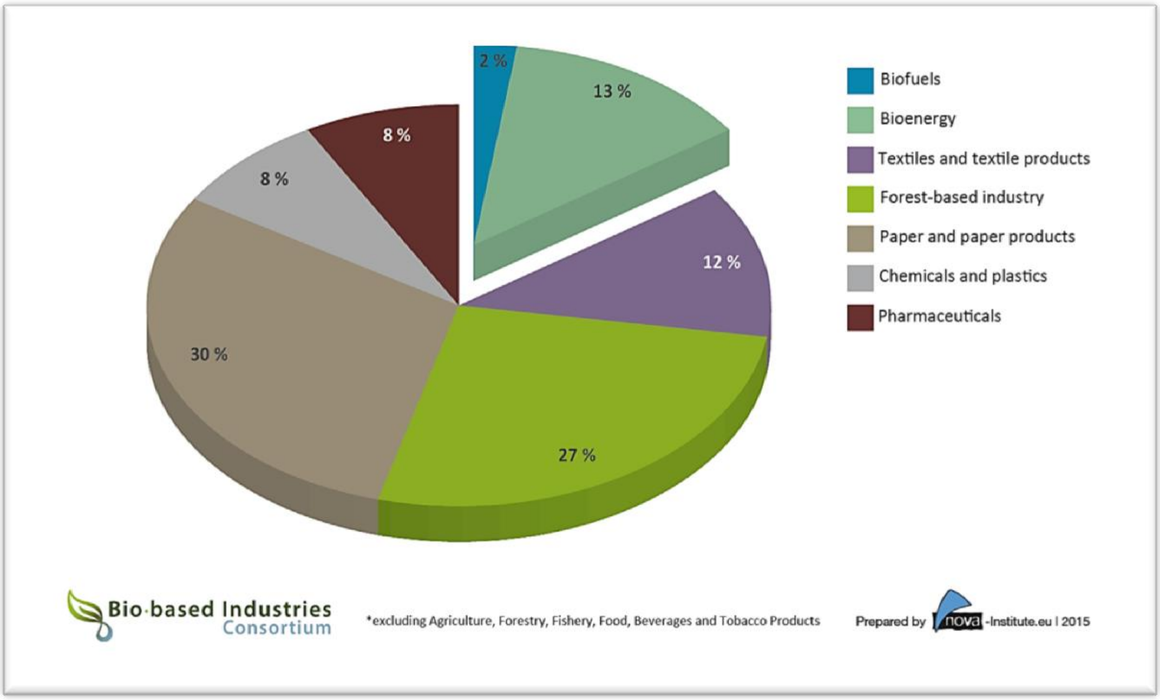

Figure 5: Turnover in the EU bio-based economy* (EU-28, 2013) Total: 600 billion EUR

The total bioeconomy (including the primary sectors such as agriculture and forestry, and the food sector) generated slightly more than 2 trillion euros in 2013 and this number is growing compared to 2008[4]. The pattern varies markedly across the European Union.

Biobased chemicals and bioplastics

To assess biomass demand by 2030, the study estimated the total production capacity of **biobased chemicals** in Europe by 2020 and 2030. The projected EU production capacity of various biobased chemicals (in million tonnes) are summarised in the table below. it is forecast that the sector of the bioplastics will be characterised by enormous market growth, more than 15 % per year in Europe.

The growth level will be dependent on many factors: policies (e.g. the implementation of the “circular economy package”, the future EU plastics strategy, the packaging and packaging waste policy, public procurement policies, etc.), the willingness of brand owners to introduce and promote bioplastics (e.g. Coca Cola, Lego, Ikea, etc.), and the progress in innovation. While bioplastics are currently mainly sugar and starch based, they can be (partially) lignocellulose based in the future.

[4] JRC - Bioeconomy Report 2016 (to be published)

Today, the current production routes for biosurfactans, lubricants and solvents are often based on vegetable oils and starch, and only a minor fraction is likely to be produced from lignocellulose. It is estimated that biolubricants and biobased solvents have growth potential of 3.6% and 4.8% per year respectively. The growth potential for surfactants is estimated to be 3.5% per year, with almost 60% being biobased.

Table 2: The projected EU production capacity of various biobased chemicals (in million tonnes)

2020	**Plastics**		**Lubricants**	**Solvents**	**Surfactants**
High	0.6		0.2	1.1	2.3
Medium	0.5				
Low	0.4				
2030	**Plastics**		**Lubricants**	**Solvents**	**Surfactants**
High	4.0		0.3	1.8	3.2
Medium	2.6				
Low	1.0				

As illustrated by the US DOE's "Top10" biochemicals and IEA Bioenergy Task 42 reports, many biobased chemicals and products are still at pilot or lab-scale (TRL 5 or lower), and will only enter the market between 2020 and 2030.

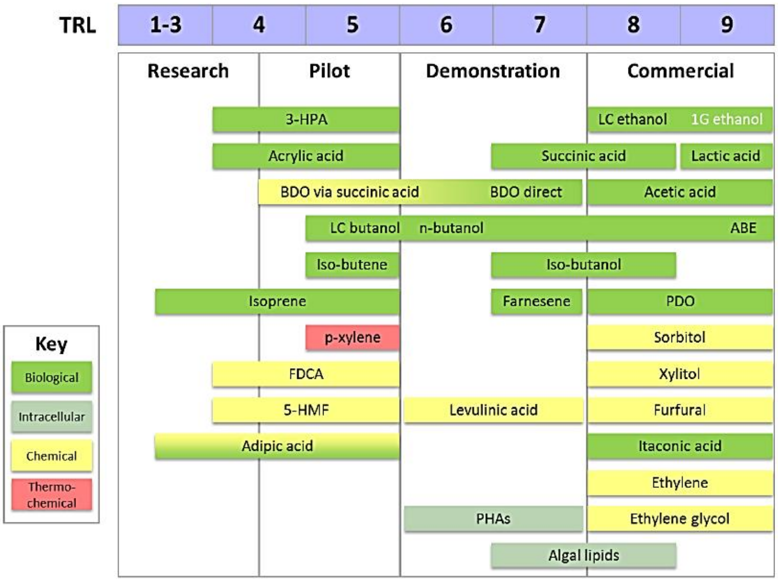

Figure 6: Commercialisation status of selected sugar platform products (Source: From the Sugar Platform to biofuels and biochemical - EC, 2015[5])

