



# The European Commission's Knowledge Centre for Bioeconomy



## Brief on biomass for energy in the European Union<sup>1</sup>

### Key messages

1. Biomass<sup>2</sup> for energy (bioenergy) continues to be the main source of renewable energy in the EU<sup>3</sup>, with a share of almost 60%. The heating and cooling sector is the largest end-user, using about 75% of all bioenergy (see section 1).
2. Bioenergy contributes to the EU's energy security, as most of the demand is met from domestically produced biomass (about 96% in 2016) (see section 2).
3. Forestry is the main source of biomass for energy (logging residues, wood-processing residues, fuelwood, etc.). Wood pellets, mainly for heating and electricity production, have become an important energy carrier (see section 3).
4. Germany, France, Italy, Sweden and the UK are the largest bioenergy consumers in absolute terms, while the Scandinavian and Baltic countries, as well as Austria, consume the most bioenergy per capita (see section 4).
5. Bioenergy can play a key role in achieving the EU's renewable energy targets for 2030 and beyond. However, biomass for energy must be produced, processed and used in a sustainable and efficient way in order to optimise greenhouse gas savings and maintain ecosystem services, all without causing deforestation or degradation of habitats or loss of biodiversity (see section 5).

<sup>1</sup> This brief is based on data from the [National Renewable Energy Action Plans \(NREAPs\)](#) and [Progress Reports](#) from Member States (under Article 4 and Article 22 of the [Directive 2009/28/EC](#)), as well as from Eurostat energy statistics ([2018a](#), [2018b](#)).

<sup>2</sup> Here "biomass" means the biodegradable fraction of products, waste and residues from biological origin from agriculture, including vegetal and animal substances, from forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin as defined in the Directive of the European Parliament and the Council on the promotion of the use of energy from renewable sources ([EU, 2018](#)). Bioenergy is the energy produced from biomass.

<sup>3</sup> European Union, comprising of the following 28 Member States (MS): Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, the United Kingdom.



## 1. What is the contribution of bioenergy to renewable energy in the EU?

Bioenergy is derived from a wide range of feedstocks, such as biomass from agriculture (crop residues, bagasse, animal waste, energy crops, etc.), forestry (logging residues, wood processing by-products, black liquor from the pulp and paper industry, fuelwood, etc.), and other types of biological waste (food waste, food industry waste, the organic fraction of municipal solid waste, etc.). Bioenergy continues to be the main source of renewable energy in the EU in terms of gross final consumption<sup>4</sup>, notwithstanding the rapid growth of wind and solar power over the past decade. Bioenergy (heat, electricity and transport fuels) contributed 116 Mtoe (59% of all renewables and 10% of all energy sources, see Figure 1) to the gross final energy consumption in 2016. In terms of end use, the largest sector is heating and cooling (H&C), which accounts for about 75% of all bioenergy consumed. Bioelectricity and transport biofuels account for 13% and 12% respectively.

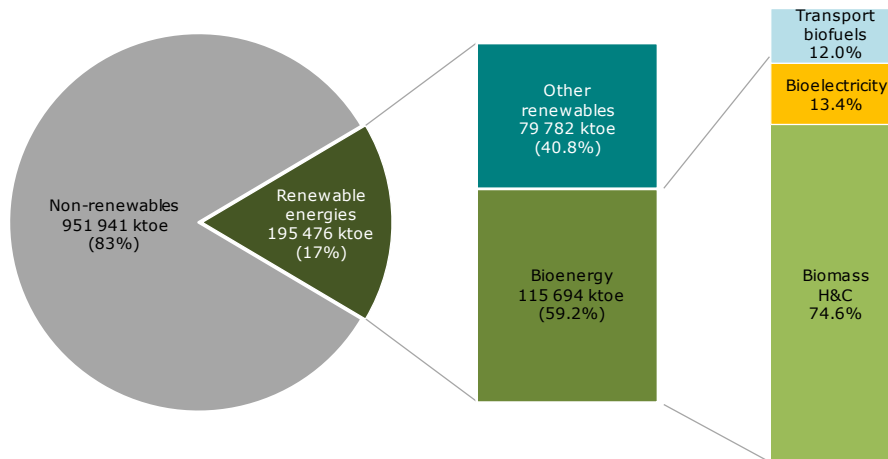


Figure 1. Share of renewables in the EU's gross final energy consumption for 2016 and breakdown of the bioenergy contribution. Source: [Eurostat 2018b](#) and [NREAP Progress Reports](#).

