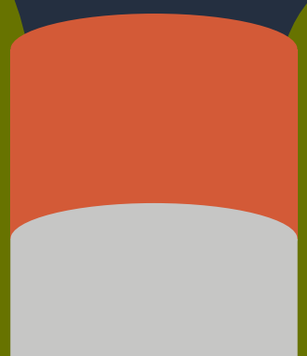
Michał Kolbusz
Augustyn Mikos

FC RESTS TO BURN

THE REAL COST OF BIOENERGY



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Author's foreword

This report is the first user-friendly, comprehensive study on forest biomass, which is used in Poland for energy production, and the resulting threats to nature and the climate. Among those energy sources classified as renewable, wood is the largest in Poland and in Europe. However, in Polish society the knowledge of this fact or the awareness of the environmental risks associated with burning trees to produce energy is very low. The aim of this report is to improve the understanding and awareness of this situation, as well as to provide materials for an informed, factual debate on the use of wood for energy production. It is addressed in particular to decision makers and non-governmental organizations involved in nature and climate protection, as well as to all citizens who wish to learn more about the topic.

Over a recent 15 year period (2004–2019) the amount of timber harvested in EU Member States has increased by nearly 25 %. This has resulted in the deterioration of forest ecosystems, threatening efforts to strengthen the contribution of forests to mitigating climate change. One reason for intensified logging is the growing use of forest biomass for energy production, promoted as "green", sustainable and climate-friendly fuel. However, current scientific knowledge undermines these claims, suggesting that in the timeframe relevant to fighting climate change the burning of trees to produce energy generates more carbon dioxide emissions into the atmosphere than the burning of fossil fuels (including coal), while also contributing to the degradation of forest ecosystems.

Unfortunately, the current EU regulations promote the use of wood for energy production. The Directive on the promotion of the use of energy from renewable sources (RED[1]), adopted by the European Union in 2009, gave a direct stimulus for the rapid growth of the use of forest biomass for energy production in Europe. Currently, biomass from European and global forests provides about 36% of renewable energy in the EU member states. Since the time the RED directive was first adopted, the increase in consumption of this fuel has been correlated with an increase in the amount of wood harvested in the European forests, a decrease in the amount of biomass in European forests and an increase in the importation of it from outside the EU. The RED has led to the destruction of large areas of forests in North America and South-East Asia, converted into plantations of trees and energy crops.

In Poland, analogously to the rest of Europe, an accelerated development of the forest biomass sector has been observed over the past decade or so. Many new energy generation facilities have been built and fuelled with biomass or co-fired with coal. In return for the energy obtained from biomass burning, these facilities are

1 The abbreviation RED is officially entitled to the Radio Equipment Directive, but it is commonly used for the Directive on the promotion of energy from renewable sources

entitled to so-called Green Certificates, which are later traded at the power exchange, increasing the profitability of wood-based energy generation. Thanks to subsidies from EU funds, tens of thousands of households and small individual consumers have replaced their coal-fired stoves with boilers fired with wood pellets. The subsidies contribute to an increase in the number of municipal and communal heating plants burning forest biomass. As a result, more and more wood is burned in Poland, which directly translates to a growing economic pressure on forests.

Meanwhile, it is forest protection that should be a priority in the environment and climate policy. In order to do this effectively, reliable monitoring of forest management and the timber market is necessary. Information on the destination of timber harvested in public forests should be methodically collected and made publicly available. Yet at the moment, in Poland, timber harvesting for energy purposes is inadequately monitored, making it very difficult to assess the impact of the bioenergy sector on the climate and forest ecosystems. This report is an attempt to make such an assessment, even if it has been made difficult by the lack of transparency and incompleteness of publicly available data on the use of wood for energy production. Therefore, in addition to the call to stop promoting the burning of wood for energy production, one of the main conclusions of the report is a recommendation to introduce a system closely monitoring the amount and origin of woody biomass used for energy production, and to allow easy access to the information collected within the system to all interested parties.

Key Findings and Recommendations

Key findings of the report

1. **Use of forest biomass for energy production harms biodiversity and climate**
   Burning wood emits more carbon dioxide per unit of energy into the atmosphere than burning fossil fuels. Waste wood (post-production and post-consumption) is the only type of woody biomass that is less carbon-intensive to burn than fossil fuels in the timeframe relevant to tackling climate change. Harvesting forest biomass for energy purposes increases the pressure on forests already exerted by wood extraction by, among other things, reducing the number of ecological niches and depleting forest soils.

2. **Sharp increase in the amount of woody biomass used for energy production**
   Between 2004 and 2020, the annual consumption of woody biomass for energy production in Poland increased by almost 70% (from 13.8 million m^3 to 23.4 million m^3) due to increased demand for woody biomass in the energy and wood-paper sectors.

3. **Spike in the amount of woody biomass consumption in the energy sector**
   Between 2005 and 2020, the bioenergy sector in Poland experienced a dynamic growth. The total installed capacity of biomass facilities increased seven times (697%), from less than 190 MW to 1512 MW. The amount of woody biomass used in the bioenergy sector increased almost 140 times (13 852%) in the same period, from 35 thousand m^3 to 4.9 million m^3 per year.

4. **Fast increase in the acquisition of woody biomass from domestic resources**
   The majority (86% in 2019) of woody biomass used for energy production in Poland comes from domestic resources. As a result of the rapid development of bioenergy, the amount of woody biomass for energy production acquired from domestic sources increased by 47.6% from 14.3 million m^3 to 21.16 million m^3 per year between 2006 and 2019. In 2020, 7.5 million m^3 of wood assortments used for energy production were harvested, which accounted for 18% of the total wood harvest in Polish forests.

5. **Dynamic growth of woody biomass imports from Belarus**
   The increased demand for wood in the energy sector has led to a significant increase in the amount of woody biomass imported to Poland. In 2010–2020, the import of woody biomass for energy production increased by 917% from 0.21 Mt to 2.19 Mt. The main exporter of woody biomass to Poland is Belarus. In

2020, about 80% of woody biomass imported to Poland came from this country.

6. **Plans for further rapid development of the bioenergy sector in the next 10 years**
   Poland's National Energy and Climate Plan provides for PLN 11 billion (EUR 2.3 billion) of investment in biomass-based electricity generation over the next 10 years. The power generating capacity in power plants and combined heat and power plants is to increase by 177% between 2015 and 2030 (from 553 MW to 1531 MW). Biomass is expected to become the main RES fuel in the heating sector. Domestic solid biomass production, 79% of which is woody biomass, is to increase by more than half (56%).

7. **The law considers woody biomass as a renewable and zero carbon energy source**
   The Renewable Energy Directive (RED) considers forest biomass to be a zero carbon fuel eligible for public financial support for RES. Despite the high carbon footprint and the threats to the environment from timber harvesting, energy from forest biomass is also counted towards meeting targets for the share of RES in total energy production.

8. **Financial incentives fuel the bioenergy sector's growth**
   In the years 2011–2020, producers of electricity from solid biomass received over PLN 21 billion worth of aid under the RES support mechanisms. Over the past 15 years, 37 municipal wood biomass-fired CHP plants and 50,000 households converting heat sources to biomass boilers have received public funding (totaling PLN 2 billion, EUR 450 million).

Summary of findings

The bioenergy sector in Poland has grown rapidly over the past 15 years and, according to government plans, will continue to grow over the next decade. The development of the bioenergy sector has been fueled by the support through public funds and favorable legislation recognizing energy generated from the combustion of biomass as zero-emission and renewable. The expansion of the bioenergy industry has been followed by a rapid increase in woody biomass consumption and harvesting from domestic sources, to a large extent directly from forests. Meanwhile, harvesting woody biomass in forests threatens biodiversity and burning forest biomass for energy production is more carbon-intensive even than burning fossil fuels.

Key Recommendations

To limit the negative impacts of the bioenergy sector on climate and biodiversity the following measures should be taken.

At the European Union level:

- primary forest biomass must be removed from the list of energy sources eligible for public support in the Renewable Energy Directive (RED);
- energy from primary forest biomass (harvested in forests directly for energy purposes) must not be included in targets for the share of RES in total energy production under the Renewable Energy Directive (RED);
- energy generated from secondary woody biomass (post-production and post-consumption waste) should be included in RES targets only if the biomass could not be used for the production of durable products.

At national level:

- burning of primary forest biomass in the energy sector must not be supported;
- these funds must be redirected to support energy efficiency and truly low-carbon energy sources (e.g. wind, solar, geothermal);
- a system for effective monitoring of harvesting and use of woody biomass for energy production must be implemented;
- regulations governing the use of woody biomass for energy production must be updated.

Summary

Harvesting and consumption of woody biomass for energy production in Poland

Between 2004 and 2020, the annual consumption of woody biomass for energy production increased in Poland by 9.5 million m^3 (69%) from 13.8 million m^3 to 23.4 million m^3. This increase was almost entirely due to growing consumption in the energy sector (an increase of 13 852%, from 35 thousand m^3 in 2004 to 4.9 million m^3 in 2020) and the wood and paper industry (an increase of 29,80% from 164 thousand m^3 in 2004 to 4.9 million m^3 in 2020). In 2004, consumption of woody biomass for energy production in these two sectors was negligible. In 2020, the energy sector and the wood processing industry were already responsible for 21% and 22% of the total woody biomass consumption for energy production in Poland, respectively. Households had the largest share in woody biomass consumption in the whole period from 2004 to 2020, the consumption remaining at a similar level (between 10.6 and 12.3 million m^3) and reaching 11 million m^3 in 2020. Woody biomass consumption in agriculture also remained at a similar level (between 2 million m^3 and 2.5 million m^3) reaching 2.1 million m^3 in 2020. In 2019, woody biomass combustion was responsible for 52% of primary energy consumption from RES and 5% of total primary energy consumption in Poland.

The amount of woody biomass for energy production obtained from domestic sources increased by 47.6% between 2006 and 2019 (from 14.3 million m^3 to 21.16 million m^3), in 2019 86% (19.7 million m^3) of woody biomass used for energy production came from domestic resources. The main domestic sources of woody biomass are forestry and the wood and paper industry. In 2018–2020, approximately 7.5 million m^3/year of wood assortments used for energy production were harvested in Polish forests, accounting for 17–18% of the total wood harvest.

Polish bioenergy sector

In the last 15 years the bioenergy sector in Poland has been developing dynamically. In 2005, the total installed capacity of biomass-fired installations was as low as 190 MW, but this figure rose sevenfold (697%) to reach 1,512 MW by 2020. Between 2004 and 2020 there was also a significant increase (by 88%) in the volume of primary energy consumption from solid biomass, biogas, biofuels and biodegradable municipal waste as well as in the share of bioenergy in total primary energy consumption in Poland (from 4.6% in 2005 to 7.6% in 2020). Woody biomass is the main fuel used in the Polish bioenergy sector. In 2019 it accounted for 65% of total primary energy consumption from solid biomass, biogas, biofuels and renewable municipal waste. Throughout this period, bioenergy accounted for the vast majority of primary energy consumption from RES. However, the share of

bioenergy in primary energy consumption from RES has steadily declined from 94% in 2006 to 81% in 2019.

At present, in Poland there are 21 renewable energy installations fuelled with woody biomass the installed capacity of which exceeds 5 MW. The largest installations consume more than 500,000 tonnes of wood chips a year each, which is equivalent to several hectares of a forest per day. The largest installation fed entirely with biomass is the so-called "Green Unit" of the Połaniec Power Plant owned by the ENEA S.A. group. Its maximum annual biomass consumption potential amounts to 2 million tons (Mt). In the Green Block about 1.1 million tons of woody biomass is burnt yearly – equivalent of 20 ha of forest per day.

According to the National Energy and Climate Plan (NEAP), we can expect further dynamic development of the bioenergy sector in Poland over the next 10 years. Investment in electricity production from biomass alone is expected to amount to nearly PLN 11 (EUR 2.3 billion) between 2021 and 2030. Between 2015 and 2030, National Renewable Eenergy Action Plan assumes an increase in: – generating capacity in biomass-fuelled power plants and combined heat and power plants by 177%, from 553 MW to 1531 MW – final energy generation from biomass in the power sector by 29%, from 776.2 ktoe to 1001 ktoe – total solid biomass consumption for energy generation by 53% – domestic solid biomass production by 56%, consumption for energy generation by 53% – domestic solid biomass production by 56%. Given that the vast majority (79% in 2019) of solid biomass used in Poland for energy production is woody biomass, rapid increase in its consumption in the power sector can be expected in the next 10 years.

Import and export of woody biomass

Classification of woody biomass as a renewable source of energy in the RED Directive in 2009 resulted in increased import of energy wood to Poland. In 2010 0.21 million tonnes (Mt) of woody biomass was imported to Poland for energy production. By 2020, this figure had risen to 2.19 Mt, which represents an increase of 917% in 10 years. Since 2013, more than 50% of woody biomass has been imported to Poland from Belarus. In 2020, 79.6% of woody biomass imported to Poland came from Belarus. In 2020, 87.9% of woody biomass used for energy production was imported to Poland from non-EU countries (Belarus, Ukraine and Russia). In the period from 2010 to 2020, imports from these countries increased by 1255%.

Woody biomass exports from Poland increased from 0.51 MT in 2010 to 1.14 Mt in 2020, which means an increase of 119%. 99% of woody biomass is exported from Poland to Western Europe, more than half of it to Germany.

Legislation

Polish regulations on the use of forest biomass in energy sector require amendment as they do not prevent the use of high-quality wood for energy generation. The definition of “energy wood” introduced in the Renewable Energy Sources Act is a weak safeguard due to the fact that the quality and dimensional parameters of energy wood have not been developed for many years, despite repeated appeals by the Energy Regulatory Office. As a result, a considerable amount of wood that could be used by the wood processing industry goes to biomass producers and ultimately to power plants. This is in contradiction with the need for cascading use of raw materials and has a negative impact on the Polish wood processing industry, forced to compete with the energy sector for raw materials.

There is no effective monitoring of the forest biomass sector in Poland. State institutions do not collect detailed information on the amount and type of biomass used for energy production from Polish forests. The location of forest biomass harvested for energy production is also not recorded, making it difficult to assess the impact of bioenergy on the precious natural forests.

CO_2 emissions from the forestry sector

A thorough accounting of the wood harvested from forests for energy production is crucial in light of the LULUCF Regulation and the obligation of reporting greenhouse gas absorption and emissions from the forestry sector.

Poland's National Forestry Accounting Plan (NFAP) predicts that by 2025, the harvest of wood for energy purposes in Poland will have decreased to zero. Instead, the harvest of fuelwood alone (which is only part of the harvest of wood for energy purposes) has been increasing for years and in 2019 was much higher than the forecast in the NFAP (the forecast is 3.56 million m^3 of energy wood in 2019, while State Forests alone harvested 4.78 million m^3 of fuelwood). If Poland reports harvesting wood for energy purposes in line with the forecast included in the NFAP 2019, the declared Polish emissions from the LULUCF sector will be significantly underestimated.

According to The National Centre for Emissions Management, in the years 2013–2019, the absorption of CO_2 by Polish forests decreased, by more than half, from approx. -45 Mt of CO_2 equivalent in 2013 to approx. -20 Mt of CO_2 equivalent in 2019. The current trend indicates a further decline of the forest carbon sink in Poland.

The projection, included by the Ministry of Climate and Environment, in the NFAP unrealistically

forecasting a decrease in the amount of wood harvested for energy purposes to zero, may lead to a situation in which the annual absorption of CO_2 by Polish forests will be artificially inflated by at least several Mt equivalent per year.

EU regulations make it possible for Member States to transfer CO_2 emissions saved in the LULUCF sector within Effort Sharing. Unreliable reporting of the emissions associated with energy wood harvesting may result in Poland saving in total and selling about 23.1 Mt of equivalents of CO_2 worth EUR 1.8 billion by 2030 (assuming the price of the permit for emission of one tonne of CO_2 for 78 euro – data form 15 March 2022).

Forest biomass harvesting and forest conservation

Harvesting forest biomass for energy production increases the pressure exerted by wood extraction on forests. Forest biomass is often harvested in a form of woody residues generated during forestry works, fallen and damaged trees, deadwood and stumps. Removal of this type of biomass from forest causes a decrease in the amount of dead wood, destruction of habitats of species dependant on the presence of dead wood, a decrease in the number of ecological niches and impoverishment of forest soils, which in turn leads to a decline in biodiversity and ecological integrity of forest ecosystems.