[5] E4tech, From the sugar platform to biofuels and biochemicals, final report for EC DG Energy, ENERC/C2/2012/423-1, 2015

The use of lignocellulosic biomass to the bio-based chemicals and plastics sector is expected to be very low till 2030. Although bioplastics may grow at rate 15% per year to 2030, the proportion accounted for by lignocellulosic biomass is expected to remain low.

Advanced biofuels

The total biofuel consumption (bioethanol and biodiesel) is expected to grow from 962 PJ in 2015 to 1216 PJ in 2020 and then further increase to 1258 PJ in 2030.

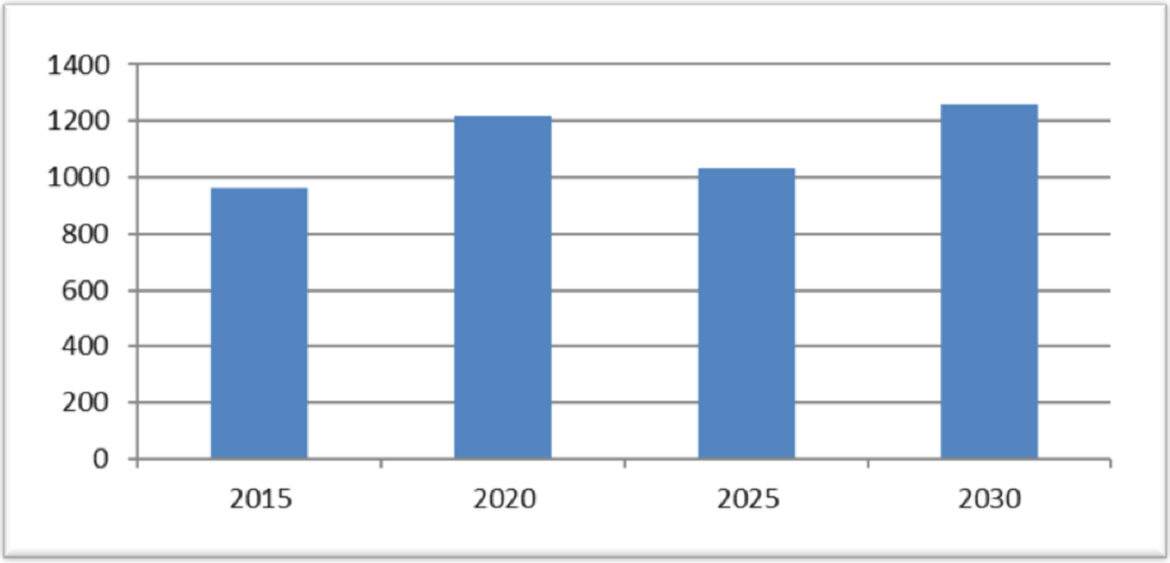

Figure 7: Future projections for biofuel demand (in PJ)

It is expected that, by 2020, almost half of biofuels consumed will be imported from outside of the pan-European region. However, after 2020, the share of imported biofuels will be reduced to about 20% of the total consumption. Where almost all domestically produced biofuels are first generation fuels in 2015, this is expected to change, with second generation biofuels production increasing to 2030.

Detailed information can be found in the S2Biom deliverable:

D7.2: Market analysis for lignocellulosic biomass as feedstock for bioenergy, biobased chemicals & materials in Europe; A quantitative estimate of biomass demand in 2020 and 2030

http://www.s2biom.eu/en/publications-reports/s2biom.html

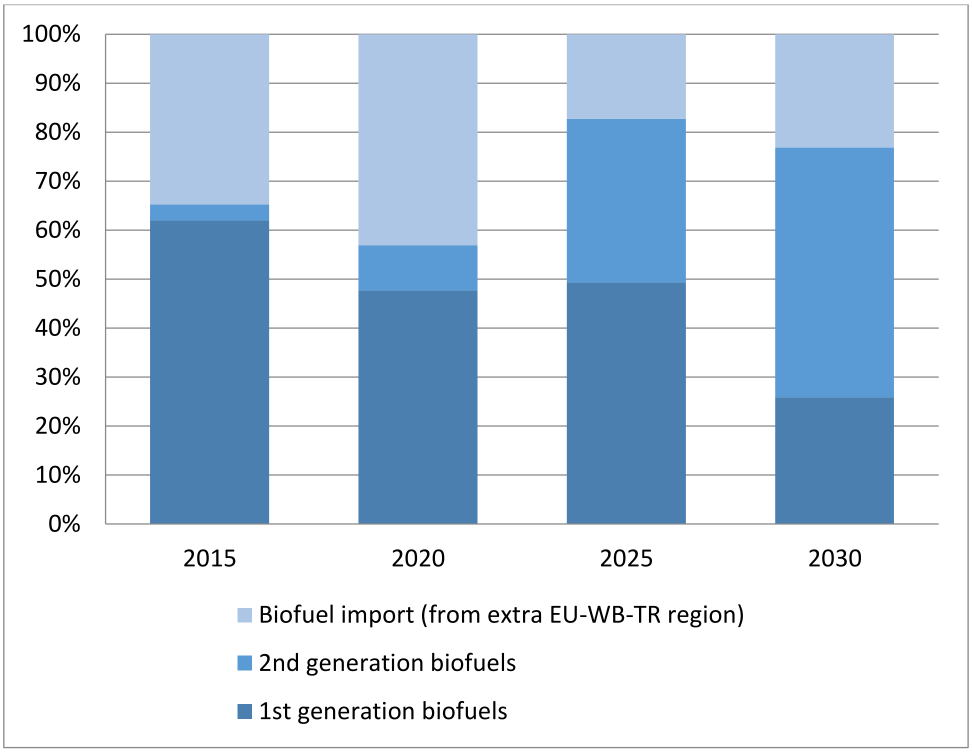

Figure 8: Division of biofuel consumption by production source and generation (excluding Moldova and Ukraine), source Green-X