## 2. Where is biomass used for bioenergy production in the EU sourced from?

Biomass supply for bioenergy (i.e. primary energy) in the EU reached 140 Mtoe in 2016. Of this, 96% was sourced from within the EU and the remaining 4% was imported from non-EU countries. EU-sourced biomass is mostly transformed into energy in the Member State in which it is produced, with only 7.2% being converted into energy in a different Member State (see Figure 2).

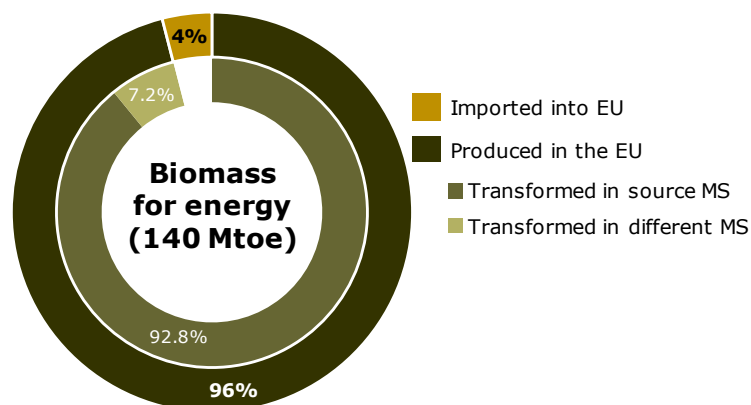


Figure 2. Origin of biomass supplied for energy in 2016 in the EU-28. Source: [NREAP Progress Reports](#).

<sup>4</sup> Gross final consumption of energy, as defined in Article 2 of Directive 2009/28/EC ([EC 2009](#)) and [EC 2018](#), means: the energy commodities delivered for energy purposes to industry, transport, households, services including public services, agriculture, forestry and fisheries; the consumption of electricity and heat by the energy branch for electricity; heat and transport fuel production; and losses of electricity and heat in distribution and transmission.

While the data on imports only covers direct trade of biomass for energy, additional biomass feedstock may come through indirect trade, such as starch and oil crops for food and feed that could be partially used for biofuels. In addition, some by-products from the processing of imported roundwood or wood chips are used for bioenergy generation. The quantification of indirect trade is complex and depends on the end uses, the conversion efficiency of raw materials, the production processes, etc.

### 3. Which sources contribute most to the supply of biomass for energy?

Forestry accounts for more than 60% of all EU domestic biomass supplied for energy purposes: in 2016, direct supply of woody biomass from forests and other wooded land contributed 32.5% (44 Mtoe), and indirect supply of wood contributed another 28.2% (38 Mtoe) (see Figure 3)<sup>5</sup>. Almost 27% (36 Mtoe) originated from agricultural biomass (equally from agricultural crops and agricultural by-products), with waste (municipal, industrial, etc.) making up the remaining 12.4% (17 Mtoe). In 2016, the share sourced from forestry was already higher than that foreseen in the NREAP projections for 2020, while the share from agricultural by-products and waste lagged behind the 2020 projections.