Forestry focused on harvesting energy biomass is a greater threat to forest ecosystems than traditional forestry aimed at producing wood for the timber industry, because it favours monoculture of fast-growing tree species with short rotation cycles. From the point of view of energy generation, it is cost-effective to harvest biomass that, being unsuitable for the wood industry, would otherwise remain in traditionally managed forests, increasing the amount of deadwood in the forest ecosystem.

Woody biomass and climate change

Due to the significantly lower calorific value of biomass compared to coal, oil and fossil gas, burning wood emits more carbon dioxide per unit of produced energy than burning fossil fuels. Emissions from biomass combustion are absorbed by regrowing trees, but it takes from several dozen to over a hundred years to eliminate the resulting net emissions, depending on the type of forests from which the biomass was obtained, the method of forest management, the degree of biomass processing and the distance over which it is shipped.

It is not true that, due to continuous carbon sequestration of growing trees, burning forest biomass results in zero net emissions already at the time of combustion (the so-called landscape scale effect), because the total anthropogenic greenhouse gas emissions are several times greater than the carbon sequestration capacity

of the world's forests. Harvesting forest biomass reduces CO_2 absorption from forests and thus increases net anthropogenic emissions. Emissions from forest biomass combustion can not be considered on a scale other than global. Greenhouse gas emissions and removals, although local in their nature, occur within a globally interconnected system of the atmosphere, biosphere and hydrosphere, and not in isolated, regional subsystems.

The often proposed "refreshing of carbon reservoirs" of forests by felling trees in order to increase carbon removals is not a viable solution, especially if it affected natural forests and old-growth forests, which are key for biodiversity conservation.

In the the timescale relevant to fighting climate change, combustion of forest biomass is more emission-intensive even than burning fossil fuels.

Burning of wood in the energy sector should not be treated as neutral or climate-friendly in the present situation, and should no longer be promoted as a tool to reduce CO_2 emissions. Forest biomass will only become a climate-neutral energy source when the total anthropogenic greenhouse gas emissions will fall below the the capacity of GHGs absorption of the Earth's forests.

The greatest potential of forests to mitigate climate change, while being one of the cheapest solutions and not requiring many years of building extensive infrastructure, lies in halting deforestation (in particular in South America and Southeast Asia), reforestation, forest restoration and changing forest management practices in order to increase the amount of carbon absorbed by commercially managed forests, including by increasing their deadwood stocks.

Policy recommendations

Primary forest biomass should be removed from the list of fuels qualified as renewable energy sources under the RED Directive. Energy generated from primary forest biomass should not be included in the renewable energy targets of the European Union and particular member states. Forest biomass should also no longer be considered as a zero-emission fuel in the EU Emissions Trading System (EU ETS).

All direct and indirect subsidies for the combustion (and co-combustion with other fuels) of primary forest biomass in electricity and commercial heating should be stopped. Funds allocated to forest bioenergy should be redirected to support energy efficiency and trully low-carbon energy sources (i.e. wind, solar and geothermal energy). Combustion and co-incineration of forest biomass for the sole purpose of producing electricity should be stopped, and new power plants powered by forest biomass should not be built due to their low energy efficiency and high GHG emissions.

The monitoring system of the harvest and use of forest biomass for energy production should be

strengthened. Detailed data on the total amount of woody biomass used for energy production should be collected, broken down to primary forest biomass and other types of woody biomass. The sources of woody biomass used for energy production should also be monitored (e.g. forestry, green areas management, agriculture, wood processing, post-consumer wood). The amount and place of origin of domestic forest biomass intended for energy production should be recorded in detail.

The definitions of primary forest biomass and secondary forest biomass should be included in the RES Act so that public institutions collecting data on bioenergy can distinguish primary forest biomass from other types of biomass.

Any type of timber extracted from forests that is for energy production – not just residential fuelwood – should be counted as 'wood for energy' purposes in the LULUCF forestry sector. Thanks to this, it will be possible to more effectively control logging related CO_2 emissions from the forestry sector, as well as ensure that Polish forests remain a net carbon sink and rebuild carbon reservoirs depleted by intensive forest management.

Poland must implement the EU RED II directive into national law. So far (since 2018), the provisions of this directive have not been transposed into Polish law, e.g. with regard to the sustainability criteria for forest biomass intended for energy production. Polish regulations are still based on the provisions of the previous RED directive of 2009, which to a lesser extent protect forests against the negative effects of using forest biomass for energy production.

Forest biomass in the bioeconomy

The bioeconomy is one of the key elements of the **European Green Deal**, being a part of the economy based on raw materials obtained from living organisms. It includes agriculture, forestry, fisheries, aquaculture and municipal waste. It is thanks to bioeconomy that, among other things, the EU has plans to become independent of fossil fuels and mineral resources and build a modern zero-carbon **circular economy based on the cascading management of raw materials.**[1]

Bioenergy production is currently the smallest part of the bioeconomy, which is not to say that it is the least important.[2] Bioenergy is energy produced with the use of living organisms, their residues or metabolic products, in the process of burning biomass, biofuels and

1 European Commission, How the Bioeconomy contributes to the European Green Deal, November 2020

2 European Commission, A new bioeconomy strategy for a sustainable Europe, 2018.

BIOECONOMY → p. 105

EUROPEAN GREEN DEAL → p. 107

CIRCULAR ECONOMY → p. 105

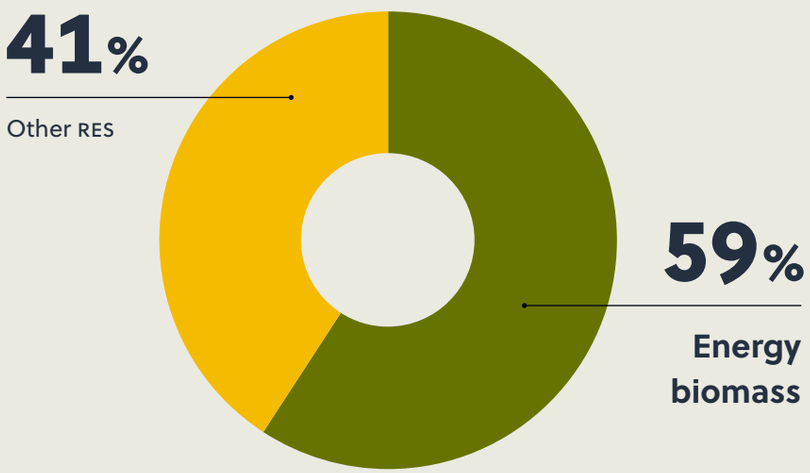
CASCADE MANAGEMENT → p. 105

BIOENERGY → p. 105

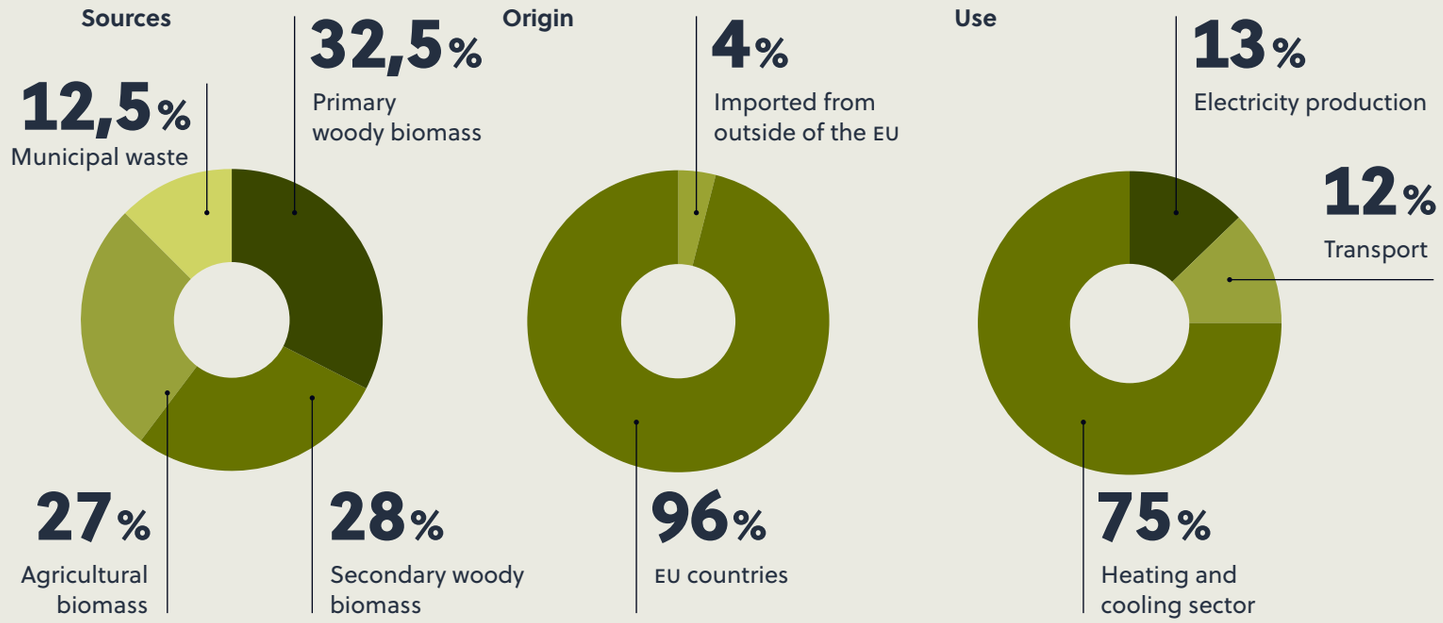
biogas. Biomass is organic matter in solid form, biofuels in liquid form and biogas in gaseous form. Today, bioenergy is the main source of **primary renewable energy** in the EU. About 60% of renewable energy sources (RES) in Europe is biomass, of which 60% comes from forestry and the wood processing industry. 32.5% of bioenergy is wood and forestry residues from forestry operations, harvested directly from forests for energy production. 96% of energy biomass comes from the EU countries and only 4% is imported. 75% of bioenergy is used in the heating and cooling sector. One of the fastest-growing consumers of forest biomass is the municipal heating sector. Also, in many member states individual households are a significant consumer of forest biomass in

PRIMARY RENEWABLE ENERGY – energy contained in renewable energy sources that has not been converted into usable energy → p. 109

The share of biomass and wood in the use of energy from renewable energy sources, EU (2016)



Energy biomass



FIREWOOD – a type of low-quality wood harvested from forests for direct burning. It can also be used to produce energy biomass → p. 107

BRIQUETTE – fuel in the form of compressed sawdust cubes. This is a household substitute for firewood (*wood briquette*) → p. 105

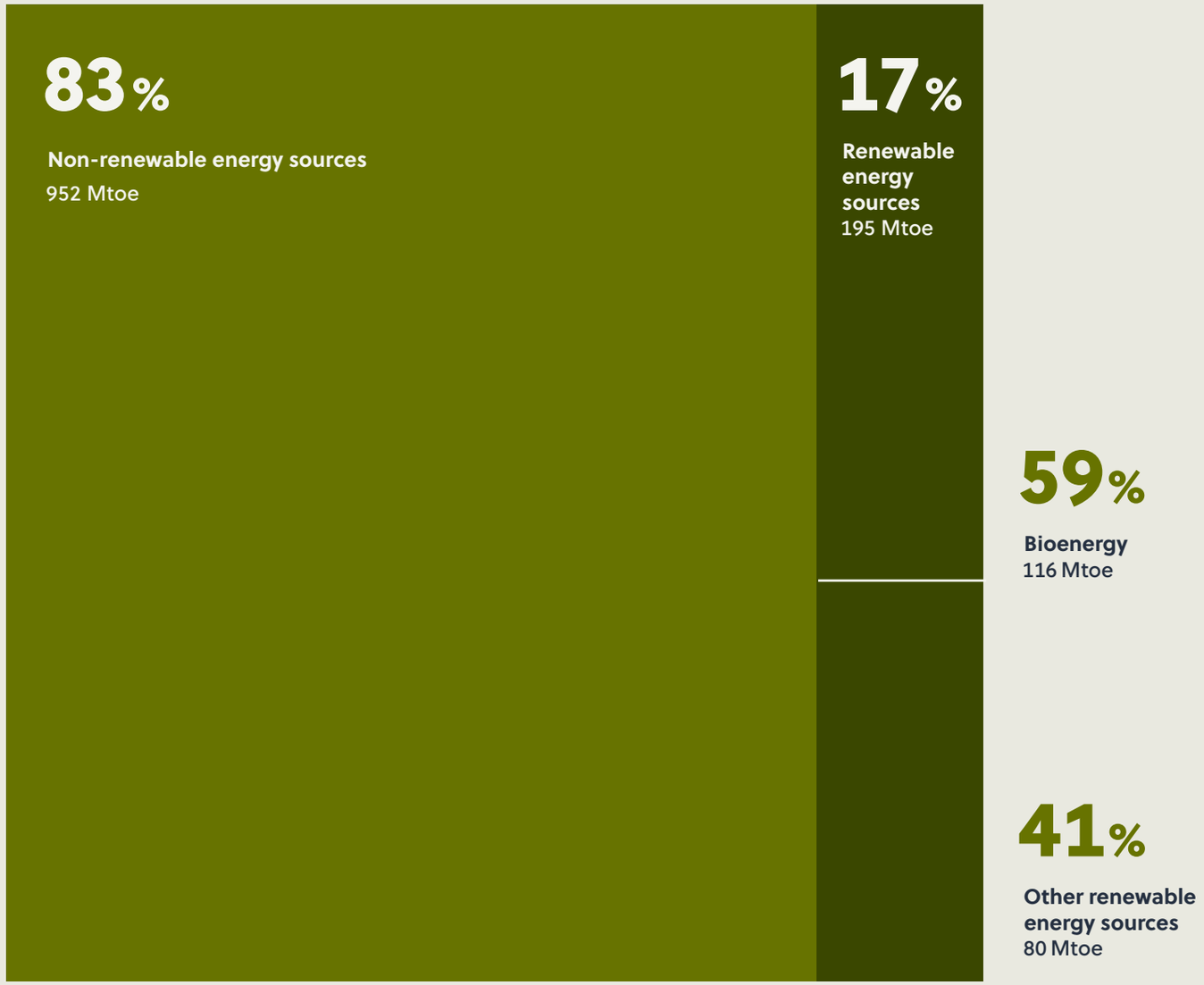
WOOD PELLETS – solid fuel in the form of shredded woody biomass compressed into granules. Wood pellets are used in many power generation facilities (e.g., in power and heating plants) and in individual households → p. 110

the form of firewood, briquette and wood pellet. In some countries, wood is the largest source of primary renewable energy.[3] As defined by the European Union, biomass is "a biodegradable fraction of products, waste and residues of biological origin from agriculture (including vegetal and animal substances), forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste".[4] In the European Union, biomass primarily consists of wood and residues from wood processing,

3 European Commission, A brief on biomass for energy in the European Union, 2019.

4 Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market

The share of individual sources in the total use of primary energy in the EU, 2016



energy crops, paper industry waste, municipal waste, sewage sludge, and agricultural biomass (e.g., straw and animal manure). Any type of organic matter that can be burned or is suitable for biofuel production can be considered biomass. Forest biomass is derived from wood and woody residues harvested in forestry and also from wood processing industries. Biomass has characteristics similar to fossil fuels as it is a form of chemical energy contained in organic matter. Its burning generates high-temperature heat, it is easy to store and transport, and it can provide energy at practically any time. It can also be used to produce solid and liquid fuels. Therefore, according to the **International Energy Agency (IEA)**, biomass should be used where other renewable energy sources (e.g. wind turbines, PV) and nuclear energy cannot be applied, e.g. in heavy industry, the chemical industry, agriculture and aviation.[5] Biomass is used to produce **biomaterials** that can replace plastics and mineral raw materials.