The market forecasts for bioethanol in transport in the EU are 7,200 M litres (3.7 Mtoe) and 11000 M litres (5.5 Mtoe) by 2020 and 2030 respectively.

Bioenergy: heat and electricity

Demand for heat from biomass resources is expected to increase significantly between 2015 and 2030, with an absolute increase of more than 2000 PJ. Most of the biomass that will be used for heat will be solid biomass, notably wood chips and wood pellets in boilers plus co-firing in coal-fired power plants.

It is expected that production of electricity from biomass will increase until 2030. The average growth until 2030 will be approximately 32 PJ/yr, with the highest growth in the period 2020 to 2025. It is estimated that most of the bio-electricity produced would be fueled by either solid biomass or biogas.

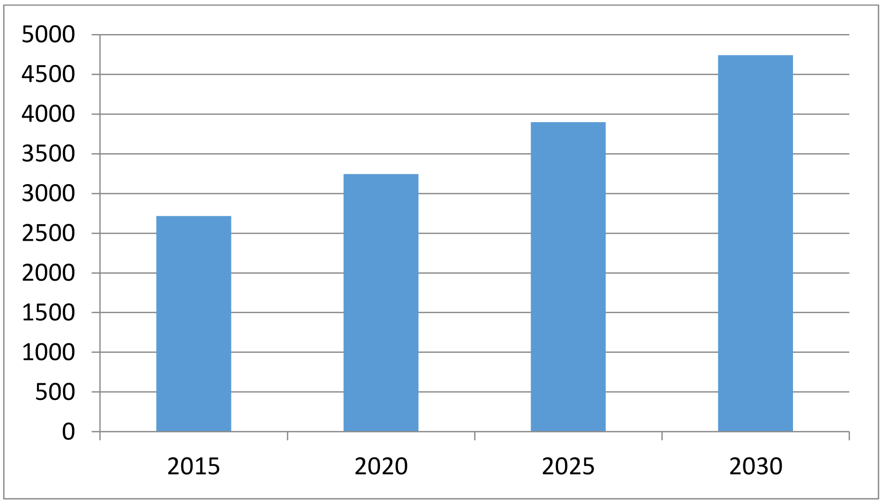

Figure 9: Future projections for heat demand from biomass resources (in PJ)

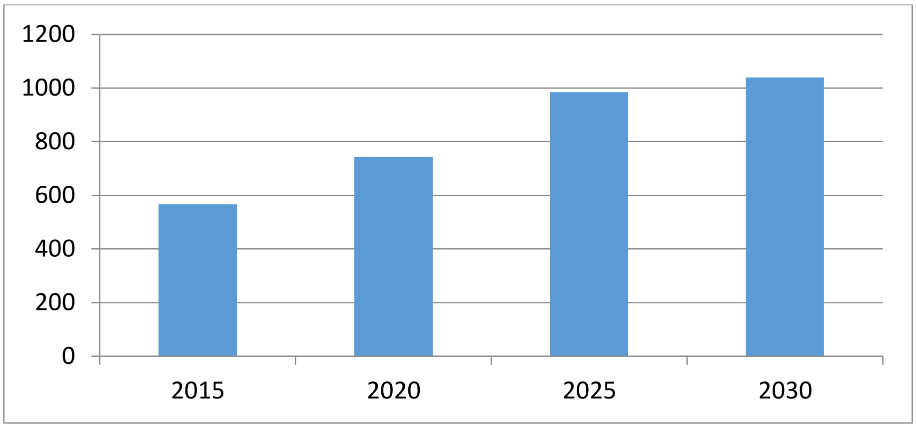

Figure 10: Future projections for electricity demand from biomass resources (in PJ)

Pulp and paper

The forest-based wood products and pulp and paper sectors in Europe[6] consist of 200,000 companies, employing 1.9 million people, providing around 75 billion euro in added value to the EU economy. The sector is for the most part based on raw materials from Europe.

The EU paper market is expected to stagnate or show modest decline. However, the EU pulp and paper sector is taking advantage of the opportunities offered by the bioeconomy. New business concepts will allow it to use the entire potential of wood and wood fibre to produce products and novel materials for the textile, cosmetics, food, and pharmaceutical industries; bio-based fuels and chemicals; and traditional wood-based products.

[6] http://www.unfoldthefuture.eu/uploads/CEPI-2050-Roadmap-to-a-low-carbon-bio-economy.pdf

Drivers and constraints for market growth

A survey[7] published by the EC in 2016 indicated that the main drivers for the biobased chemicals industry were product competitiveness, profitability and development of innovative products followed by environmental performance. Policy is currently ranked as the least important driver, though could become more prominent in the future.

The main constraints for the development of the bio-based industry are declared to be the availability of funds to invest in production capacity; the higher production cost of bio-based products as compared to the conventional ones; and high and/or variable feedstock prices. The existence of products and/or process patents, or other intellectual property issues, and the barriers for achieving product certification were generally ranked lowest on the list of constraints by the surveyed companies.