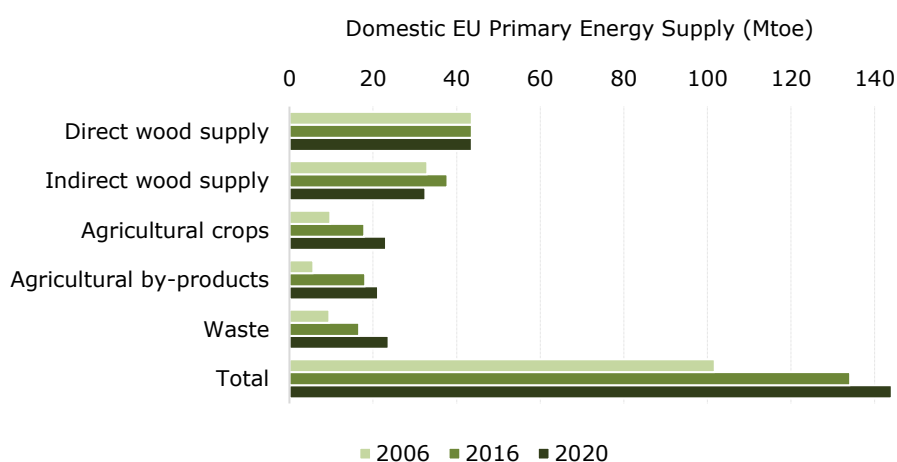


Figure 3. Domestic biomass supplied for energy in 2006, 2016 (EU country data) and initial projections for 2020 (according to the projections in the National Renewable Energy Action Plans)<sup>5</sup>. Source: [NREAPs](#), [NREAP Progress Reports](#).

Wood is the most important single source of energy from renewables in many Member States. Latvia (29%), Finland (24%), Sweden (20%), Lithuania (17%) and Denmark (15%) had the largest share of wood and wood products in gross inland consumption of energy<sup>8</sup> ([Eurostat 2018a](#)). A large proportion of solid biomass is used directly by households and other final consumers (industries, services, agriculture/forestry). The use of fuelwood in households is particularly important in France, Italy, Germany, Romania and Poland.

Wood pellets have become an important energy carrier traded on a large scale and over long distances, due to their high energy density<sup>6</sup> and stable characteristics. Global production reached 29 million tonnes in 2016, of which more than 50% was produced in the EU. The EU is also the main consumer globally (23 million tonnes, of which 32.6% is consumed in the UK, 9.1% in Italy, 8.7% in Germany, 8.7% in Denmark and 7.4% in Sweden). In some Member States, the consumption of wood pellets relies mostly on imports, e.g. the UK (94.7%) and Italy (81%). Wood pellets are mostly used in the residential sector for heating (in Italy, Austria, etc.) or for electricity production (in the UK, Austria, etc.).

<sup>5</sup> According to Commission Decision C(2009) 5174 ([EC 2009](#)):

- Direct supply of woody biomass from forests and other wooded land for energy generation includes: fellings, residues from fellings (tops, branches, bark, stumps) or landscape management residues (woody biomass from parks, gardens, tree rows, bushes).
- Indirect supply of woody biomass includes: residues from sawmilling, woodworking, furniture industry (bark, sawdust), by-products of the pulp and paper industry (black liquor, tall oil) or processed fuelwood, post-consumer recycled wood (recycled wood for energy generation, household waste wood).

<sup>6</sup> Wood pellets have a Lower Heating Value of 17.5 GJ/tonne on average (1 tonne=0.418 toe)

Agricultural crops represented the largest source of feedstock for biofuel production (72% of about 14 Mtoe used in transport in 2016<sup>7</sup>), with various waste products and residues contributing to the remainder (28%). Most of the biofuels were produced from domestic feedstock, with less than 7% imported in 2016, confirming a trend towards fewer imports over the past few years.

#### 4. Who are the largest consumers of bioenergy?

Germany, France, Italy, Sweden and the UK are the top five EU Member States as regards gross inland consumption<sup>8</sup> of bioenergy according to 2016 data, considering both domestic production and imports of the bioenergy carriers (Figure 4a). Those countries also experienced the highest levels of growth in bioenergy consumption over the period 2005-2016 (Figure 5). During that period, bioenergy consumption in the EU increased by more than 60%. On the other hand, the Scandinavian and Baltic countries, as well as Austria, are the largest consumers on a per-capita basis (Figure 4b).