As biomass comes from plants that continually bind atmospheric carbon dioxide, it has been recognized that replacing fossil fuels with it could help reduce anthropogenic greenhouse gas emissions. In 2000, according to the state of scientific knowledge at the time, it was considered a **climate-neutral energy source**[6] by the Intergovernmental Panel on Climate Change (IPCC), which argued that biomass would bring quick and cheap **mitigation benefits**, because as a coal replacement it did not require new infrastructure or technological base that would take several decades to build, and all emissions from its burning would be absorbed by regrowing plants. In accordance with IPCC recommendations, the European Union included biomass in the list of zero-emission RES. This allowed the owners of energy and industrial installations to be exempted from the obligation to buy CO_2 emission permits within the **ETS system**, provided that they began burning **woody biomass** instead of fossil fuels. The coal-based power and heat industry, unable to compete with RES when it came to pricing, began switching to burning biomass. This led to a boom in the use of biomass, and an increase in bioenergy consumption in the EU of 100% in the period 2000-2017, from 60 **Mtoe** (million tonnes of oil equivalent) to 120 Mtoe per year, and in 2020, according to Europe 2020, it was expected to be 140 Mtoe.[7] This is only a little less than the total EU annual consumption of hard coal and lignite combined (169 Mtoe in 2019[8]).

5 International Energy Agency, Net Zero by 2050: A Roadmap to the Global Energy Sector, Paris, 2021.

6 Intergovernmental Panel on Climate Change, The Fifth Assessment Report of the IPCC, Chapter 11 Agriculture, Forestry and Other Land Use, pp. 811-922, 2014.

7 Bioenergy Europe, *Bioenergy Europe Statistical Report 2018*, https://bit.ly/3jQ1ga3

8 Eurostat, https://bit.ly/3GwpZsh

INTERNATIONAL ENERGY AGENCY (IEA) → p. 108

BIOMATERIALS → p. 105

CLIMATE-NEUTRAL ENERGY SOURCE → p. 106

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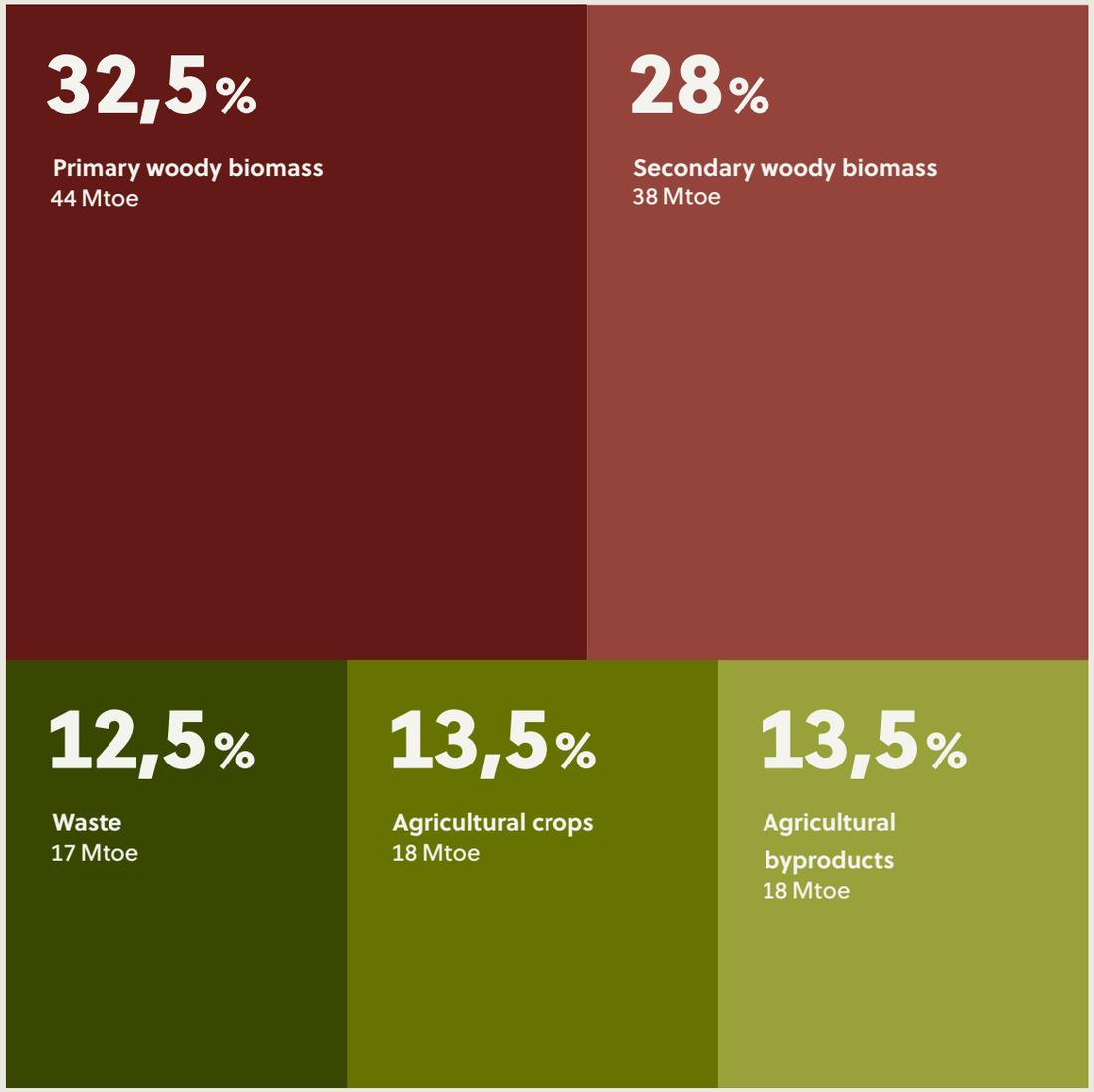
EU ETS SYSTEM → p. 106

WOODY BIOMASS → p. 110

MTOE (MILLION TON OF OIL EQUIVALENT) → p. 108

The share of woody biomass in EU bioenergy production in 2016



Moreover, government subsidies for bioenergy investments, intended to support the proportion of RES in the **energy mix**, began to flow. In 2020, the subsidies for bioenergy in the EU amounted to Euro 16 bn.[9]

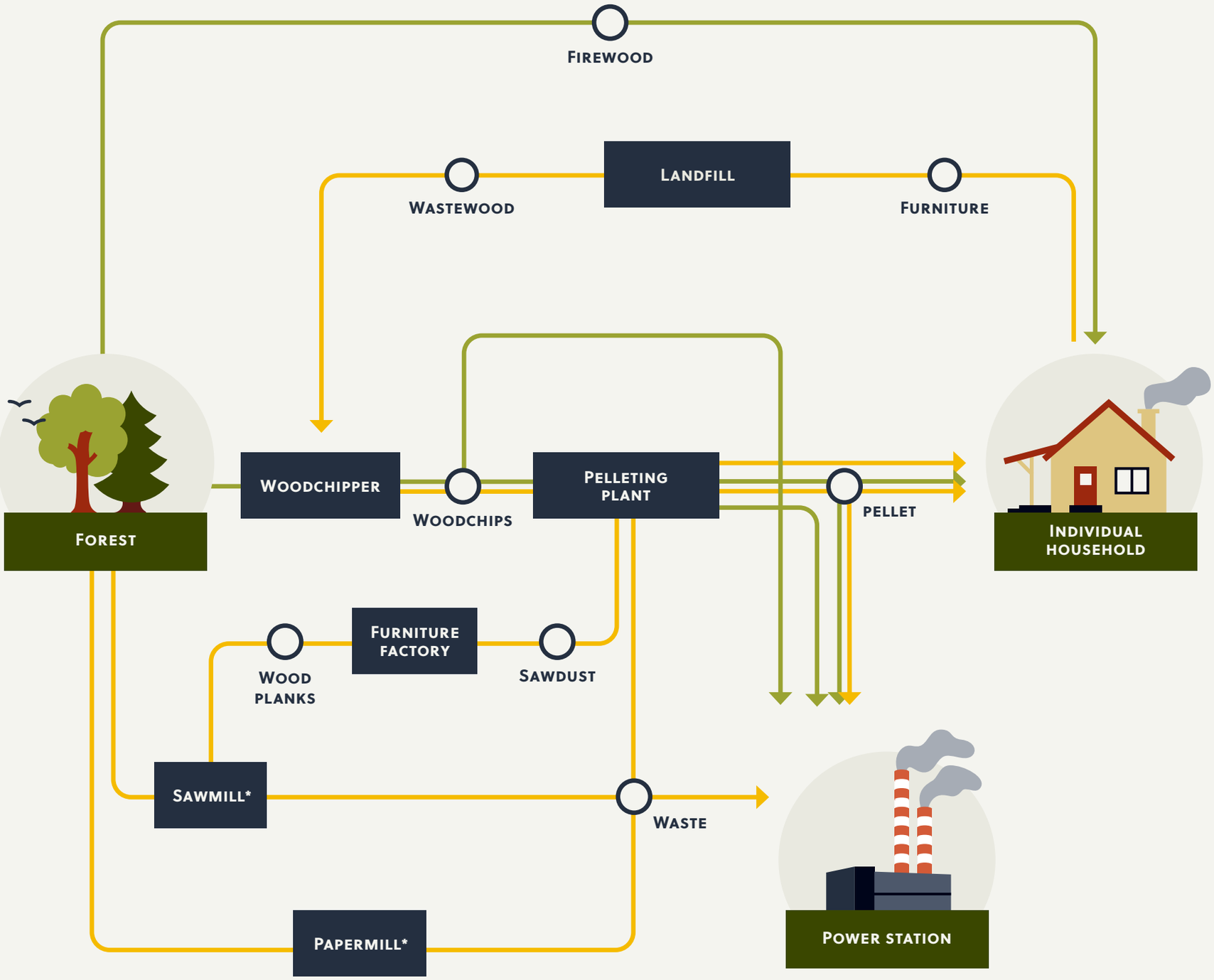
Meanwhile, current scientific knowledge shows clear threats to nature, the environment and humans associated with the extraction of forest biomass and its use in the energy sector.

The claim that forest biomass is a climate-neutral fuel has also been challenged. In fact, greenhouse gas emissions per unit of energy produced are higher than in the case of burning fossil fuels, and the absorption of an equivalent amount of CO_2 by regrowing trees is spread over many decades. In the current climate emergency, which requires rapid and drastic reductions in greenhouse gas emissions, burning forest biomass proves to be even more harmful than burning fossil fuels.

9 European Commission, Directorate-General for Energy, Lee, L., Rademaekers, K., Bovy, P. et al., Study on energy subsidies and other government interventions in the European Union: final report, Publications Office, 2021, https://data.europa.eu/doi/10.2833/513628

ENERGY MIX – a summary of the energy sources present in a country or group of countries, showing the proportion of each source in the total energy production
→ p. 106

Forest biomass pathway from its source to conversion to energy



The source of forest biomass both primary and secondary, is the forest. The difference between the two types becomes apparent in the main purpose of the felled forest trees. In the case of primary biomass, the main purpose is to produce energy, so after harvesting, the wood goes directly to burning or is processed into products to be burned. In the case of secondary biomass, the main purpose is manufacturing products. The waste generated in the production process and used-up products are burned.

The path of primary woody biomass

The path of secondary woody biomass

Biomass form

Biomass processing and storage sites

* Most of the biomass being waste from wood processing, is burned on the spot.

1

PART I

The environmental impact of forest biomass production and harvesting

01 Nature

Biomass harvesting and nature

The extraction of primary forest biomass is not indifferent to nature. By disturbing the integrity of forest ecosystems, it negatively affects their biodiversity and, in most cases, leads to their degradation. It also intensifies the pressure that forest management exerts on the forest ecosystem. For the purposes of biomass production, dead wood and forestry residues are also removed from the forest areas, which are not only important but also necessary elements of the ecosystems, ensuring their high biodiversity.

In this way, the production of forest biomass can lead to the transformation of natural forests into monocultures of industrial trees (often invasive plants), which are habitats even poorer than the traditional forests intended for timber production. Also, afforestation for biomass purposes may lead to the transformation of valuable non-forest ecosystems into homogeneous plantations, with the effect of destroying habitats of many species.

The condition of an ecosystem can be described in many different terms – among the most commonly used concepts are 'biodiversity' and 'ecological integrity'. Ecological integrity is the ability of an ecosystem to maintain functional ecological processes and sustain diverse species composition. It can be broadly defined as the ability of an ecosystem to resist change.[10]

The biodiversity of an ecosystem is often regarded to be a primary measure of the condition the ecosystem is in, even though speaking about this only in terms of numbers of species rather than of an overall ecological condition of a system is a major oversimplification. For example, deserts show little biodiversity, but are integral ecosystems that are well resistant to disruptions. Increasing numbers of species may be a sign of a presence of strong stressors, the emergence of disruptions, and mark a loss of integrity, being more of a warning sign of something undesirable actually happening. A commercial forest may, periodically and on a certain scale, be characterized by a higher number of species than a natural forest. As a result of logging and higher availability of light, forest management creates new ecological niches that are inhabited by non-forest species. Such an increase, however, should be treated as an interfering presence.

Also, although it is true to say that the entry of invasive species to an ecosystem increases the initial number of species , it threatens the system's ability to remain in good condition.

Despite the various imperfections, biodiversity is a good indicator and a useful tool allowing to evaluate the condition of ecosystems, particularly because modern anthropogenic areas show very low levels of it. A monoculture of **industrial trees** or intensively cultivated agricultural land are significantly less biodiverse than a natural forest or even a species-diverse commercial forest. In this light, an increase in biodiversity indicates a positive change towards more natural forest ecosystems.

In our report, biodiversity is treated as an indicator that allows for an assessment of the impact of forest biomass **production** and harvesting on forest ecosystems.

CARBON POOL are reservoirs of carbon that have the capacity to both take in and release carbon → p. 105

NATURAL FOREST – a forest formed without human intervention and lasting as a result of natural processes: renewal, maturation, ageing and decay. In this type of forest human interference shall be limited → p. 108

INDUSTRIAL TREES – a species of fast-growing trees whose wood has characteristics that are valuable to the wood processing industry → p. 107

10 Karr, J. R., *Defining and assessing ecological integrity: Beyond water quality,* Environmental Toxicology and Chemistry 12, 1521-1531, 1993.

Biomass production and forest ecosystems

The production of primary forest biomass has a direct impact on nature as a result of harvesting wood material from forests, the conversion of forests to produce this type of biomass, and the **deforestation** and **afforestation** of land for biomass production purposes. Intensive, unsustainable logging leads to the degradation of forest ecosystems, deforestation and a decline in biodiversity.[11] **According to the European Environment Agency, forest management is the biggest threat to Natura 2000 forest habitats in Poland, and it equally threatens certain groups of forest species on the European scale.[12]** Increased demand for wood, associated with the growing needs of the energy sector and higher consumption of wood pellets in households may lead to the further intensification of forest management, and thus to an escalation of its negative impact on forest ecosystems. The additional risks associated with the harvesting of forest biomass depend on the kind of raw material that is harvested for biomass purposes and whether forest management (silviculture) does move towards producing a stand that is optimal for bioenergy production at the expense of biodiversity.

Notably, the purpose of wood harvesting itself does not impact forest ecosystems. What matters is the kind of material that is being harvested, its quantity, the methods being used and the frequency of operations.[13] The current EU subsidies and programmes that promote the use of forest biomass encourage the removal of all burnable wood and tree debris from the forests. This poses a serious threat to organisms that depend on the presence of decaying wood in them, including many rare and endangered species.

DEFORESTATION – a permanent conversion of forest to non-forest land → p. 106

AFFORESTATION – a permanent conversion of non-forest land to forest through the intentional planting of trees → p. 105

SILVICULTURE is the set of activities carried out within the framework of forest management on forest land (or land temporarily deprived of vegetation) in order to plant a new forest. Silviculture includes growing trees in nurseries, transplanting them to their final location and caring for young trees → p. 109

11 FAO and UNEP, The State of World's Forests 2020, FAO and UNEP, 2020.

12 European Environment Agency, State of nature in Europe health check https://bit.ly/3BoJmQY

13 Camia A. et al., *The use of woody biomass for energy production in the EU*, Joint Research Committee for Science Policy Report, 2021.

20–40%

forest species require decaying wood at some stage of their life cycle.