The Bio-TIC non-technological roadmap highlighted several barriers affecting the bio-based industries. Feedstock related barriers were found to be important, with the challenge being availability of feedstock at affordable prices as well as the logistics of securing large quantities of biomass feedstocks all year round. It was also reported that there were various investment barriers and financial hurdles, including limited public funding for R&D and scale-up activities, and limited access to finance for SMEs, spinoffs and start-up companies. Investment was perceived as high risk. Moreover, public perception and awareness of industrial biotechnology and bio-based products was poor. There were also significant demand side policy barriers, including an absence of incentives or efficient policies and lack of frameworks to promote bio-based products.

The recent “BioEconomy 2030” study[8] by the EC concludes that the changes in real GDP growth and per capita income are dominated by macroeconomic projections shocks, and that policy shocks have limited ‘economy-wide’ impacts. For specific bio-based sectors however, EU policy matters much more. Biofuel mandates generate growth in the infant bio-based industries of bioeconomy supply and bioenergy, whilst within agriculture biofuel feedstock activities (i.e., oilseeds, crude vegetable oil and oilcake) also grow.

[7] “The EU bio-based industry: Results from a survey” (JRC, 2016) https://biobs.jrc.ec.europa.eu/sites/default/files/generated/files/documents/eu-bio-based-industry-survey.pdf
[8] Drivers of the European Bioeconomy in Transition (BioEconomy2030)” – EC, 2016 https://biobs.jrc.ec.europa.eu/sites/default/files/generated/files/documents/drivers-of-the-eu-bioeconomy-in-transition.pdf

Environmental impact

Impact: S2Biom has compiled a set of consistent sustainability criteria & indicators (C&I) for the short- and medium-term bioeconomy. The criteria include environmental, economic and social parameters. This information is expected to improve understanding on possible metrics that can be used to evaluate value chain sustainability across the biobased sectors (energy and non- energy ones).

Life Cycle Analysis (LCA) case studies show that the bioeconomy is complex with regards environmental issues, with extensive relationships between different impacts. For example, the bio-based products studied produce lower environmental loads in comparison to their fossil references for impact categories of climate change and non-renewable energy consumption. On the other hand, other indirect impacts such as eutrophication, acidification and land use, are less clear[9].

While the plastics sector could account for 15% of global GHG emissions by 2050 (assuming continued large growth in plastics consumption), bioplastics can save 2-6 kilograms of CO_2 equivalents per kilogrammes of plastic compared to petrochemical-based plastics[10]. Most studies show that wood products (includingconstruction and furnishing) have lower GHG emissions than alternatives over the complete life cycle of the product[11].

In a recent study, the European Commission (via JRC) made an overview[12] of the potential environmental benefits or disadvantages of moving from fossil products to their bio-based alternatives based on the available and accessible scientific literature and databases.

The bulk of publications deal with bio-based polymers and composite materials. The results (figures 11 and 12) show that there is significant uncertainty over LCA results. This is due to several factors such as the definition of the system boundaries and functional unit and the poor uniformity in the presentation of results – for example the use of different terminologies for the same impact.

Nevertheless, the data show that, bio-based products provide environmental benefits versus fossil references with regards the categories of climate change and non-renewable energy consumption. On the other hand, biobased products appear to provide lower environmental performance for impacts categories such as eutrophication, acidification and land use. The higher impacts found for bio-based

[9] JRC - Bioeconomy Report 2016 (to be published)
[10] http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/the-new-plastics-economy-rethinking-the-future-of-plastics
[11] Forestry for a low-carbon future, FAO, 2016
[12] https://biobs.jrc.ec.europa.eu/sites/default/files/generated/files/documents/BeO%20EnvSust%20-%20Bio-products%20-%20Comparison%20fossil-bio%20v1_160309.pdf

products in these categories are a consequence of the agricultural activities (such as the use of fertilizers and pesticides) necessary for biomass production.