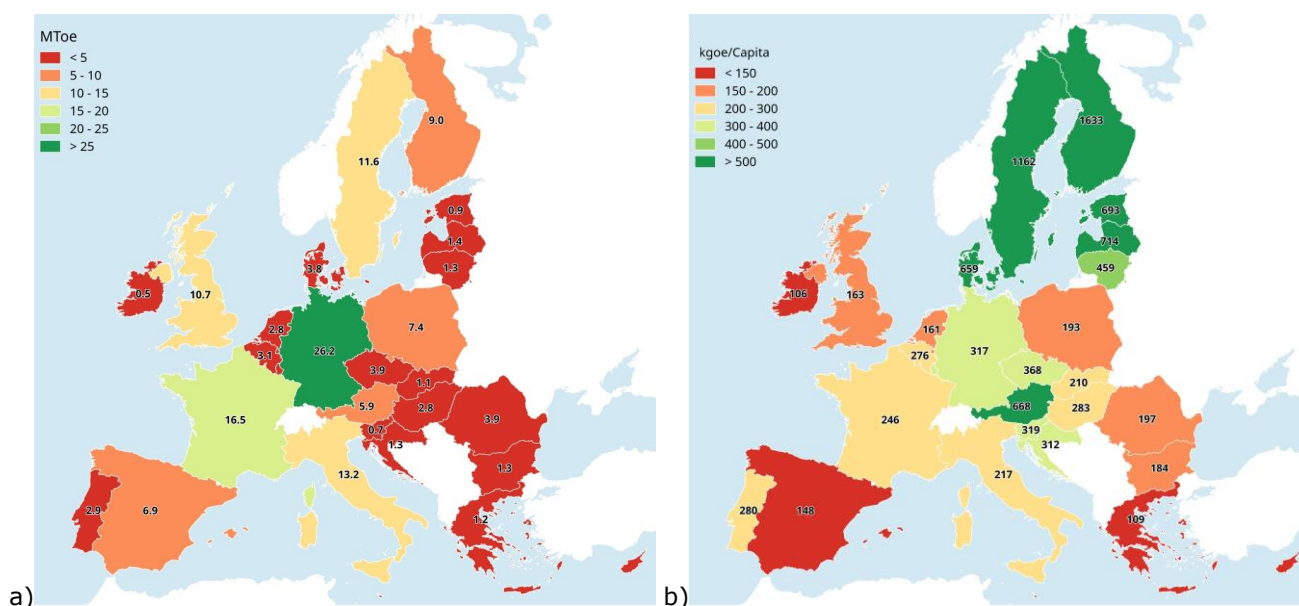


Figure 4. Gross inland bioenergy consumption<sup>8</sup> in EU Member States in 2016: total in Mtoe (a) and per capita in kgoe/per capita (b). Source: [Eurostat 2018a](https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&plugin=1)

Within the bioenergy sector, bioelectricity has experienced the most significant relative growth over this period (about 160% increase at EU level) as a result of various support schemes. In 2016, Germany, the UK, Italy, Finland and Sweden were the largest bioelectricity consumers, and Germany, France, Sweden, Italy and Finland the largest consumers of bioheat (Figure 6). The biofuels for the transport sector are mainly consumed in France, Germany, Sweden, Spain, Italy and the UK, with a large gap between their consumption and that of the rest of the Member States.

<sup>7</sup> This figure includes only compliant biofuels - as of 2011 those in compliance with the sustainability requirements of Articles 17 and 18 of Directive 2009/28/EC ([EU, 2009](https://eur-lex.europa.eu/eli/dir/2009/28/oj)).

<sup>8</sup> Gross inland energy consumption represents the quantity of energy necessary to satisfy inland consumption and covers the consumption by the energy sector itself, the distribution and transformation losses, and the final energy consumption by end users. It is defined as primary production plus imports, recovered products and stock changes, minus exports and fuel supply to maritime bunkers ([Eurostat 2018c](https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&plugin=1)).