The role of dead wood in the ecosystem

Wood with low economic value is often used for energy purposes. It is the so-called dead wood, consisting in tree debris and standing dead trees, which decompose naturally. Even though this type of wood is useless for the wood processing industry, it plays a crucial role in the forest ecosystem. This means that an increased demand for forest biomass leading to an even stronger trend towards the removal of all dead wood from forests, and the overall deterioration of its condition, poses a serious threat.

In fact, it is the dead standing trees and decaying wood that largely determine the degree of biodiversity in a forest. 20-40% of forest species require the presence of decaying wood at some stage of their life cycle. dead wood supplies nutrients to the forest ecosystem and creates new ecological niches.[14] Species inhabiting and feeding on dead trees have different requirements as to the degree of wood decomposition. For the proper functioning of the forest ecosystem, the presence of decaying wood of various size (especially large-size wood) and in various stages of decomposition, including standing dead trees, is crucial. The presence of decaying wood supports the growth of a large number of species of fungi, which are to a large extent responsible for the natural richness of old forests. Decomposing fungi ensure the circulation of matter and energy in the forest ecosystem. A complementary role in this process is played by mites and insects, including saproxylic beetles. Because intensive forest management removes most of the decaying wood from the forest in a short period of time, many saproxylic species are threatened with extinction. In Central Europe, the number of species of saproxylic beetles exceeds 1500, and in Poland the figure is 1300 species in approximately 70 families.[15] These include, among others, Schneider's beetle (***Boros schneideri***), flat bark beetle (***Cucujus cinnaberinus***), ***Rhysodes sulcatus***, and the hermit beetle (***Osmoderma eremita***),[16] which are all strictly protected in Poland, including in

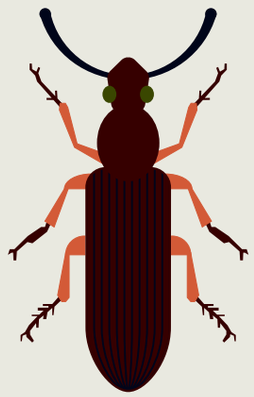
DEAD WOOD –remains of dead or felled trees left in the forest, together with standing dead trees. The term covers all types of tree debris, from trunks to branches, stumps and small twigs. Dead wood plays a crucial role in the forest ecosystem and its amount affects the biodiversity of the forest → p. 106

14 Bauhus, Jürgen & Baber, Kristin & Müller, Jörg. (2018). ***Dead Wood in Forest Ecosystems***. 10.1093/obo/9780199830060-0196.

15 Gutowski J. M. (eds.), Bobiec A., Pawlaczyk P., Zub K., ***Drugie życie drzewa*** [The second life of a tree], 2004.

16 General Directorate for Environmental Protection, https://bit.ly/30xYGY5, https://bit.ly/2YimYuB, https://bit.ly/2ZRHzWN

Saproxylic beetles are strictly protected in Poland.



Boros schneideri

Cucujus cinnaberinus

Osmoderma eremita

Rhysodes sulcatus

the Natura 2000 protected areas. The most endangered species inhabit wood that is advanced in decomposition (has aged for even several decades), which is very rarely found in commercial forests.[17] Numerous saproxylic species enrich the forest ecosystem by creating an extensive feeding base for others. Many birds, including woodpeckers, feed on insects and their larvae that live in wood. The three-toed woodpecker (***Picoides tridactylus***), strictly protected under the Birds and Habitats Directive , needs a large number of standing dead and dying spruce trees, because it is unable to feed or nest in living, healthy trees. Its presence in a forest indicates a high proportion of old-growth trees, as it is the removal of dead trees that leads to the destruction of its habitat and feeding base, and is therefore identified as a major threat to its survival.[18] Other species may be indirectly associated with dead trees, but are dependent on them. The hollows created by woodpeckers provide nesting for a large number of bird species (including the ***Glaucidium passerinum*** owl) and shelter many mammals and other animals. A landscape rich in fallen trees is also preferred by lynx, which hunt their prey by ambushing on logs and blowdowns. Wolves also prefer forests with trees lying on the ground as they create barriers that make the escape of their prey more difficult.

Decaying wood is a source of organic carbon and minerals. Forests, in contrast to agricultural land, are not fertilized. Intensive removal of residues from forest

SAPROXYLIC SPECIES – pecies that feed on or live in dead wood. The species that need dead wood to live are called *saproxylobionts*, and those that prefer dead wood are *saproxylic* species → p. 109

17 Gutowski et al., ***Drugie życie drzewa*** [The Second Life of a tree], WWF Poland, 2004.

18 General Directorate for Environmental Protection, https://bit.ly/3ovadaJ

AMOUNT OF DEAD WOOD is given in cubic metres per hectare [m³/ha] or tonnes per hectare [t/ha] → p. 105

FOREST RESIDUE – minor residues from forestry operations which are not a full-value raw material but have calorific value. These are branches, small branches, bark, stumps and pieces of larger logs. However, this term is not entirely identical to "logging waste" in the Polish terminology → p. 107

JRC Joint Research Centre, one of the Directorates-General of the European Commission; it aims to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. → p. 108

operations can have a negative impact on the availability of mineral nutrients and cause a decrease in organic carbon in the soil, which threatens the productivity of the forest.[19] The **amount of dead wood** has been adopted by the EU as a key indicator of the biodiversity of forest ecosystem. The European Environment Agency estimates that its levels are currently too low in European forests and need to increase, which is one of the important goals of the EU Biodiversity Strategy 2030. Monitoring of the amount of dead wood is also supposed to be the method for controlling whether or not the EU's developing bioeconomy, based to a large extent on wood, will harm the nature of our forests.[20] In this respect, Poland's situation compared to other Member States is negative because the amount of dead wood in the forests is half of the European average and should definitely increase.[21]

19 Federer A. et al., *Long term depletion of calcium and other nutrients in eastern US forests*, Environmental Management issue pp13,. 593-601, 1989.
20 European Commission CORDIS, Spotting dead wood: Measuring forest biodiversity for the bioeconomy, https://bit.ly/3iAVSWj
21 European Environment Agency, Forest: dead wood Assessment, https://bit.ly/3ixAqBM

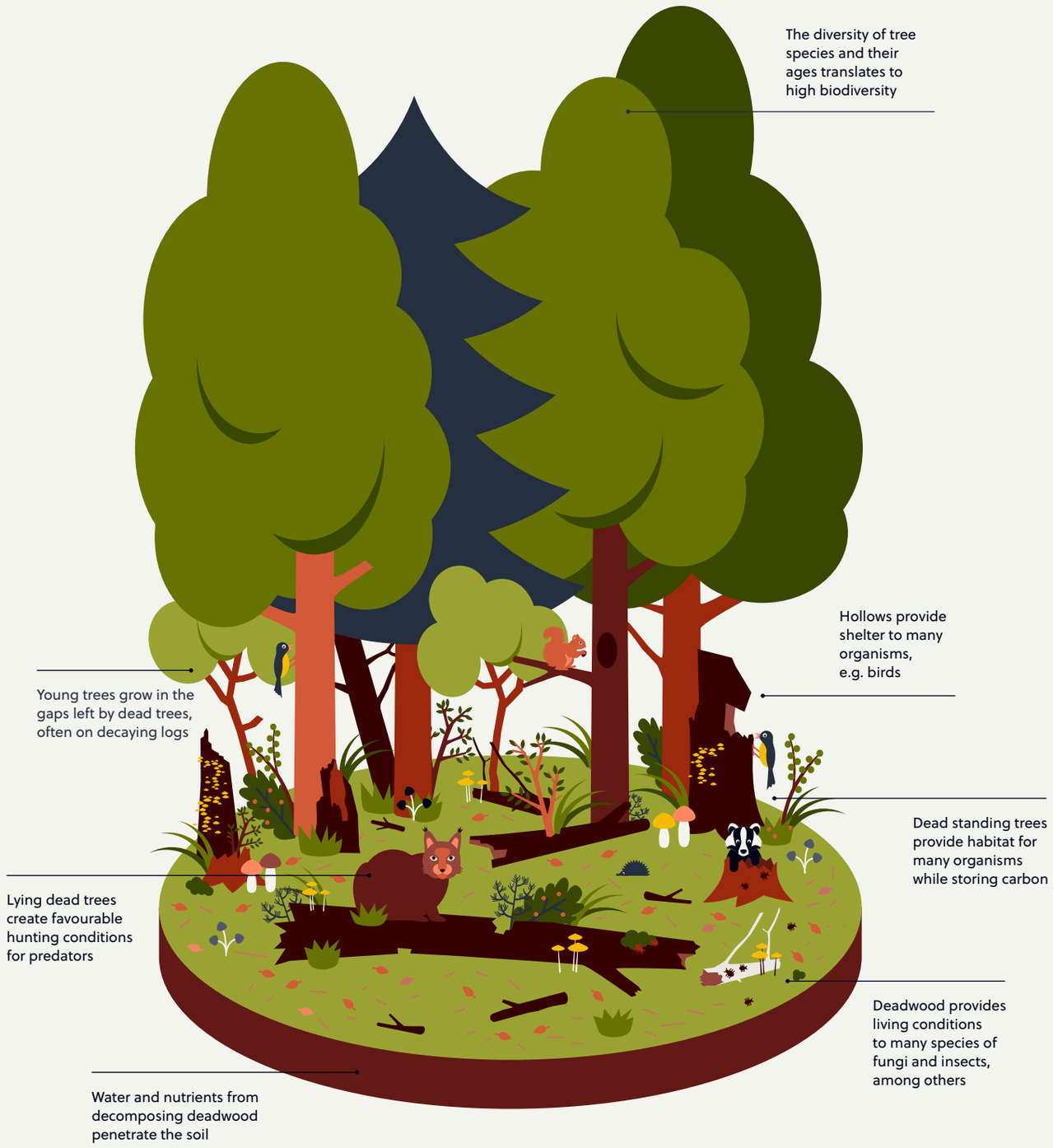
Impact of forest residue removal on biodiversity

The forest biomass used in the energy sector is often waste from forestry operations (**forest residues**).[22] While wood debris that is unsuitable for sawmills is promoted as a source of nature-safe primary biomass, current scientific knowledge shows that its removal from forests has a negative impact on the ecosystem. A report by the European Commission's Joint Research Centre (JRC) on the use of woody biomass for energy purposes in the EU identifies the removal of woody debris left after forestry operations as one of the biggest threats to forest biodiversity.[23] The authors of this report analysed nine scenarios of harvesting different types of forest residues in terms of their impact on forest biodiversity, taking into account the type of woody debris (coarse, fine and stumps), its source (coniferous or deciduous trees), and whether they are removed in amounts greater than the level considered safe for forest biodiversity (40% for fine debris and 15% for low stumps).

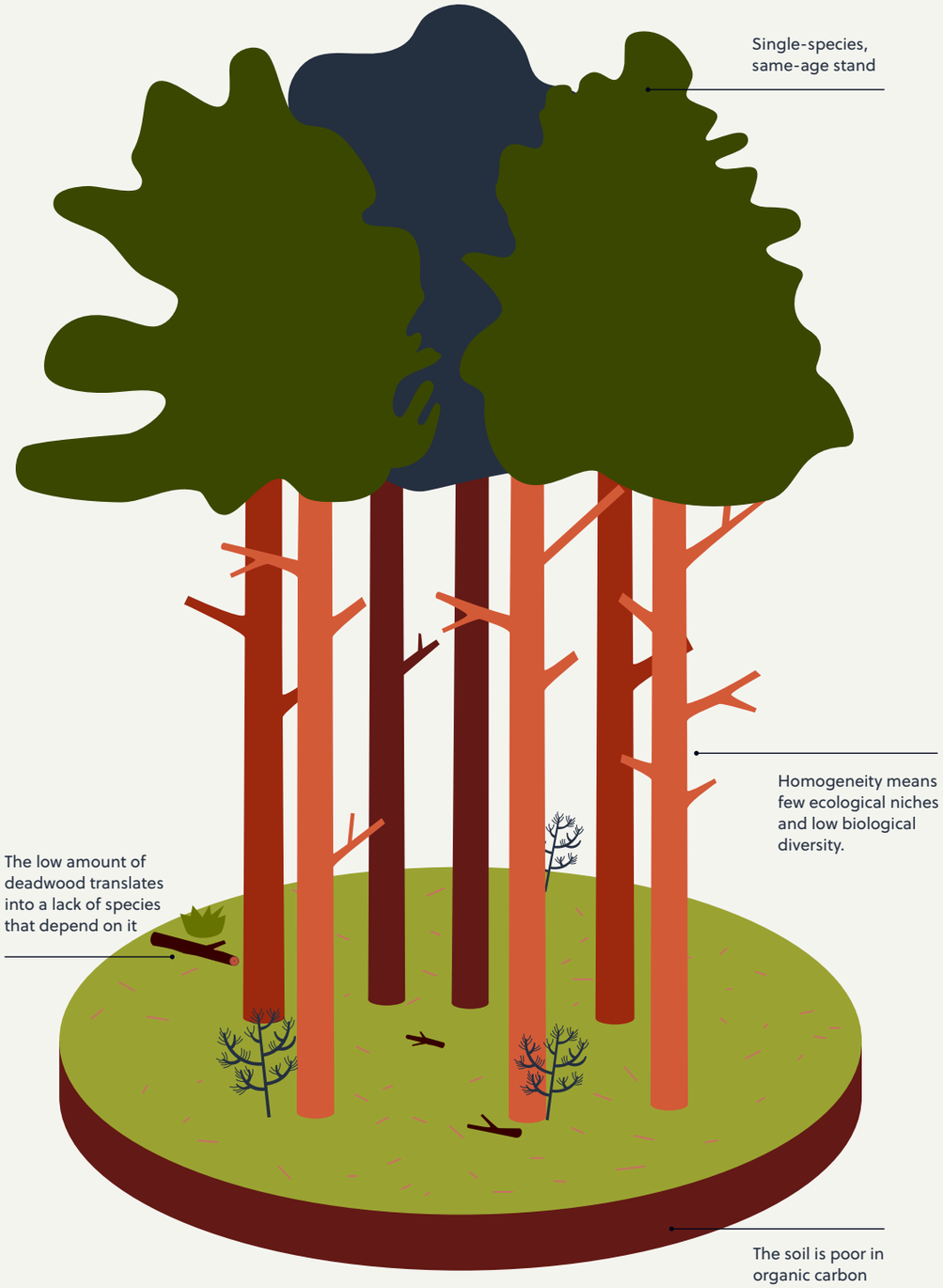
The **JRC** report concludes that the removal of woody debris from the forest has most often a negative, rarely neutral, and most rarely positive impact on biodiversity. According to the authors of this report, the removal

22 Elżbieta Kloc, *Tematyczny słownik leśny* [The dictionary of forest terms], Centrum Informacyjne Lasów Państwowych, 2015.
23 Camia A. et al, *The use of woody biomass for energy production in the EU*, Joint Research Committee for Science Policy Report, 2021

Natural forest



Commercial forest



of **coarse woody debris** and tree stumps significantly reduces the amount of decaying wood in a forest, negatively affecting its biodiversity and destroying important habitats for protected species. The removal of fine woody debris from deciduous trees is also a threat to forest ecosystems.

The JRC report also suggests that the only scenario with a neutral impact on the forest ecosystem is a removal of fine residues from conifers up to the threshold of 40%. Researchers recommend leaving all of the coarse forest debris, snags and over half of the fine debris on site, whereas in reality it is not uncommon to see a complete clearing of the forest floor off all post-operational left-overs, or tree stumps, which is unacceptable from the point of view of biodiversity.

Effects of wood removal after large-scale disturbance to the forest ecosystem

Another issue is the removal of trees damaged by natural disasters or infestations from the forest area, which according to Polish legislation can be considered to be **'energy wood'**, i.e. implicitly a source of renewable energy.[24] The amendments to the definition of 'energy wood' in the Renewable Energy Sources Act, introduced in 2020, were justified by the Ministry of Climate and Environment and the State Forests as aiming to ensure that the growing number of damaged trees would provide enough climate-neutral fuel. Harvesting wood for bioenergy purposes after large-scale forest disturbances is also a common practice in other European countries, according to the JRC report.