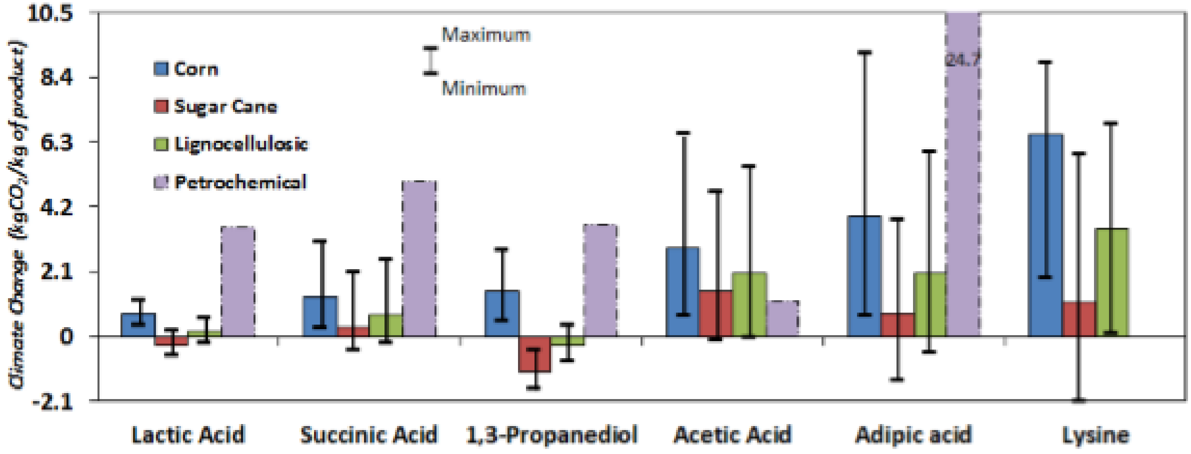

Figure 11: Climate change impacts of different chemical building blocks

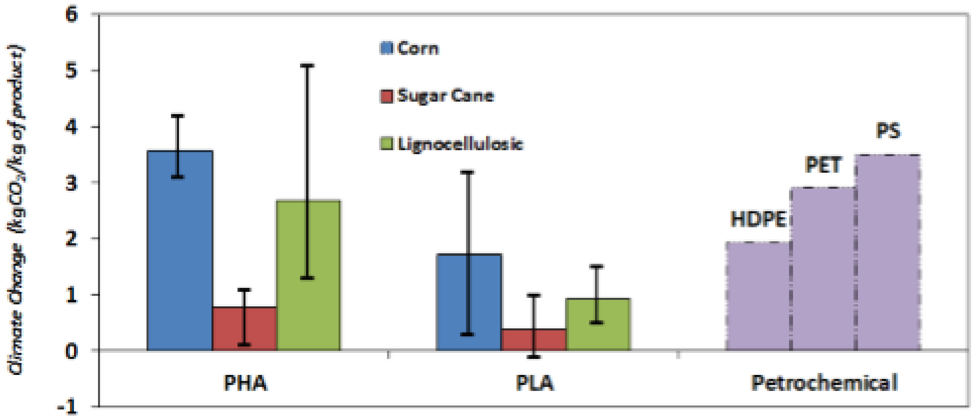

Figure 12: Climate change impacts of different polymers

An important aspect is the difference in technology maturity. Fossil-based products have been produced commercially at scale for decades so processes are optimised. Production of bio-based products is in its infancy and significant gains in efficiency are expected which will improve environmental performance.

Although impacts on climate change and non-renewable energy demand from biobased products obtained from sugar cane were lower in comparison to other feedstock due to the high productivity yields of the crop, when produced from lignocellulosic residues, impacts on land use were significantly lower due to the economic allocation applied to the co-products[13]. In addition, when lignin-rich wastes are co-produced from the hydrolysis of lignocellulosic materials, their use for heat

[13] Bioeconomy Report 2016 (European Commission, to be published).

and power helps to reduce impacts on non-renewable energy demand and climate change.

Bioenergy and biofuels have been subject of several life cycle-based environmental assessments over recent years.

S2Biom has provided a better understanding regarding sustainability requirements in biomass value chains. The compilation of consistent sustainability criteria & indicators (C&I) for the short- and medium-term bioeconomy is one of the specific objectives of the research performed within the project.

Based on the compilation of sustainability requirements and provisions made in this project and literature review, the work has provided:

a) an overview of different angles to be acknowledged when delineating the approach to sustainability, and
b) a specific proposal of sustainability C&I for non-food biomass.

The approach to sustainability has considered the scope of the assessment (biomass value chains and calculation of biomass potentials), the sustainability ambition (a "basic" and a more "advanced" set of C&I), and the types of indicators to be considered (minimum requirements, comparative with non-renewable or biomass references, and descriptive indicators).

The sustainability C&I proposal developed in S2Biom has considered the three "pillars" (dimensions) of sustainability, i.e. environment, social and economic. In total, twelve (12) criteria and twenty-six (26) indicators are included. This set aims to serve as an **umbrella** to the bioeconomy (bioenergy and bioproducts) that can be the basis for more specific indicators in certain applications.

In the environment dimension, the following C&I are proposed:

- Resource Use: Land use efficiency, secondary resource efficiency, energy efficiency, and functionality,
- Climate Change: Life cycle-based CO_2eq including direct land use change, and other GHG emissions,
- Biodiversity: Protected areas and land with significant biodiversity value, and biodiversity conservation and management,
- Soil: Erosion, Soil Organic Carbon, and soil nutrient balance,
- Water: Water availability and regional water stress, water use efficiency, and water quality,
- Air: emissions of SO_2 equivalents, and $PM_{10.}$

In the social dimension:

- Participation and transparency: Effective participatory processes, information transparency,

- Land Tenure: Compliance with the Voluntary Guidelines on the Responsible Governance of Tenure of Land to secure land tenure and ownership,
- Employment and labour rights: Full direct jobs equivalents along the full value chain, full direct jobs equivalent in the biomass consuming region (or country), Human and Labor Rights, and occupational safety and health for workers,
- Health: Risks to public health,
- Food & fuelwood: Measures to avoid risks for negative impacts on price and supply of national food basket and fuelwood.

The criterion related to the economic dimension is:

- Production costs: Levelised life-cycle cost, excluding subsidies, incl. CAPEX and OPEX

Most of these indicators are "mid-point" indicators that need further elaboration to be implementable for specific feedstocks, locations or value chains. Further work will refine these indicators and develop respective thresholds, if applicable.

Table 2 provides an overview of the S2Biom criteria and indicators. These include both qualitative and quantitative values and are based on work developed within the S2Biom project and narrowed to a set of representative values which could also be populated by valid data.

Table 3 Sustainability Criteria and Indicators used for the impact assessment (qualitative indicators are shaded grey)

Theme	Criterion	Indicator		
		#	Indicator	Definition
Environment	1. Resource use	1.1	Land Use Efficiency	Biomass (including by- and co-products along life cycles) per hectare of cultivated area
		1.2	Secondary Resource Efficiency	Heating value of biomass output divided by heating value of secondary resource; applies to conversion of residues and wastes
		1.3	Energy Efficiency	Cumulative energy requirements (all inputs based on LHV primary energy) compared to outputs
		1.4	Functionality (Output service quality)	Economic value of outputs (€/GJ and + €/ton), compared to economic value of heat which could be produced from burning (dried) primary inputs (reference = heat from NG ~ 10€/GJ); economic values excluding taxes, for industrial customers
	2. Climate Change	2.1	Life Cycle-based CO_2eq including direct land use	GHG emissions during the whole value chain (i.e. crop growth & harvesting, logistics, pretreatment and conversion, distribution and end-use phase) in relation to the final output (combination of