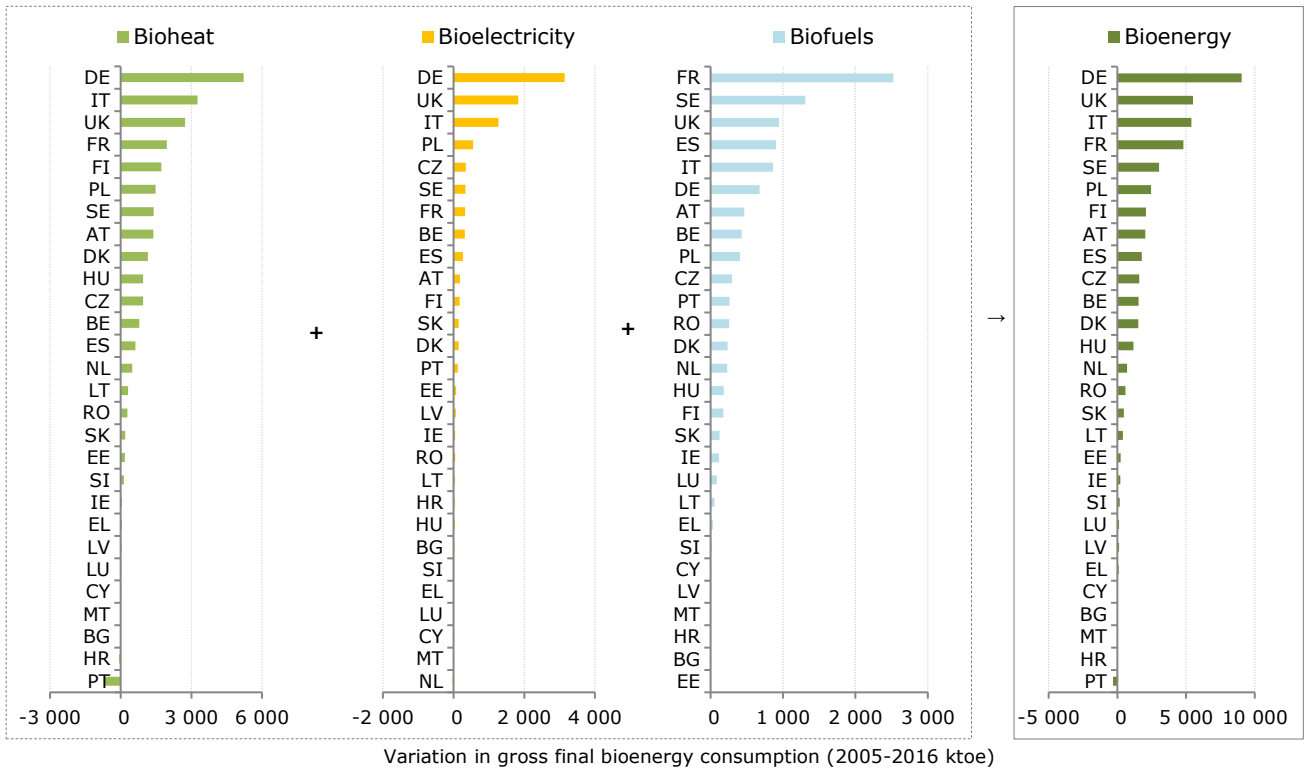


Figure 5. Variation in gross final bioenergy consumption (ktoe)<sup>4</sup> in EU Member States between 2005 and 2016. Source: [Eurostat 2018a](#) and [NREAP Progress Reports](#). Note: Biofuels data includes only those biofuels that are compliant with sustainability criteria, as provided by the Renewable Energy Directive<sup>7</sup>.