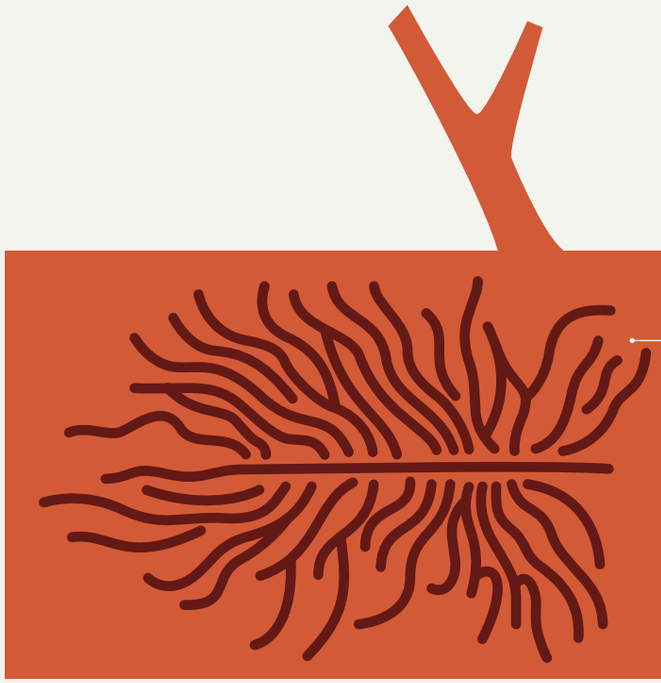
The frequency of extreme weather-related events increases as the climate changes. Warmer temperatures and water shortages are the factors favouring, among other things, the infestation of the bark beetle (***Ips typographus***) that feeds on the bark of spruce trees (***Picea abies***) so eagerly planted in large monocultures by foresters in the mountains, as well as the sharp-toothed bark beetle (***Ips acuminatus***), which feeds on the common pine (***Pinus sylvestris***), which is the most abundant tree species in the Polish forests.

24 Renewable Energy Sources Act of 20 February 2015.

LARGE-SIZE WOOD – wood with a minimum top diameter without bark of at least 14 cm. This includes primarily trunks, logs and boughs → p. 108

ENERGY WOOD – wood for energy production from forestry, agriculture and other sources → p. 106

LARGE-SCALE FOREST STAND DAMAGE – damage to forest stands over a large area caused by natural or anthropogenic factors. This may be, for example, damage to trees on many thousands of hectares caused by wind or damage to the assimilative apparatus of trees over a large area caused by air pollution → p. 108

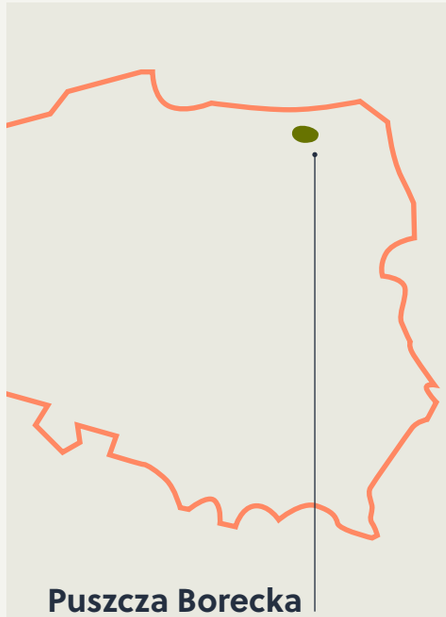


The destruction of the whole swathes of trees by the bark beetle need not jeopardise forest biodiversity; it can even benefit the forest, if the damaged trees are left in place, allowing it to regenerate itself.

As a result of weather phenomena and insect infestations, large-scale damage to tree stands occurs with growing frequency. A good example is the storm that passed over the ***Bory Tucholskie*** forest on 11/12 August 2017. The State Forests Authority estimated that as a consequence almost 10 million m^3 of trees on an area of 120,000 ha were damaged, defining this event as the biggest disaster in the history of Polish forestry.[25] From the economic perspective, broken and fallen trees constitute raw timber of lower quality, often of no use to sawmills, but suitable for energy production. Their removal makes economic sense, but from the point of view of nature conservation it is undesirable. It may seem that for the forest ecosystem, the blowing down the whole areas of trees or a bark beetle infestation is as catastrophic as it is for forestry, but many examples globally demonstrate that catastrophic events do not threaten forest biodiversity, and can even be beneficial if the damaged trees are left in place, while allowing the forest to regenerate itself. Therefore in order to preserve biodiversity, at least some of the damaged trees should be left in place, including those in commercial forests. In areas that are protected and those excluded from forest management, all damaged trees should be left behind, because from the point of view of forest ecology a natural disaster or infestation are completely natural, cyclic phenomena which do not threaten the survival of the forest itself.[26] Natural disasters and insect outbreaks provide the forest ecosystem with large amounts of large-size dead wood and standing dead trees, which are crucial to the survival of a number of endangered species. A landscape of dead trees creates ecological niches that most commercial forests lack. Leaving dead trees in place after a disturbance also supports the forest regeneration process. Decaying wood provides nutrients and good soil for new seedlings and improves water retention. What is more, fallen trees create a physical barrier for herbivores that feed on seedlings and young trees, increasing their survival rate and accelerating their growth. The ability of a forest to regenerate in the aftermath of the European spruce bark beetle infestation is well evidenced by the example of the Bavarian Forest

25 11 July 2019, State Forests, The Greatest Cataclysm in the History of the State Forests, https://bit.ly/3FgEoID

26 Thorn S. et al, ***Estimating retention benchmarks for salvage logging to protect biodiversity***, Nature Communication 11, 2020



Puszcza Borecka

170 yr.

This is how long the forest ecosystem of Puszcza Borecka needed to regenerate itself after an infestation of bark beetle that caused massive damage to the commercial forest once planted in its place. The dead trees were not removed, and, as a reult, in place of the monoculture of commercial forest, a multi-species, rich ecosystem was spontaneously revived.

National Park in Germany, where 55% of the area was excluded from active protection, giving the forest a chance for spontaneous reforestation.[27]

An example of a spontaneous forest renewal in Poland is the Puszcza Borecka forest in the north of the country. 170 years ago an infestation of nun moth (***Lemantria monacha***) caused massive damage to the commercial forests that used to grow on the same site.[28] The losses were significant because it affected the single-species spruce forests planted by the Prussian foresters at the time. The dead trees were not removed due to lack of technical means and, as a result, in place of the monocultural commercial forest a multi-species rich forest ecosystem spontaneously revived, showing many features of a natural forest. Today the ***Puszcza Borecka*** forest, being a refuge for many endangered species of fungi, insects, birds, lichens, bryophytes and others[29], is one of the most precious forests on Poland's territory in terms of its natural value.

27 Jakoniuk H., ***Consequences of the hailstorm Ips typographus (L.) in the Czech and German national parks Šumava and Bavarian Forest***, Studia i Materiały Centrum Edukacji Przyrodniczo Leśnej 18, |1[46], 2016.

28 Draft Plan of Conservation Tasks of Natura PLB2800062000 Puszcza Borecka, 2012.

29 Sikora A, Neubauer G, ***Cenne gatunki ptaków i znaczenie OSO Natura 2000, Puszcza Borecka*** [Valuable bird species and the importance of the Natura 2000 Puszcza Borecka], Ornis Polonica 2016, 57: 12–28

The impact of afforestation and forest conversion to satisfy bioenergy production on nature

The world's forests are under increasing management pressure as more and more wood is being harvested. As forest bioenergy production is expected to increase in the future, afforestation of new non-forest land is being promoted so as not to increase pressure on existing forests while meeting the growing demand for raw material. Afforestation can be either targeted (i.e. all planted trees will be harvested for forest biomass) or secondary (energy wood will come from silvicultural work, thinning and forest residue). The bioenergy industry prefers the targeted planting of fast-growing industrial trees, as they provide a more homogenous raw material of higher quality. Increasing areas of energy tree plantations can carry serious threats to nature: the conversion of natural forests to tree plantations, the spread of invasive species, and the loss of ecosystem services associated with forests.

Planting trees is generally perceived as unequivocally beneficial. Trees absorb carbon dioxide, produce oxygen, give protection to animals and are a source of wood. Massive forest planting is promoted as one of the strategies for combating the climate crisis and loss of biodiversity.[30,31]

30 UNEP, Plant for The Planet: The Billion Tree Campaign, 2008.

31 Council Decision (EU) 2016/1841 of 5 October 2016 on the conclusion, on behalf of the European Union, of the Paris Agreement under the United Nations Framework Convention on Climate Change

However, many spectacular reforestation programs have failed to achieve their intended results because they failed to consider the fact that a forest is more than just a large number of trees planted in one place, and that the success of creating new forests depends on a good understanding of the natural history of the area, its current condition, and the proper selection of planted tree species. Planting a forest which is mismatched to a habitat and too homogenous is a common mistake that leads to unsuccessful afforestation campaigns. Poor selection of planted trees for the local habitat, the impact of climate change, insect infestation and natural disasters all contribute to a complex problem, leading to so-called **forest die-offs**[32], also observed in Poland.

Many afforestation and reforestation campaigns are carried out around the world to counteract the loss of ecosystem services provided by forests and at the same time to supply wood and energy biomass.

The largest afforestation campaign in the history of the earth continues in China. Despite many successes, the programme has been accompanied by a decline in natural forest, grassland and scrub ecosystems in favour of tree plantations. Many natural forests have been converted to rubber tree and eucalyptus tree plantations. Since 1988, the reforestation program on Hainan Island has reduced the area of natural rainforest in favour of plantations by 22%, and the area of natural grassland and scrubland by 70%.[33] According to Yale School of the Environment, 82% of the promised restoration of the Amazon Rainforest in Brazil are actually monoculture plantations rather than natural forest.[34]

Unsuccessful afforestation campaigns have also taken place in Poland. After World War II many previously deforested areas were afforested with single-species forests intended to bring maximal economic benefit. Large areas of the Carpathians and Sudetes were planted with homogeneous spruce forests, excluding other native species including firs, beeches, hornbeams and sycamore maple. These monocultural spruce forests proved to be vurneable to insect infestations and climatic changes. Mass infestations by European spruce bark beetle led to the decay of mountain tree cover while the warming climate and scarcity of water mean that spruce regeneration is no longer possible in many places, and that mixed stands, which are more resistant to disturbances[35], have to be put in place.

FOREST DIE-OFF – a decline of stands caused by a number of overlapping, mutually reinforcing, factors. An example is a decline of spruce trees in the Polish mountains, caused by the combined effects of a warming climate, lack of water, and insect infestation → p. 107

32 28 June 2021, PGL Lasy Państwowe (State Forests National Forests Holding), ***Kornik ostrozębny dziesiątkuje lasy. Kolejna ciepła zima pogorszyła sytuację,*** [Ips acuminatus decimates forests. Another warm winter has made the situation worse] https://bit.ly/2ZXej14

33 2 August 2013 Finlayson Rob, ***World's largest reforestation scheme fails to protect natural forests and threatens more***, World Agroforestry Blog, https://bit.ly/2Yu6rUd

34 16 April 2019, Pearce Fred, ***Why Green Pledges Will Not Create the Natural Forests We Need***, Yale Environment 360 https://bit.ly/3FhWA4q

35 28 June 2021, PGL Lasy Państwowe, ***Pustyni nie będzie. Lasy a zmiany klimatyczne*** [There Will Be No Desert. Forests and climate change], https://bit.ly/3ozzyAq

60%

of Polish forests are covered by pine, which is currently the most common tree in the country.

INVASIVE SPECIES – plants, animals, pathogens and other organisms that are not native to ecosystems and can cause damage to the environment or the economy, or have a negative impact on human health. Invasive alien species can have a particularly negative impact on biodiversity, through population decline or elimination of native species, food competition, predation, pathogen transmission, and disruption of ecosystems → p. 108

In other parts of the country, pine has become the preferred species for afforestation. Currently, it is the most common Polish tree, occupying 60% of the country's forest area, which is mainly species-poor and of low age diversity. Although the overall forest cover in Poland has increased[36], the quality of new forests is low. Pine can withstand difficult conditions, warm temperatures and water shortages better than spruce, but its monocultures are also threatened by massive insect outbreaks.

Some popular species of industrial tree, also used for energy biomass production, have been classified as **invasive species**. The Food and Agriculture Organization of the United Nations (FAO) identifies the spread of invasive plants (as a result of changing land-use patterns) as the second most important cause of decline in global biodiversity, after habitat loss.[37] On the Iberian Peninsula, plantations of eucalyptus, classified in several countries as an invasive species, cover a larger area than natural forests, and scientific studies clearly indicate that plantations have lower biodiversity compared to forests.[38] It should be noted that new energy tree plantations are usually monocultures, more homogeneous than traditional commercial forests, as this greatly facilitates the work, reduces planting and maintenance costs and facilitates the acquisition of biomass.

In Poland plantations of black locust (***Robinia pseudoacacia***), which has been present in the country for a long time and is classified as an invasive plant, may become a threat in the future.[39] Due to the high calorific value of its wood and high biomass growth, its plantation for energy purposes is done, for example, in Germany. Currently, the issue of black locust plantations is being discussed in Poland and its potential for the production of bioenergy is being investigated by ***Instytut Badawczy Leśnictwa***

36 28 June 2021, PGL Lasy Państwowe, ***Nasze Lasy*** [Our forests], https://bit.ly/3miQf04

37 21 May 2021, FAO, https://bit.ly/3l9eEWl

38 Sandra G. et al, ***Effects of eucalyptus plantations on avian and herb species richness and composition in North-west Spain, Global Ecology and Conservation*** Issue 19, June 2019,

39 Tokarska-Guzik B., et al., ***Rośliny obcego pochodzenia w Polsce ze szczególnym uwzględnieniem gatunków inwazyjnych*** [Plants of foreign origin in Poland with particular emphasis on invasive species], Generalna Dyrekcja Ochrony Środowiska, 2012

[the Forestry Research Institute].[40,41] According to Polish law, these plantations shall be treated as agricultural land, but since they form quasi-forest ecosystems they should be mentioned in this context. Moreover, the raw material obtained from black locust will be classified as energy wood as if it were obtained from forests.

Land conversion for forest biomass production and its impact on biodiversity

The JRC report mentioned earlier indicates that converting land into forests for the production of energy biomass can have a negative impact on biodiversity. The key factors that determine the extent of these impacts are the type of forested land as well as the means of foresting and managing it. The JRC analysed 14 scenarios in which natural grassland ecosystems, pastures, meadows and agricultural land were converted into forests for the production of energy biomass, along with anthropogenic heathlands, old natural forests and naturally regenerating forests.

The JRC has demonstrated that replacing natural forests and old-growth forests with monocultures of energy trees or species-poor commercial forests is a serious threat to biodiversity, similarly to planting trees on non-forest natural or near-natural sites. For example, natural grasslands (steppes, meadows) and scrublands are extremely rich and valuable ecosystems whose characteristic biodiversity is lost if they are converted to forests.[42] Moreover, the presence of natural steppe areas is a testimony to an annual level of precipitation which is insufficient for trees, which means that any planted forest will not last long.

The JRC has demonstrated that replacing natural forests and old-growth forests with monocultures of energy trees or species-poor commercial forests is a serious threat to biodiversity.