Theme	Criterion	#	Indicator	Definition
			change	electricity, useful heat, biofuels & biomaterials)
		2.2	Other GHG emissions	GHG from indirect land use changes (iLUC) and carbon stock changes in forests
	3. Biodiversity	3.1	Protected areas and land with significant biodiversity values	Categories established by the RED: - Protection of land with high biodiversity value (Art. 17.3). Primary forests, areas designated by laws, and other highly biodiverse areas (recognized by international agreements or International Union for Conservation of Nature (IUCN)) and natural and non-natural highly biodiverse grasslands should be excluded. - Protection of land with high carbon stocks (Art. 17.4). Wetlands, continuously forested areas and lightly forested areas with this status in January 2008 but no longer have it should be avoided (not applicable if the status in January 2008 is maintained) - Protection of peatlands (Art. 17.5).
		3.2	Biodiversity conservation and management	"Agrobiodiverse cultivation" (crop rotation; diversity in the landscape; avoidance of alien species), amount of chemicals (pesticides/herbicides), and release/monitoring of Genetically Modified Organisms
	4. Soil	4.1	Erosion	Probability of erosion where mitigation measures are not feasible
		4.2	Soil organic carbon	Probability of soil organic carbon loss where mitigation measures are not feasible (it depends on the type of crops - perennials and annual crops- and respective land management)
		4.3	Soil Nutrient Balance	Probability of nutrient balance loss where mitigation measures are not feasible
	5. Water	5.1	Water availability and regional water stress	Water use in relation to TARWR (total actual renewable water resources), or average replenishment from natural flow in a watershed
		5.2	Water use efficiency	Water use for biomass production (cropping) + irrigation + processing/kg biomass
		5.3	Water quality	Presence of water pollutants (e.g. nitrate, phosphorous, pesticides, biochemical oxygen demand)
	6. Air	6.1	SO_2 equivalents	Life cycle emissions of SO_2, NO_x, NH_3 and HCl/HF from bioenergy provision, expressed in SO_2 equivalents and calculated in accordance to GHG emissions
		6.2	PM_{10}	Life cycle emissions of PM_{10}, calculated in accordance to GHG emissions

Theme	Criterion	Indicator		
		#	Indicator	Definition
Social	7. Participation and transparency	7.1	Effective participatory processes	Enable effective participation of all directly affected stakeholders by means of a due diligence consultation process, incl. Free Prior & Informed Consent when relevant
		7.2	Information transparency	Documentation necessary to inform stakeholder positions shall be made freely available to them in a timely, open, transparent and accessible manner
	8. Land Tenure	8.1	Compliance with the Voluntary Guidelines on the Responsible Governance of Tenure of Land to secure land tenure and ownership (CFS 2012)	Share of area or share of biomass that could be under secure land tenure, based on literature revision and national (or international) statistics.
	9. Employment and labor rights	9.1	Full direct jobs equivalents along the full value chain	Number of jobs (gross figure) from biomass (see methodology from Franke et al. 2013)
		9.2	Full direct jobs equivalent in the biomass consuming region (or country)	Number of jobs (gross figure) from biomass (see methodology from Franke et al. 2013)
		9.3	Human and Labor Rights	Adherence to ILO (1998) principles and voluntary standards
		9.4	Occupational safety and health for workers	Measures taken to guarantee occupational and health safety for workers
	10. Health risks	10.1	Risks to public health	Measures taken to safeguard public health, i.e. regulation of noise level and prevention of accidents
	11.Food & Fuelwood	11.1	Measures to avoid risks for negative impacts on price and supply of national food basket and fuelwood.	This indicator needs to be fully described and will consider the BEFS methodology (FAO 2014) and literature reference

Theme	Criterion	Indicator #	Indicator	Definition
Economic	12. Production costs	12.1	Levelized life-cycle cost (excl. subsidies, incl. CAPEX and OPEX)	Levelized life-cycle cost, excluding subsidies

Detailed information can be found in the S2Biom deliverables:

D5.1 Report on benchmark and gap analysis of criteria and indicators (C&I) in legislation, regulations and voluntary schemes at international, European and MS level

D5.2 Report on final version of Environmental Footprint methods for non-food biomass supply chains

D5.4 Report on consistent sustainability requirements for bioeconomy value chains, including guidelines for harmonized methodologies to determine sustainability performance

http://www.s2biom.eu/en/publications-reports/s2biom.html

Potential market uptake of lignocellulosic biomass as supply to the biobased economy by 2030

Impact: S2Biom modelled the expected uptake of lignocellulosic biomass by 2020 and 2030 for the under study biobased Product to Market Combinations (see Table 1). Model- based estimates are provided in detail for EU and non-EU countries covered by S2Biom (Western Balkans, Moldova, Ukraine and Turkey). This information is expected to give new insights on how much of the estimated by S2biom as available lignocellulosic biomass will be uptaken for energy, fuel, biobased materials and chemicals.

S2Biom research performed an integrated assessment of lignocellulosic biomass chains in Europe, for energy as well as chemicals and materials. Its aim was to provide answers to questions related to the future costs of biobased options, competition and synergies between energy and chemical-material applications, and overall system implications of the development of a robust biobased sector.