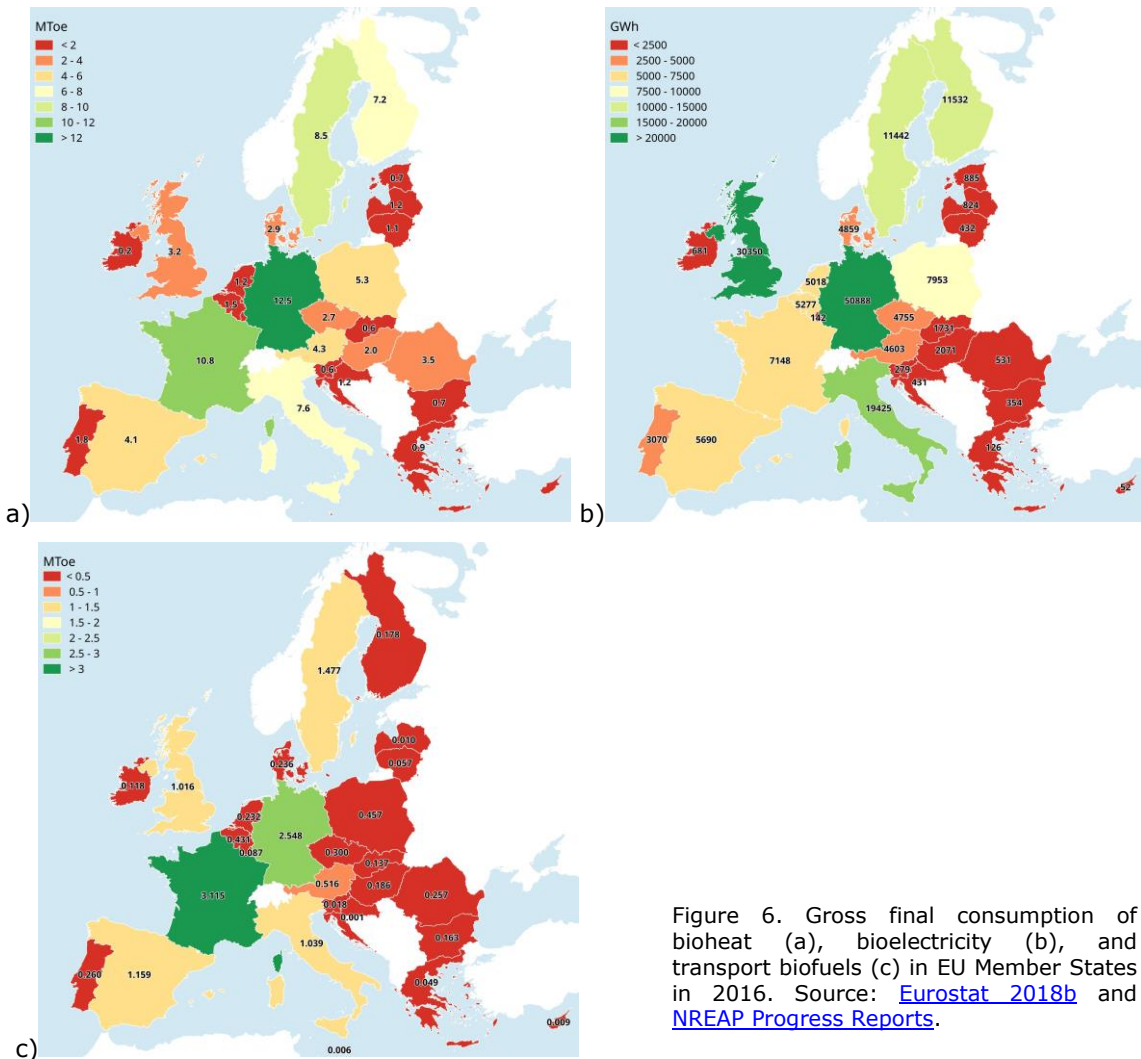


Figure 6. Gross final consumption of bioheat (a), bioelectricity (b), and transport biofuels (c) in EU Member States in 2016. Source: [Eurostat 2018b](#) and [NREAP Progress Reports](#).

## 5. What role can bioenergy play in the future?

Bioenergy plays an important role in helping to meet the EU's 2020 target of 20% renewable energy. Under the 2010 National Renewable Energy Action Plans, total biomass demand for electricity, heating and transport is planned to reach 178 Mtoe by 2020. As seen in Section 2, by 2016 the biomass supply for energy had reached 140 Mtoe. However, growth has been slower than foreseen. The domestically sourced biomass supply (almost 135 Mtoe, see Figure 3) will need to increase by 7.4% to reach the planned 2020 level. While the share from the forestry sector is above the expected level (already 81 Mtoe in comparison to the 76 Mtoe level expected for 2020), the supply from agricultural crops would need to increase by 29% and from agricultural by-products by 17%. However, the largest relative increase is needed in bioenergy from waste, where 42% growth would be required to reach 23.7 Mtoe by 2020.