According to the JRC, growing commercial forests for energy purposes will have a positive effect if they are planted on intensively cultivated agricultural land, preferably where a forest grew in the past. The safest solution for nature is the establishment of a mixed forest, with a species composition close to natural, **managed extensively**, created preferably as a result of spontaneous tree succession. However, even a species-poor commercial forest will be a richer ecosystem than, for example, a monoculture of cornfield. Not everywhere,

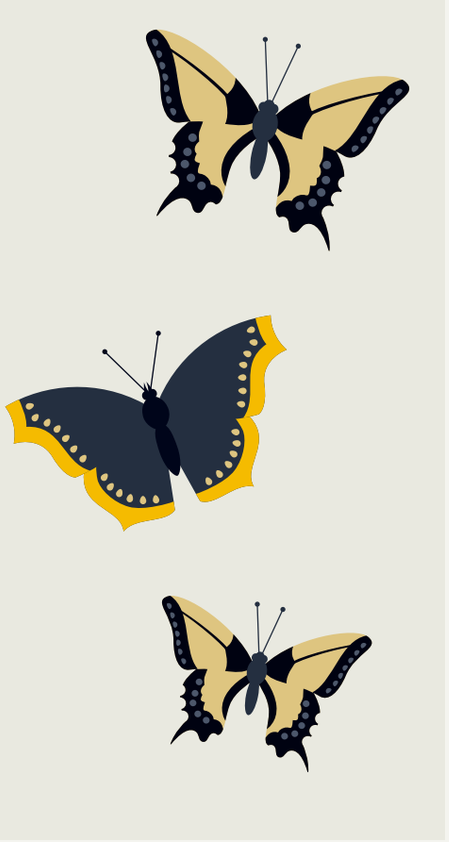
EXTENSIVE FOREST MANAGEMENT – a way of managing forests in a non-industrial, sustainable manner that does not harm the health and integrity of the ecosystem. In extensive use, only enough wood is harvested to ensure the continuity of the forest, i.e. only individual trees are felled. The forest is also harvested at appropriate intervals so as to maintain the integrity of the stand. This type of forest management does not allow clear-felling or ploughing of the forest soil → p. 107

40 Zajączkowski K., Wojda T., ***Robinia akacjowa Robinia pseudoacacia L. w gospodarczej uprawie plantacyjnej*** [Robinia pseudoacacia L. in commercial plantations], Studia i Materiały CEPL w Rogowie 135 R. 14. Zeszyt 33/4/2012

41 Klisz M., Wojda T., ***Jak wykorzystać robinię?*** [How to use Robinia?], Drwal nr 2, 2014.

42 Yang Yi et al., Soil carbon sequestration by restoring grassland biodiversity, Nature Communication, 2018. https://go.nature.com/3Db6frN

The disappearance of traditionally used meadows and pastures is the most significant factor behind the decline of butterfly species in Europe.



however, is natural regeneration an unequivocally positive phenomenon for biodiversity. The JRC points out that in Europe the greatest factor in the decline in the diversity of butterfly species is the disappearance of traditionally used meadows and grasslands, as a result of grassland being converted to other uses or being spontaneously overgrown by trees.[43, 44] In order to conserve biodiversity on a broad scale, it is important to maintain a mosaic of different ecosystems that are as close to natural as possible. Planting trees everywhere is not the best possible solution

Changes in silviculture towards biomass production – other environmental impacts

The promotion of forest biomass can lead to a shift in the direction of silviculture towards planting fast-growing and short-rotation tree species. The wood processing industry has different requirements for raw material than the bioenergy industry. Trees for planks have to grow longer than those for pellets or chips. Fast **rotation of trees** can lead to a shortage of mature, large-sized trees in commercial forests that provide natural habitat to many species, e.g. woodpeckers.

This leads to a lack of standing dead and dying trees, which play a significant role in forest ecology. Despite the threats to biodiversity posed by plantations, the cultivation of fast-growing trees is believed by many to contribute positively to the conservation of natural forests. Planted on wastelands and farmland, fast-growing trees are supposed to reduce pressure on **traditional forests** and natural forests. Tree plantations provide a large amount of raw material in a shorter period of time,

43 IPBES, 2018a. The IPBES assessment report on land degradation and restoration. Secretariat of the Intergovernmental Science-Policy Platfo rm on Biodiversity and Ecosystem Services, Bonn (Germany).

44 Bubová, T., Vrabec, V., Kulma, M., Nowicki, P., 2015. Land management impacts on European butterflies of conservation concern: a review. J. Insect Conserv. 19, 805–821. https://bit.ly/3Dab840.

FOREST ROTATION AGE – the period of time over which a stand is replaced by felling. Energy tree stands are characterised by fast rotation (e.g., 30 years), while commercial timber stands have a longer rotation period (50, 60, 70 years or more) → p. 107

TRADITIONAL FORESTS – forests providing many types of wood as raw material and services, e.g. wood for construction materials, the paper industry and firewood, but also places for recreation, hunting, and picking mushrooms or forest fruit. This is in contrast to industrial tree plantations which are grown for a single purpose – e.g., for paper or forest biomass → p. 110

giving hope for lower timber harvesting from natural forests. However, it turns out that in countries where this approach is promoted (e.g., India), total timber harvesting from all types of forests is on the increase. It is in fact hard to say to what extent non-forest tree plantations reduce pressure on traditional forests.[45] However, from the point of view of nature, the most beneficial solution is the conversion of formerly deforested or agricultural land into forest, provided that native species are planted and the forest are used extensively.

The authors of the JRC report point out that national nature conservancy policies rarely consider the possibility of leaving forests without any interference from man. Meantime, ecologists say, this could be one of the best strategies for protecting forest ecosystems.

45 Ministry of Environment and Forests, Government of India, ***National Mission for a Green India*** (Under The National Action Plan on Climate Change), New Delhi, 2010.

02

Climate

Climate impact of forest biomass production and combustion

Burning forest biomass to produce energy emits more carbon per unit of energy than burning fossil fuels. Even if the replanted trees absorb the emitted carbon over time, it takes a long time, from decades to over a century. Given the need to take a quick and decisive action to reduce anthropogenic greenhouse gas emissions, the use of forest biomass for energy production is not a good solution, especially that there are ways of producing and using forest biomass for energy that are climate neutral or even negative when it comes to long-term net emissions. These are not, however, the same measures as currently promoted in the energy sector substitution of fossil fuels by woody biomass harvested directly from forests.

In the process of photosynthesis, plants incorporate carbon dioxide taken from the air into their tissues. Carbon dioxide levels in the atmosphere have been steadily decreasing since the appearance of photosynthesizing organisms.[46] This is because the remains of dead plants are deposited on land and seas, sequestering carbon, that is, taking it out of the carbon cycle. The main carbon pools are biogenic carbonate sedimentary rocks, soil, living plants and the fossil remains of living organisms (commonly called fossil fuels). In 2021, atmospheric carbon dioxide concentrations exceeded 419 ppm, and are now at their highest they have been in at least 4.0–4.5 million years.[47] The main cause of this is human activity, specifically the reincorporation into the carbon cycle bound in oil, coal, and natural gas.[48]

The ability of plants to absorb carbon dioxide from the atmosphere and sequester it in their tissues has been recognized as a promising way to reduce the amount of greenhouse gas in the atmosphere, and stop the progression of climate change, driven primarily by emissions from the energy sector. In this way, the idea of bioenergy was born, which was until recently promoted

The greatest mitigation potential of forests, and technically the simplest way to reduce carbon emissions, according to the IPCC is

stopping deforestation in Latin America, Africa and Asia.

by some of the most important institutions involved in climate protection (including IPCC) as an effective tool for emission mitigation. However, it is now being increasingly accepted that biomass combustion is in fact a "false solution" that exacerbates the climate crisis.

A disputed role of forest biomass in climate change mitigation according to IPCC and IEA

IPCC reports are the most important source of international and national climate strategies. In 2014, the fifth report (AR5) pointed out at the huge potential of forest

46 Inglis, Gordon N., et al., ***Descent toward the Icehouse: Eocene sea surface cooling inferred from GDGT distributions.*** Paleoceanography 30.7, pp. 1000–1020, 2015.

47 https://bit.ly/2YnS3g8

48 Lear C. H. et al., ***Geological Society of London Scientific Statement: what the Geological record tells us about our present and future climate***, Journal of the Geological Society ed. 18, 2020.

biomass in reducing anthropogenic CO_2 emissions.[49] Replacing coal with biomass was supposed to be one of the most financially viable and effective mitigation measures. Co-firing, i.e., the addition of biomass to coal, which does not require any additional investments (biomass may be mixed with coal up to a dozen or so percent by volume without the need to upgrade boilers[50]), was considered the simplest and cheapest measure. As an additional advantage, it has been pointed out that biomass may be used as a raw material in industry and construction, binding coal in its structure for a long time (tens or even hundreds of years) and, afterwards it may be utilized as waste for bioenergy production.

Theoretically, forest biomass is intended to help accelerate the decarbonization of certain industrial sectors, such as steel and cement production, which together account for 10.2% of global CO_2 emissions, and for which there are no commercially viable, easily scalable alternatives (hydrogen could be used as a substitute for fossil fuels in certain sectors of heavy industry and air transport, but is used only on a small scale as its production costs are very high). The production of steel and cement requires an uninterrupted supply of high-temperature heat from solid fuels, which are currently coal and coke.[51] The IPCC has identified wood as a climate-friendly substitute for these fuels, and the International Energy Agency (IEA) in its latest Roadmap to a Zero-Carbon Energy Sector by 2050, clearly indicates woody biomass (which it describes as modern biofuel) as an alternative to coal in the production of steel and cement.[52]

At this point it should be stressed that the greatest mitigation potential of forests, and at the same time technically easiest way to reduce carbon dioxide emissions, according to the IPCC, is to halt deforestation in Latin America, Africa and Asia which accounts for 8% of the total anthropogenic emissions in the world.[53] By 2050, this would bring twice the benefits compared to afforestation and should therefore be a priority.[54] The IPCC points to the mitigation potential of halting deforestation and afforestation (a total of 7995 Mt CO_2 per year by 2030) which is several times higher than the difficult to estimate (from 420 do 4400 Mt CO_2 annually up to 2030) mitigation potential of forest biomass.[55]

49 The Intergovernmental Panel on Climate Change, ***The Fifth Assessment Report of the IPCC, Chapter 11 Agriculture, Forestry and Other Land Use***, pp. 811–922, 2014.

50 European Bioenergy Networks, ***Biomass Co¬Firing: An Efficient Way to Reduce Greenhouse Gas Emissions***, 2003.

51 Fridley D. Steniberg R., ***Our Renewable Future. Laying the Path for One Hundred Percent Clean Energy***, Island Press, 2016.

52 Międzynarodowa Agencja Energii, ***Net Zero by 2050: A Roadmap to Global Energy Sector***, Paryż, 2021.

53 Seymour F., Busch B. ***Why forests, why now?***, Center for Global Development, 2016

54 The Intergovernmental Panel on Climate Change, ***The Fourth Assessment Report of the IPCC***, Chapter 9 Forestry, pp 543–584, 2008.

55 The Intergovernmental Panel on Climate Change, ***The Fourth Assessment Report of the IPCC***, Chapter 9 Forestry, pp. 543–584, 2008.

According to the conclusions of the JRC report, in the timeframe relevant to stopping global warming at the level of 1.5°C, such measures are unhelpful, and will cause more emissions to the atmosphere than burning fossil fuels.

The role of afforestation in mitigating climate change remains controversial. As with biodiversity, the possible benefits depend on the nature of the land to be planted with new forest, and the choice of tree species. Afforestation of a single species forest on agricultural land and wastelands is supposed to have a positive impact on the climate, as trees store large amounts of carbon in their above-ground biomass, even if in homogeneous plantations. According to the JRC, growing energy tree plantations is preferable to maize fields in terms of climate protection. Whether planting trees on grassland has mitigation benefits remains to be seen. Such ecosystems bind large amounts of carbon underground, in the soil and roots. Research shows that under varying climatic conditions (droughts, heat waves, etc.) natural grasslands can be more stable carbon pools than forests.[56] Soils store around 80% of carbon on land, which is several times more than plant biomass aboveground. The conversion of steppes, pampas and prairies to forests may disrupt this reservoir, releasing some of the carbon bound in it.[57] Well-conceived tree and energy plantations can only be an effective mitigation tool if they do not disturb natural carbon pools.

The IPCC promotes the burning of forest biomass as a climate-neutral substitute for fossil fuels, arguing that deforestation is no longer a problem in OECD countries. Since the end of World War II, forest cover in Europe has been increasing[58] while the potential for afforestation of new land on the Old Continent is small. AR5 cites opinions that the carbon pools of European forests are "saturated", meaning that the forest ecosystem has reached a balance between CO_2 emissions and its absorption. Some researchers see this as an opportunity to "refresh" these carbon pools by harvesting some forest biomass as a climate-neutral fuel. In an ideal IPCC scenario, the harvested timber would be converted into construction material, binding CO_2 for years. After use, this wood would be converted to energy biomass and burned, preferably in installations that sequester emitted carbon dioxide in underground reservoirs (bioenergy with carbon capture and storage, BECCS).

56 Dass P. et al., ***Grasslands may be more reliable carbon sinks than forests in California***, Environ. Res. Lett. 13 074027, 2018

57 Lal R., ***Carbon sequestration.*** Philosophical Transactions of the Royal Society B 363, pp. 815–830 (2008).

58 European Environment Agency, FOREST EUROPE (2015): ***State of Europe's Forests 2015.***

However, such activity is expected to have a significant mitigating effect because:

- it will bind CO_2 in wood for a long time;
- waste will be used for energy production;
- CO_2 emitted during its combustion will be captured and stored;
- replanted trees will absorb additional carbon from the atmosphere.[59]

There are currently no studies to verify the actual effectiveness of such activities, and BECCS installations are still in the experimental phase.[60,61] The JRC report concludes that in the timeframe relevant to stopping global warming at the level of 1.5°C, such activities are unhelpful (the JRC does not take BECCS into the account) and will result in higher emissions to the atmosphere than the burning of fossil fuels. They can only have a positive effect over a timeframe longer than required for effective climate protection. Moreover, according to the current state of scientific knowledge old-growth forests sequester carbon even hundreds of years after they reach maturity, and the supposed **"saturation" of carbon pools** does not take place.[62]

Emission and absorption of CO_2 in the life cycle of forest biomass

In the short term, let's say from a few to about 30 years, which is the rotaion age of some fast-growing energy trees, burning forest biomass causes net emissions to the atmosphere. In order to assess whether biomass can be a climate-neutral fuel and when the emitted CO_2 is absorbed by the regrowing plants, a life cycle analysis (LCA) of the biomass must be carried out. The LCA should cover the period from harvesting the biomass (alternatively, from planting a designated tree), through all stages of its processing and use, to combustion and possibly absorption of the emissions of the next tree planted. Such analysis is not an easy process. Even though there are many methodologies of varying complexity, range and the number of considered factors in use to calculate net emissions of forest biomass, there are still questions such as whether to take into account the emission related to building a wood pallet factory or add the emission related to forest maintenance (use of machinery).

Similar problems need to be considered in relation to all renewable energy sources, which show different

59 The Intergovernmental Panel on Climate Change, ***The Fifth Assessment Report of the IPCC***, Chapter 11 Agriculture, Forestry and Other Land Use, pp. 811–922, 2014.