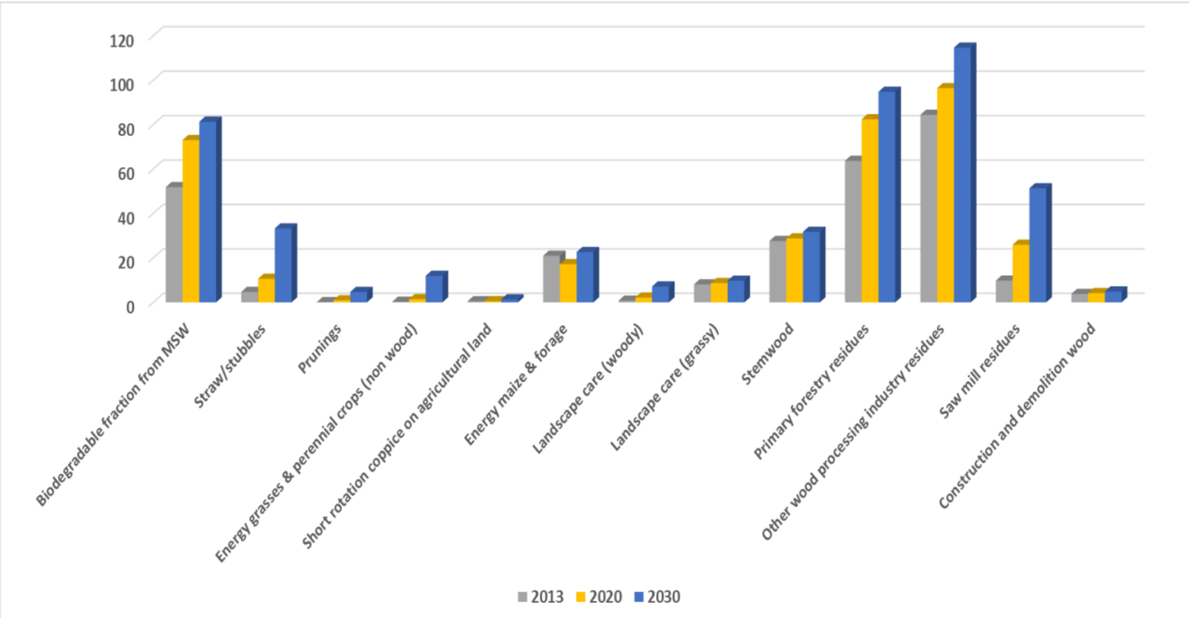

Figure 13 Lignocellulosic biomass uptake (in million tonnes as received), modelled by RESolve, in Europe in 2013, 2020 and 2030

Figure 13 above presents the estimated uptake of lignocellulosic biomass in 2013 and projections for 2020 and 2030. All figures correspond to consumption of domestic biomass, not imported from outside S2Biom area (EU, Western Balkans, Moldova, Ukraine and Turkey).

Detailed information can be found in the S2Biom deliverable 7.3: Integrated assessment of biomass supply chains and conversion routes under different scenarios. http://www.s2biom.eu/en/publications-reports/s2biom.html

Direct employment and location

The study by the Biobased Industries Consortium and the nova institute (2016), based on Eurostat, estimates the employment in the "industrial biobased sectors" (so excluding also the primary biomass production/extraction and the food sector), to be 3.2 million jobs. The most prominent sectors are the forest-based industry, paper and paper products, and the textile industry[14].

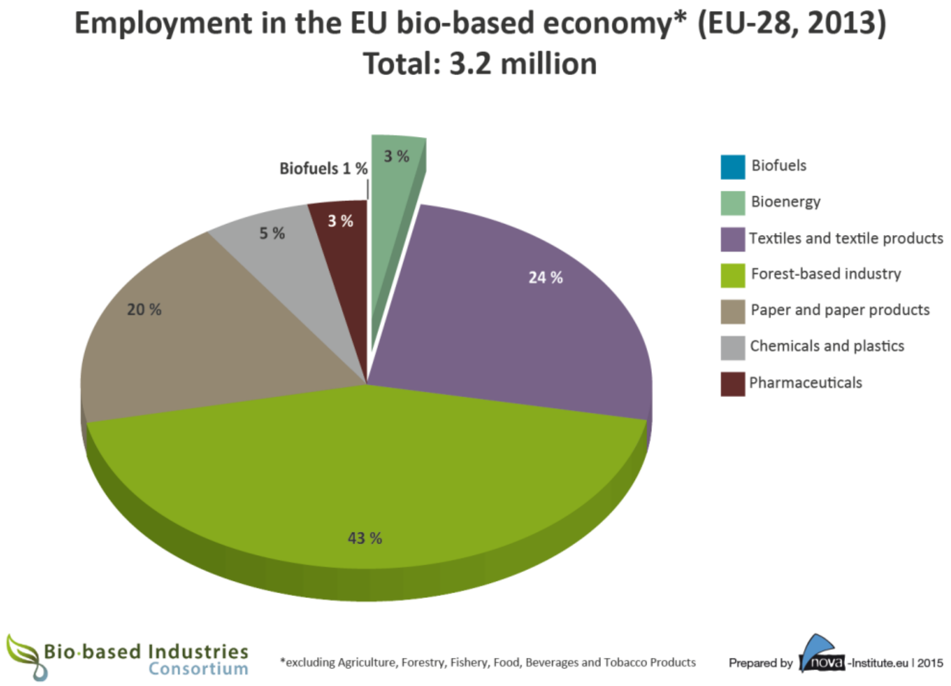

Figure 14: Employment in the EU bio-based economy (EU-28, 2013) totals 3.2 million in 2013

Across the EU the total bioeconomy (including primary sector and food sector) employed at least 18 million people in 2013, though this number is around 1 million down on figures for 2008[15]. Just as for the turnover the pattern varies markedly across the European Union.

Although it employs only 1.5% of the workforce in the total European bioeconomy, the manufacturing of bio-based chemicals, bio-based pharmaceuticals, rubber and bio-based plastics is growing. The number of people employed has increased by approximately 30,000 between 2008 and 2013 (i.e. +12%). The remaining sectors

[14] http://biconsortium.eu/sites/biconsortium.eu/files/news-image/16-03-02-Bioeconomy-in-figures.pdf
[15] JRC - Bioeconomy Report 2016 (to be published)

show little fluctuations around the 2008-2013 average over the period, but with no clear upward or downward trend[16].