Looking further ahead, the EU has recently adopted a 32% target for renewables in total gross final energy consumption by 2030. Overall, the bioenergy sector has grown substantially and the 2016 data shows good progress towards the 2030 target. In line with the trend noted above for biomass (i.e. primary energy supply), the EU's gross inland bioenergy consumption increased by more than 69% during the period 2005-2016, but this growth rate has fallen since 2010 (from an average annual growth rate of 7.9% in 2005-2010 to 2.6% in the period 2011-2016).

The Commission's long-term vision for a prosperous, modern, competitive and climate-neutral economy estimates that, by 2050, the gross inland consumption of bioenergy will amount to between 170 and 252 Mtoe (depending on the scenario). Figure 7 combines the 2005-2016 reported data for bioenergy and projections of bioenergy consumption, based on eight scenarios for mitigation options<sup>9</sup>.

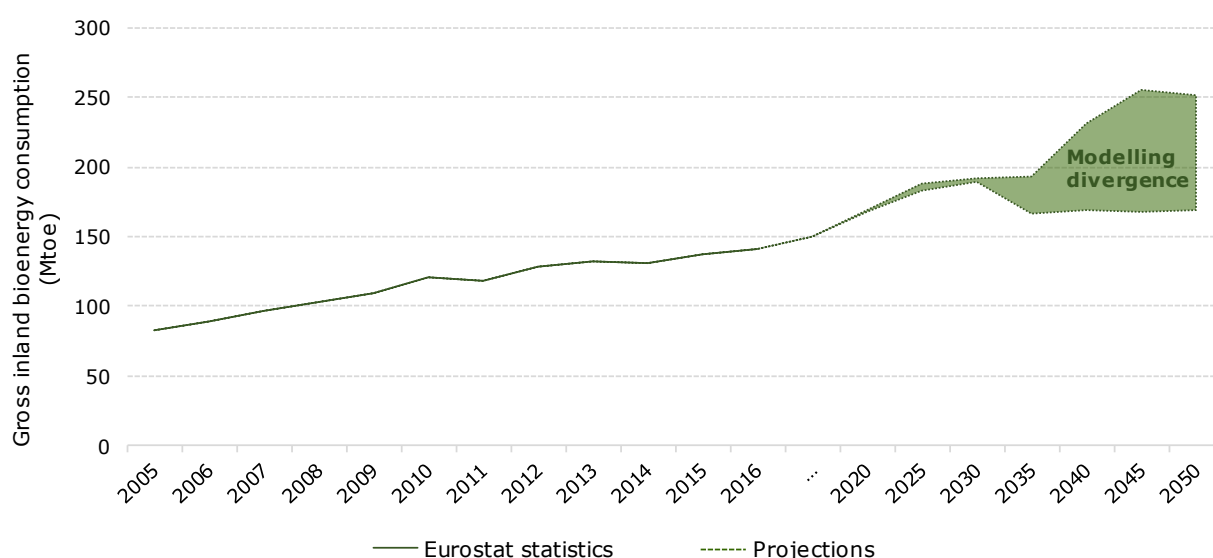


Figure 7. Gross inland bioenergy consumption during the period 2005-2016 and projections until 2050 based on mitigation scenarios. Sources: [Eurostat 2018b](#) and In-depth analysis of the European Commission ([EC 2018](#))<sup>9</sup>.

There are significant opportunities for developing the use of agricultural residues and by-products, as well as waste. Biogas production is based on the use of various waste products and residues, landfill gas and energy crops (energy grasses, silage maize, etc.). The EU is the world leader in biogas electricity production (more than 10 GW and 17 400 biogas plants installed in 2015) as well as in biomethane production for use as a vehicle fuel or for injection into the natural gas grid (459 plants producing 1.2 billion m<sup>3</sup>) (Scarlat et al., 2018). Perennial energy grasses and short rotation coppices cultivated in a sustainable manner can play an important role as feedstock for gasification and pyrolysis in the production of biogas and biofuels. They represent one of the few alternatives for decarbonising the air transport, road freight and maritime sectors as well as for replacing fossil fuel methane in the gas grid.