60 8 June 2021, Carbon Brief, Around the world in 22 carbon capture projects, https://bit.ly/3Deghby

61 8 June 2021, Power technology, Drax's great biomass carbon capture experiment, https://bit.ly/3mpQ3ft

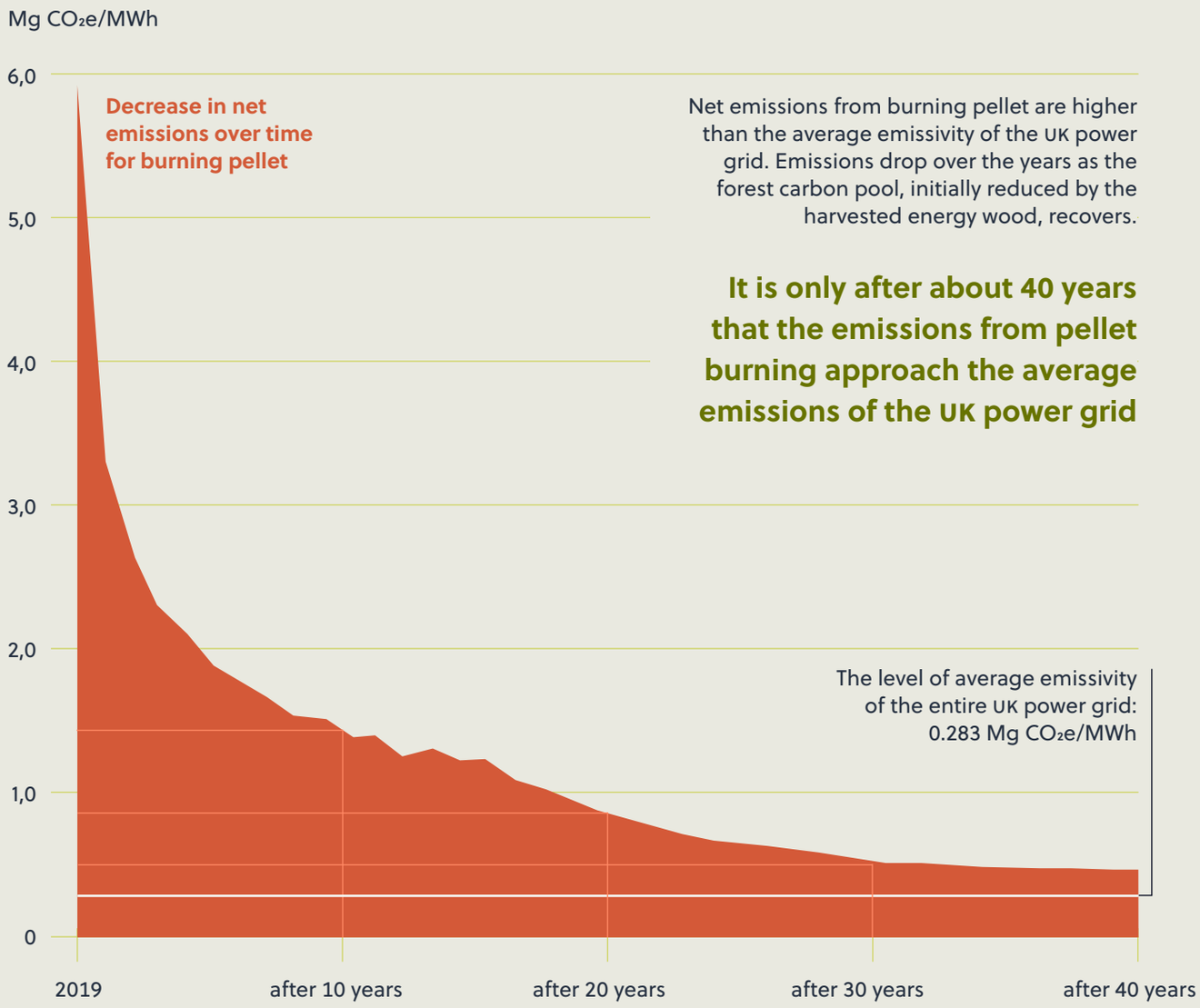
62 8 June 2021, Power technology, ***Drax's great biomass carbon capture experiment***, https://bit.ly/3mpQ3ft

emission levels depending on the choice of a particular LCA methodology. In order to reliably assess the mitigation potential of forest biomass, it is important to remember that the timeframe relevant to this report is set by international strategies to stop climate change, most of all the Paris Agreement (2015) and the European Green Deal (2019). According to the declarations adopted by Poland and other countries, keeping the global temperature increase at 1.5°C, compared to the pre-industrial era, requires a drastic reduction of net greenhouse gas emissions to the atmosphere (by at least 55%) by 2030, and by 2050 climate neutrality must be achieved. In this view, forest bioenergy must demonstrate zero (or negative) net emissions in the short term.

To assess the mitigation capacity of forest biomass, JRC scientists have proposed the concepts of ***carbon debt, carbon debt payback time*** and ***carbon parity***. As already mentioned, because forest biomass is a less calorific fuel than fossil fuels, replacing them results in more CO_2 emissions in the short term, and so a carbon debt is created.[63] The ***payback time*** is the time needed to pay off the carbon debt (taking from the atmosphere CO_2 in the amount equal to the surplus emitted). With the end of the payback time comes the moment when the debt is paid off and the mitigation effect of the bio-energy system begins. Before the payback time is reached, the

63 9 June 2021, Forest Research UK, *Typical calorific values of fuels*, https://bit.ly/3FlX8WW

Simulation of net carbon dioxide equivalent emissions from burning US wood pellets of forest origin at a UK power station per unit of energy produced over time



Based on: Buchholz, Sharma, Gunn, 2021

bio-energy system contributes more to climate warming than the fossil fuel system. The bioenergy system should reach a point of carbon parity at which bioenergy becomes climate-neutral, i.e. the point at which negative emissions related to the absorption of CO_2 by trees equal positive emissions from bioenergy. According to the JRC, the moment of carbon parity will occur over long time of several decades, or even more than a century.

The performance of the LCA model has been well demonstrated in a study of the commonly used in Europe practice of burning wood pellets imported from the US.[64] The authors of the study calculated when the carbon debt payback point would be reached in a modern, high-efficiency biomass installation in the UK, fuelled with feedstock from the whole trees purpose-harvested for the bioenergy needs. Assuming that the pellets will replace hard coal and that will contain 20% sawdust (sawmill waste lowers emissivity), the payback point would be reached not earlier than after 40 years, or probably even later (emissions from raw material acquisition, pellet production and shipping have been included in the LCA). This means that for the first 40 years, the installation will emit more CO_2 than if it used coal as fuel. The study shows that other, faster and more effective mitigation measures, such as reforestation, should be sought.

Some researchers[65,66] disagree with this approach, arguing that zero net emissions from forest biomass combustion are already achieved at the moment of combustion if it is put in a framework of the so-called ***landscape scale***. In the landscape scale, the emissions from the burning of woody biomass in a given area are supposed to be zero, because the growing stands absorb CO_2 all the time, also at the moment of emission. On this approach, a sufficiently large absorption area is determined as a reference point for the mitigation effect for a specified maximum, carbon-neutral ceiling of the use of biomass for energy purposes.

Similar situation obtains in Poland. In 2019, Polish forests absorbed only about 5% of Polish greenhouse gas emissions.[67, 68] Including the absorption of forest emissions of countries from which we import forest biomass in the accounts for Polish emissions from the forestry

64 Buchhoz T., Gunn J., Sharma B., ***When Biomass Electricity Demand Prompts Thinnings in Southern US Pine Plantations: A Forest Sector Greenhouse Gas Emissions Case Study***, Frontiers for Forest and Global Change, 10 May 2021, https://bit.ly/3a5Kj4X

65 Chudy R, et al., ***Biomasa drzewna jako surowiec dla energetyki: Czy spala¬ nie jej może być przyjazne dla klimatu?*** [Wood biomass as a raw material for energy: Can burning it be climate-friendly?], Magazyn Polskiej Akademii Nauk 1/65/2021, pp.62-65

66 International Energy Agency, Bioenergy, ***The use of forest biomass for climate change mitigation: dispelling some misconceptions***, https://bit.ly/3A94p8R

67 Ministry of Climate and Environment, National Forestry Accounting Plan 2019 ENG Final, 2020.

68 The National Centre for Emissions Management , ***KRAJOWY RAPORT INWENTARYZACYJNY 2021: Inwentaryzacja gazów cieplarnianych w Polsce dla lat 1988–2019, Raport syntetyczny***, 2021

sector is wrong, because these countries have already accounted for this absorption, so it would lead to a double-accounting error. It follows that according to this approach, negative net emissions on a landscape scale remain a scientific hypothesis, which would be true only if mankind has reduced anthropogenic emissions to the lower level than the earth's forests can absorb. The burning of forest biomass leads to higher net emissions because the forest absorption is reduced by the amount of CO_2 emitted through burning, and thus their mitigation effect decreases.

The authors of the JRC report analysed different scenarios of forest biomass harvesting and production in three timeframes: short (10 years), medium (50 years), and long (several centuries), and gave them appropriate weight in mitigation efforts. A summary of their results illustrates the complexity of the problem (see infographics on p. 45).

The mitigation potential of replacing coal and gas with forest biomass as presented by JRC depends on the time horizon in which it is considered. Due to the urgency of taking rapid and ambitious action to reduce GHG emissions, only the shortest time period analysed (10 years) is relevant. The possible positive role of forest biomass in the medium and long term is irrelevant in this context.

In the short term, primary forest biomass as a fuel emits more CO_2 than burning coal and gas, particularly if it comes from purpose-harvested large-size wood. If it were only residues from forestry operations, thinning, and waste wood that would be used for energy production, the emissions would be comparable to the burning of fossil fuel.

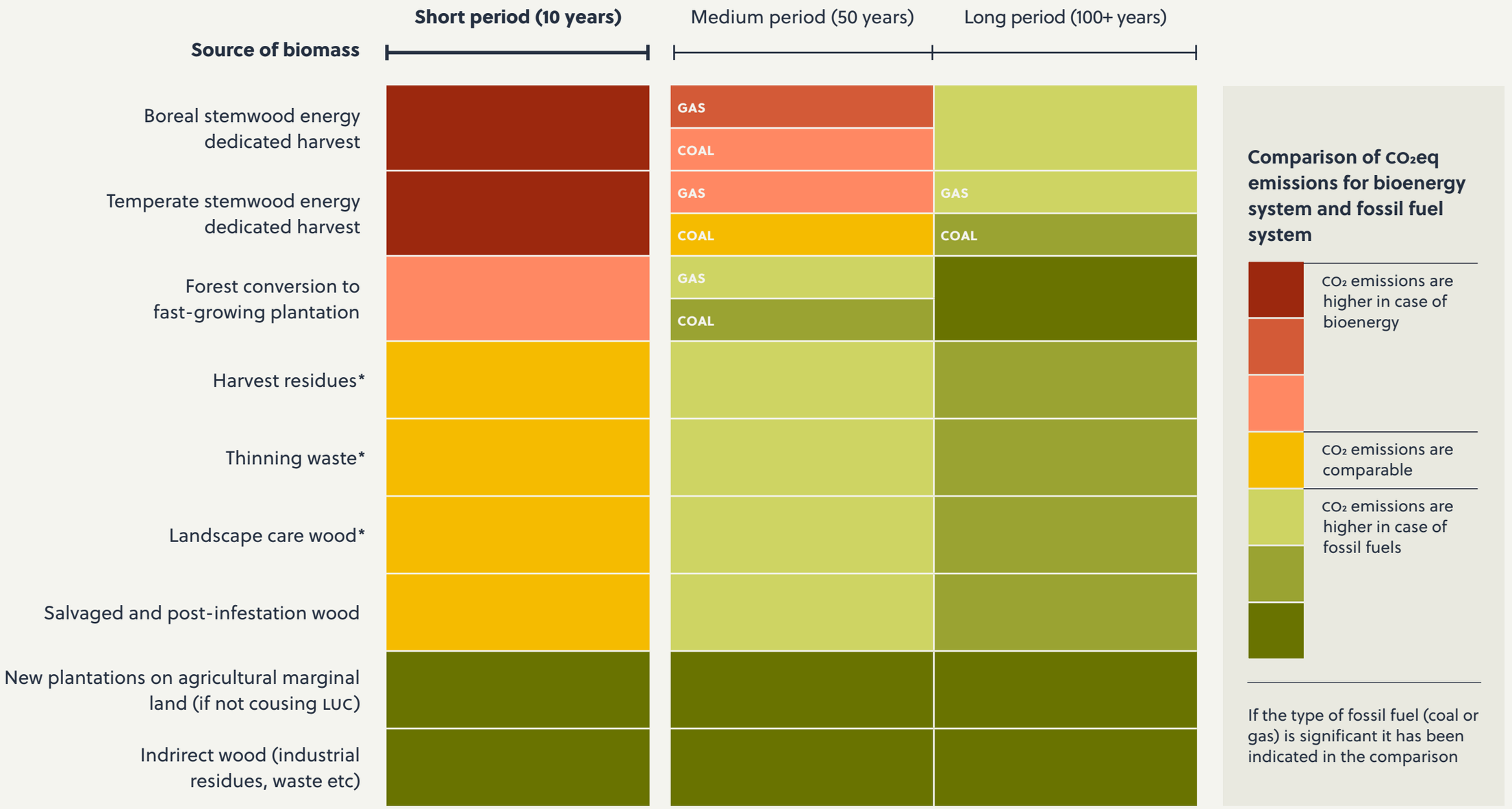
Positive mitigation effect could be only reached if coal or gas were to be substituted with waste from wood processing and waste wood (e.g., from construction).

In the medium to long term, the benefits of burning woody biomass are growing. The JRC indicates that taking advantage of the potential of forest biomass to combat climate change should first involve afforestation of uncultivated land with new trees, and the use of residues from wood processing as a substitute for fossil fuels. This assessment is consistent with IPCC AR6, which suggests that the greatest and most rapidly available mitigation potential of forests is in cessation of deforestation, restoration of degraded forests and afforestation of new areas, i.e. in retention of carbon in forests.

JRC also points to the important climatic aspect of leaving harvest residues behind after forestry operations. Woody debris that is left in the forest immediately becomes a reservoir of carbon, binding it for many years to come. Large-size wood and stumps are most significant for this process, as they decompose slowly and hold carbon for decades. In this respect, large-size, **salvaged wood** is of great importance not only for nature, but also

Qualitative evaluation of the reduction of carbon emissions in forest bioenergy scenarios, compared to two fossil fuel reference systems and three timeframes.

Source: Agostini et al., (*Carbon accounting of forest bioenergy conclusions and recommendations from a critical literature review*, Publications Office of the European Union, 2014), after Camia et al., 2021.



* For post-felling waste, thinning and harvesting of salvaged wood, the value depends on alternative uses such as leaving on site for natural decay.

for the climate. Some of it should be left in the forest, and it should not be removed at all from the protected areas that are excluded from forestry work. Fine woody debris (branches, leaves, needles, bark) decompose faster, releasing the carbon they contain, which is why leaving them behind does not have as much mitigation potential. This is why JRC identifies fine woody debris as the only source of primary forest biomass, potentially comparable in CO_2 emissions to coal and gas.

However, fine woody debris is not the preferred fuel for the bioenergy sector. It contains more water, alkali salts and impurities than large-size wood and generates more ash, which makes it less calorific, speeds up the corrosion and causes the clogging of boilers. For this reason, it is a common practice to convert larger wood sorties into pellets and chips, the so-called pulpwood, the combustion of which is in the short to medium term more harmful to the climate than the burning of combustible fuels. Considering the above, the potential of forests as a source of climate-neutral fuel is small. Even more significantly, many pellet producers (e.g., the world's largest producer, the American Enviva) try to cover up the fact that they use round wood and not only waste.[69]

SALVAGED WOOD – wood harvested from forests damaged by natural disasters (e.g. hurricanes or insect infestations).
→ p. 109

69 Brack D., *Woody Biomass for Power and Heat: Impacts on the Global Climate*, Chat ham House, 2017

PART II

Forest biomass in Polish law and economy

01

Legal status

Legal status of forest biomass in Poland

Forest biomass legislation in force in Poland fails to provide appropriate conditions for developing responsible strategies for its use in the energy sector. Clear definitions of forest biomass and energy wood are lacking, making it impossible to reliably collect data and monitor the use of wood for energy production effectively. The RES Act defines agricultural biomass, but does not include a definition of forest biomass, making it difficult to trace the origin of the raw material used in the power industry. The Central Statistics Office use of the term ‘solid biofuels’, which is not used in law, further complicates the situation. The lack of a definition of full-value wood, as well as the qualitative and dimensional parameters that must be met by energy wood, creates opportunity for abuse and opens a leeway for burning wood which could be otherwise used in the wood processing and paper industry, thus ensuring cascade use of raw materials.

BIOCHAR is another term for charcoal. Charcoal is produced at high temperatures by pyrolysis (dry distillation) → p. 105

TORREFIED BIO-COAL – charcoal produced in low temperatures. Wood pellets are sometimes torrefied to obtain a fuel with a calorific value close to that of bituminous coal. → p. 110

ENERGY CROPS are grown for energy purposes, i.e., the production of heat, electricity and gas or liquid fuels. → p. 106

The status of forest biomass in Polish legislation is defined by the Act of 20 February 2015 on Renewable Energy Sources (RES Act)[70] and the Act of 25 August 2006 on Biocomponents and Liquid Biofuels (Biofuels Act).[71]

The RES Act does not explicitly define forest biomass. The definition can be found under different names in several articles of the act. Article 2(3) of the RES Act provides a definition of biomass that is consistent with the definition of the Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market. Within the meaning of Article 2(3) (forest) biomass is, among others, the product or waste from forestry and wood processing industry (including papermaking), [...] processed biomass, in particular in the form of briquette, pellet, **torrefied bio-coal** and **biochar**. It should be noted that biomass from cultivation of **energy crops** is classified as agricultural biomass (Article 2(3b)) – the status is given to the raw material from cultivation of willow and poplar or other energy crops.