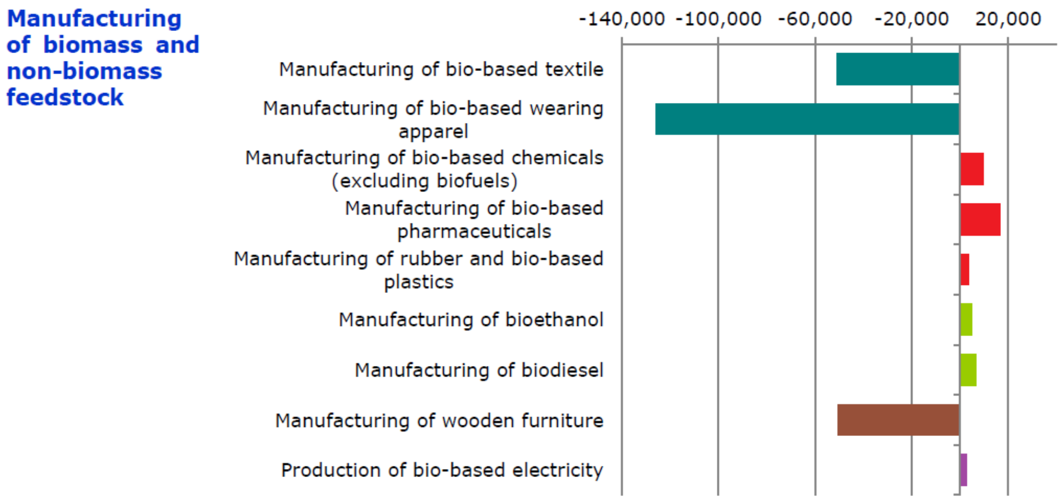

Figure 15: Change in number of people employed in the bioeconomy sectors between 2008 and 2013

The study "BioEconomy 2030[17]" by the EC concludes also that a large proportion of bio-based employment is centred in the primary agricultural sector. However, there are some risks. The study estimates that a removal of Pillar 1 support and the elimination of the biofuel mandates may lead to a decrease of employment in the agricultural sector between now and 2030, while a possible removal of the mandate will result in an employment fall in the bioenergy sector.

Location

A study for biobased products producing companies indicates that in Europe, the location of all facilities (headquarters, R&D, demonstration and production) shows a similar distribution as the main European chemical industry clusters. Respondents indicated that the main reasons for choosing the facilities' location are related to feedstock availability and to proximity to already existing activities, both commercial and R&D.

[16] JRC - Bioeconomy Report 2016 (to be published)
[17] Drivers of the European Bioeconomy in Transition (BioEconomy2030) – EC, 2016

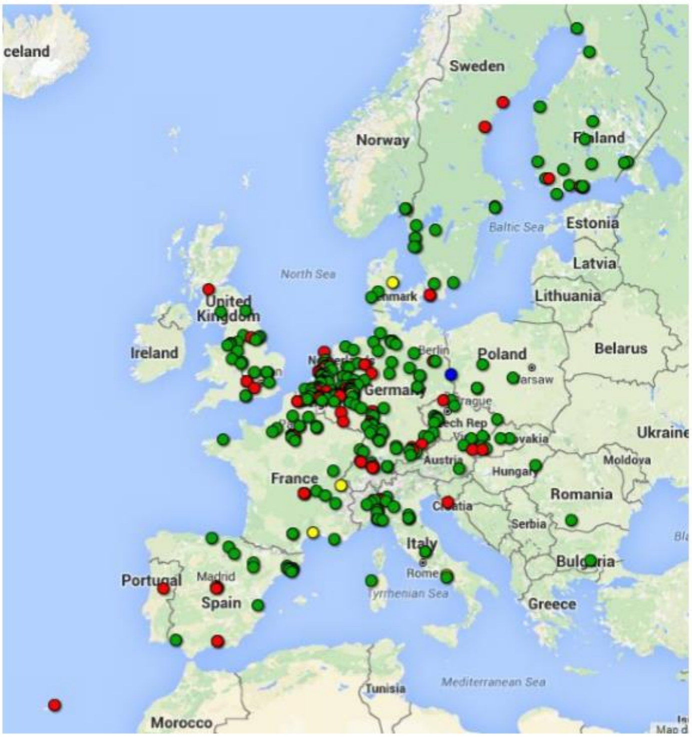

Figure 16: Location of the premises within EU, showing headquarters (red), R&D sites (yellow), demonstration plants (blue) and production plants (green); (source: EU Biobased Industries survey)

Conclusions

Evidence, tools and data developed within S2Biom are well aligned with the aim and work programmes of the Biobased Industrial Initiative (BBI)[18] and the the Biobased Industries Consortium (BIC)[19] to improve and refine information for European regions in terms of sustainable biomass supply. This can be a good starting point for the regions to:

- "Valorise" their domestic feedstock: agricultural residues, primary and secondary forest residue streams, biowastes, postconsumer wood etc.
- Design and set up local value chains, so their farmers, foresters and local industry benefit from it.
- Select neighboring regions with high occurrence of lignocellulosic biomass and strengthen interregional collaboration.
- Mobilise the use of regional and rural development funds and other finances to support and attract investments, and as such create new jobs and opportunities for their primary sector.

[18] The Bio-Based Industries Joint Undertaking is a €3.7 billion Public-Private Partnership between the EU and the Bio-based Industries Consortium. Operating under Horizon 2020, it is driven by the Vision and Strategic Innovation and Research Agenda (SIRA) developed by the industry. http://www.bbi-europe.eu/

[19] a multi- sector organisation established in 2012 to represent the private sector in the Public-Private Partnership BBI Bio-based Industries (EC representing the public sector). http://biconsortium.eu/