Furthermore, the use of bioenergy combined with carbon capture and storage (CCS)<sup>10</sup> represents a promising negative emissions technology, especially in bioenergy installations with large and highly

<sup>9</sup> See the in-depth analysis accompanying COM(2018) 773 ([EC 2018](#)). A Clean Planet for all. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy ([https://ec.europa.eu/clima/sites/clima/files/docs/pages/com\\_2018\\_733\\_analysis\\_in\\_support\\_en\\_0.pdf](https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf)).

concentrated CO<sub>2</sub> flue gases (to overcome the high capital costs of CO<sub>2</sub> capture). However, its role will depend on its ability to supply large amounts of biomass in a sustainable way and the development of CCS technologies.

Bioenergy can also play a significant role as a flexible producer, balancing the power system and allowing for higher shares of variable renewable energy sources, such as solar and wind, in the electricity grid. Integrated bioenergy hybrids that combine bioenergy with solar thermal, concentrated solar power, heat pumps and waste heat recovery can ensure flexible options for both energy (heat and power) supply and energy storage.

The key condition for bioenergy development is the availability of reliable, affordable and sustainable biomass<sup>11</sup>. Biomass production and use involves a chain of activities ranging from the growing and harvesting of feedstocks, processing, conversion and distribution of bioenergy carriers to final energy use. Each step can pose different sustainability challenges that need to be managed. The environmental performance of a bioenergy source depends on the specific characteristics of those steps in the value chain and should therefore be assessed on a case-by-case basis.

If well managed, bioenergy pathways can deliver significant greenhouse gas savings, whilst ensuring food security and protecting ecosystems and the services they provide from deforestation, degradation of habitats and loss of biodiversity<sup>12</sup>. Bioenergy production can also bring significant opportunities to deliver social, environmental and economic benefits and contribute to rural development. Possible alternative uses of biomass (e.g. for food, feed, wood products, etc.) also need to be considered to ensure the sustainability of feedstock supply from an overall bioeconomy perspective.

Cascading the use of biomass could improve resource efficiency and limit pressure on natural resources; indeed, resource efficiency can be a basis for differentiating between different biomass pathways. Within an interlinked bioeconomy, the approach to biomass production for food and feed, bioenergy and other purposes should evolve from single end-use orientation to integrated production systems (IEA Bioenergy, IRENA and FAO, 2017).

### Knowledge gaps

1. More detailed statistics are needed on the use of biomass from agriculture, forestry and waste for energy purposes (e.g. energy crops, agricultural and industrial residues and by-products, biowaste, wood waste, sewage sludge, etc.).
2. Differences in reporting (e.g. biomass supply or energy consumption, volumes or energy units) hinder the comparison and equivalent breakdown of the biomass feedstock used and bioenergy production.
3. Scarce and/or incomplete data on biomass trade for energy use needs to be addressed.
4. Comprehensive assessments are required of the benefits and impacts on the environment and socio-economic pillars (greenhouse gas emissions, biodiversity and ecosystem services), including through natural capital accounting.
5. Future research should develop methodologies for prioritising the bioenergy pathways that can bring significant greenhouse gas emission reductions in relation to fossil fuel use in biomass production, transport and conversion, as well as efficiencies of conversion, etc.

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<sup>10</sup> Through CCS, the carbon that is taken up during plant growth and transformed into CO<sub>2</sub> during energy conversion is captured from large point sources (e.g. power plants and industrial installations) for geological storage in suitable sites underground (including oil and gas reservoirs, unmineable coal seams, and deep saline reservoirs).

<sup>11</sup> Article 29 of the [EU 2018](#) includes specific sustainability and greenhouse gas emissions savings criteria for biofuels, bioliquids and biomass fuels.

<sup>12</sup> Ecosystem services are the direct and indirect contribution of ecosystems to human well-being, such as climate regulation, water purification, pest and disease control, soil diversity maintenance and cultural services provision (<https://biodiversity.europa.eu/topics/ecosystem-services>).

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