A definition of forest biomass, distinguishing it from biomass broadly understood, can be found in the EU RED directive amended on 11 December 2018 (Article 2(26)). According to the RED directive, forest biomass originates in the forest production; the Polish RES Act does not include such definition.

A definition of biomass identical to that in the RES Act can be found in the Biofuels Act (Article 2(1)), which contains regulations concerning biofuels and bio-sources for their production, including e.g., biodiesel, bioethanol, which is increasingly referred to as the "green" fuel of the future, i.e., hydrogen produced through energy from biomass. In this act, woody debris from forestry operations may be recognised as residues from [...] forestry (Art. 2. (111b)) and as lignocellulosic material (Art. 2. 132a)) and serve as raw material for the production of biofuels and biocomponents.

Energy wood

On the other hand, the RES Act includes the concept of 'energy wood', which does not feature in the European law (Article 2(7a)). It is defined as wood as raw material, which due to its physical and dimensional characteristics has a reduced technical and functional value, preventing its industrial use, as well as woody raw material constituting agricultural biomass.

In 2020, the Polish Parliment passed an amendment to the RES Act, in which the definition of energy wood is extended. The introduced regulations are of a transitional nature and were in force from 1 October 2020 to

70 Renewable Energy Sources Act of 20 February 2015.
71 The Act of 25 August 2006 on bio-components and liquid biofuels, consolidated text 13 July 2020.

31 December 2021. Article 184f of the amended Act recognises energy wood as:

1. *wood material other than sawnwood and sliced wood, consisting of logs, sawnwood and sliced logs, and other than wood material which has been produced by a process of deliberate fragmentation of the wood material;*
2. *by-products from the processing of wood raw material which are not contaminated with the substances that are not naturally present in the wood;*
3. *waste that results from the processing of wood raw material and is not contaminated with substances not naturally present in wood, managed in accordance with the waste processing hierarchy.*

According to these provisions, energy wood is low-quality wood (and woody biomass from agriculture), unsuitable for wood processing industry, and therefore only of calorific value. The legislator introduced the concept of energy wood into the Act to ensure that high quality timber, suitable for wood processing is not used for energy, which would be detrimental to the timber industry and inconsistent with the principles of cascade use of raw materials.

Installations that use energy wood or unpolluted biomass for energy production are entitled to energy certificates of origin (Art. 44, RES Act) issued by the Energy Regulatory Office (ERO) which confirm that they have generated renewable energy. In some cases, such certificates are not granted, e.g., if polluted biomass or non-energy wood is used for energy production. Notably, it is not the producer (in Poland, mainly the state holding State Forests) or the importer of wood that confirm that biomass is considered to be energy wood but the responsibility lies with the Energy Regulatory Office. The State Forests holding as such does not sell energy wood; it is only the owners of energy producing installations that can apply to the Energy Regulatory Office for a **certificate of energy origin**, presenting the office with a statement from the forest biomass supplier to the effect that the biomass meets the requirements for energy wood. Forest biomass producers which buy wood from forest district authority, also have to submit the relevant documents, including a stock survey classifying the timber into the appropriate assortment.

RENEWABLE ENERGY CERTIFICATE (REC), ALSO KNOWN AS THE CERTIFICATE OF ORIGIN, "GREEN CERTIFICATE" – document confirming that electricity was produced from renewable energy sources. The certificates are issued by the Energy Regulatory Office. Since July, 2016 separate *Renewable Energy Certificates* (*RECs*) have been issued for electricity generated from agricultural biogas (the so-called "blue certificates"). → p. 109

Unclear legislation on forest biomass and energy wood

In principle, the purpose of the Polish RES Act is to guarantee that bioenergy production will not be based on high, but only on low-quality wood, wood from energy crops (as well as e.g., from municipal greenery maintenance and roadside tree removal), forestry residues and by-products of wood processing. The Ministry of Climate and Environment has explained the need to introduce a new, temporary definition of energy wood by an increase in the amount of **salvaged wood** in forests, which poses a fire risk, and the need to increase the harvest of forest biomass to raise the share of renewable energy[72] win the energy mix. The Ministry has declared that the legislation guarantees that full-value wood will not end up in the boilers of power and heating plants, and the wood processing industry will not be forced to compete for raw material with the energy sector. Unfortunately, the current RES Act does not guarantee that this will indeed be the case, while it creates a number of other problems.

First of all, the RES Act lacks a definition of forest biomass, separate from the general definition of biomass. This legal situation creates considerable difficulties in collecting data on the production and use of raw wood harvested from forests for bioenergy purposes, and thus hinders an effective supervision of the forest bioenergy sector. State institutions are not obliged to collect data on forest biomass, and in official statistics, it is not distinguished from other types of biomass. The Central Statistical Office, which collects and compiles data on renewable energy in Poland, includes forest biomass in the category of solid biofuels. Such a category does not exist in the Polish legislation, but according to the explanations provided by the Central Statistical Office, it is solid biomass, excluding biomass from the municipal waste sector.[73] This approach causes a serious problem, because the actual amount of forest wood burned as RES is hidden amongst other types of biomass. Although CSO states that solid biofuels are primarily wood, it is not known what its actual share in the energy mix is. Neither does CSO collect data on how much energy is produced from wood processing waste, including wood briquettes or pellets.At the moment, firewood is the only type of forest biomass whose annual harvest is counted reliably. Unfortunately, the use of firewood is not monitored, so it is not known what share of it goes to individual households and how much is destined for the power industry.

SALVAGED WOOD wood harvested from forests damaged by natural disasters (e.g. hurricanes or insect infestations).
→ p. 109

72 Opinion of the Minister for European Union Affairs on the compliance with European Union law of the draft act amending the act on renewable energy sources, expressed by the minister competent for the membership of the Republic of Poland in the European Union of 9 June 2020, Ref: KPDPUE.920.363.2020.MR(4) re: RM-10-40-20 (New text).

73 Central Statistical Office, *Energy from renewable sources in 2019*, Warsaw, 2020

Also the current definition of forest biomass does not distinguish between primary and secondary biomass. This means that wood harvested deliberately for energy production is treated in the same way as wood processing waste. In the light of nature conservation and the climate change (discussed in Part 1 of this report), there should be a distinction between the two types of raw material. In contrast to secondary forest biomass, the use of primary forest biomass in the energy sector poses a threat to forests by increasing the demand for wood and thus raising pressure of forest management. In addition, the use of primary biomass for energy purposes is contrary to the principles of cascade use of raw materials in circular economy. Following the principle of cascade management, only the maximally exploited waste wood should be used as an energy source.

It must be also stressed that Polish law recognises and recommends cascade use of raw materials only in the case of waste. According to ERO, cascade utilisation should only be applied to e.g., old furniture or construction waste wood, and not to the wood harvested in the forest or wood industr waste. ERO explains[74]that felling waste or sawdust, shavings, chips, slivers, etc. are not waste, but by-products of forestry and wood processing, so there is no obligation to follow the hierarchy of waste management (e.g. produce chipboard first out of woodchips), as these are not regarded as waste and can be managed as decided by their owners.

The RES Act lacks provisions to ensure that forest biomass (and biomass in general) is produced in a sustainable manner, that its harvesting does not lead to degradation of ecosystems, and that the raw material base is renewed. Forest biomass and energy wood are recognised ***a priori*** as renewable energy sources in the RES Act, regardless of whether their renewability is actually guaranteed. Furthermore, it is particularly worrying that the RES Act does not indicate the possible sources of forest biomass, thus it does not prohibit its sourcing from the protected areas or environmentally valuable sites. This means that an energy producing installation can obtain a green certificate of by burning wood even from national parks, Natura 2000 protected areas or nature reserves. The Ministry of Climate argues that the failure to specify the permitted sources of energy wood will allow for obtaining the raw material from sources other than forestry (e.g. from the removal of trees along roadsides or from municipal greenery maintenance). In such a situation, city park or roadside trees can be processed into woodchips and used to produce renewable energy. However, no effort will have been made to ensure that only unprotected areas can be used as sources of wood.[75]

74 19.08.2021, Gram w Zielone, ***URE clarifies doubts on energy wood***, https://bit.ly/3BD4ra1

75 Government Bill to amend the Renewable Energy Sources Act, print no. of455 July12020. (hereinafter: Project); https://bit.ly/3BxHJ32

A major problem is the lack of **qualitative and dimensional parameters**, which must be met by wood to be recognised as energy wood. This is due to the temporary suspension of the application of regulations based on Article 119a of the RES Act, which requires the determination of qualitative and dimensional parameters for energy wood and rules for optimal use of the raw material (Article 184g of the RES Act), in accordance with the principles of cascade raw material management, and the introduction of a new definition of energy wood, which is a wood not suitable for industrial use. This has created room for abuse. In the absence of clearly defined qualitative and dimensional parameters, it is impossible to define the characteristics of wood unsuitable for industrial use precisely. Furthermore, the RES Act lacks definitions of full value wood, sawnwood and machined wood, which would help tighten the rules. At the moment, it is up to wood producers to declare that the raw material offered is unsuitable for the wood processing industry and sell it for energy production. Also, the problem of unspecified qualitative and dimensional parameters for energy wood was not solved in the 2020 amendment to the legislation. Despite its existence several years earlier, ERO, which is obliged to verify the legality of energy wood, applied three times to the Ministry of Climate and Environment to define detailed qualitative-dimensional and physicochemical characteristics of energy wood, but the Ministry failed to respond. As a consequence, in 2017, ERO decided to rely on the provisions of the Energy Law[76], which (on the basis of, among others, regulation issued by the Ministry of Economy[77]) provides a legal definition of full value wood, indicating the wood sorts that meet technical standards and thus ensuring that full value wood is not us-ed as energy wood. The ERO decision was valid for two years, from 1 July 2018 to 1 July 2020[78]. After this date, ERO failed to issue a new decision, so it can be assumed that the amended RES Act is now in force, and therefore ERO cannot refer to wood quality and size standards, as there are no such standards in place. This situation creates a large scope for abuse and fails to provide a legal protection for full-value wood not to be used as fuelwood.

QUALITATIVE-DIMENSIONAL PARAMETERS – physical characteristics of wood (e.g. diameter, length, wood defects), on the basis of which it is classified to the appropriate wood sort. → p. 109

76 The Act of April 10, 1997 – Energy Law

77 Ordinance of the Ministry of Economy of October182012. on the detailed scope of the obligation to acquire and present certificates of origin for cancellation, pay the substitution fee, purchase electric energy and heat generated from renewable energy sources and the obligation to confirm the data concerning the amount of electric energy generated from a renewable energy source (Journal of Laws of 20112012, item. 538, as1229, amended)

78 Energy Regulatory Office, ***Information of the President of the Energy Regulatory Office No. 75/2017 on the implementation of the prohibition to use wood other than energy wood referred to in Article 27a of the Renewable Energy Sources Act for generating electricity in renewable energy source installations indicated in the Act***, Warsaw 18.10.2017.

02

Harvesting and consumption

Woody biomass harvesting and consumption in the Polish economy

In 2004–2020, the use of woody biomass for energy production increased by 9.5 million m^3 (69%) from 13.8 million m^3 to 23.4 million m^3. Over the whole period, households had the largest share in woody biomass consumption which remained at a similar level (between 10.6 million m^3 and 12.3 million m^3). The consumption of woody biomass in agriculture did not change much either (between 2 million m^3 and 2.5 million m^3). The increase in total woody biomass consumption for energy production was almost entirely due to growing consumption in the power industry (up by 13852%, from 35,000 m^3 in 2004 to 4.9 million m^3 in 2020) and the wood-paper industry (up by 2980%, from 164,000 m^3 in 2004 to 4.9 million m^3 in 2020). In 2020, the energy sector and the wood-paper industry already accounted for 21% and 22% of the total woody biomass consumption for energy production in Poland, respectively.

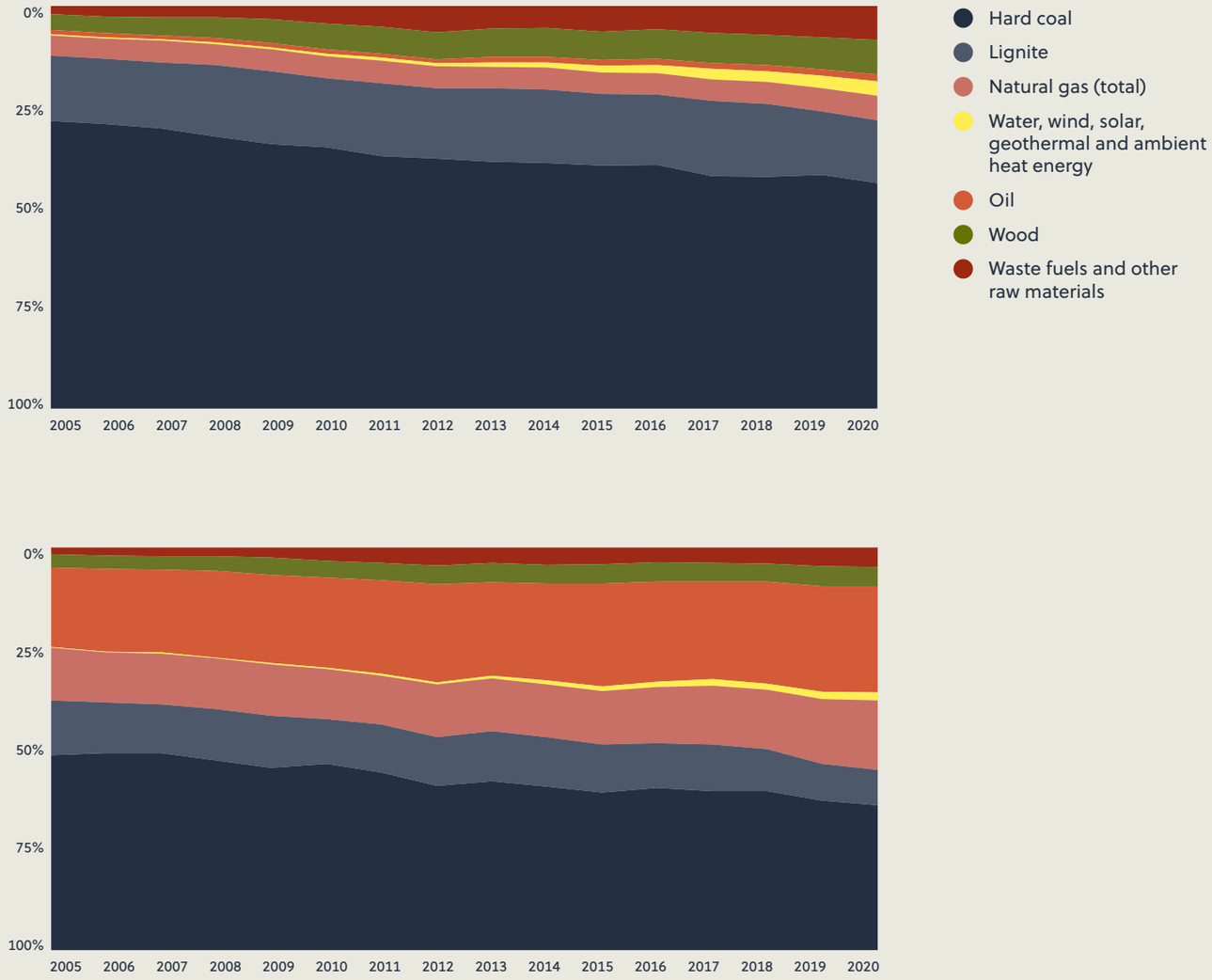
The amount of wood (primary and secondary woody biomass) from domestic sources designated for energy production increased between 2006 and 2019 by 47.6% (from 14.3 million m^3 to 21.16 million m^3). At least 7.5 million m^3 per year of forest biomass for energy purposes is obtained directly from forests managed by State Forests national holding. Meanwhile, according to information provided by Poland in the interim reports on implementing the National Renewable Energy Action Plan (NREAP) in Poland in 2015-2018, direct supply of woody biomass from Polish forests and other wooded areas amounted to about 21 million m^3/year. The differences between the data on energy wood harvesting provided by State Forests and the reports show that there is no effective system for collecting information on the use of woody biomass for energy production in Poland. The largest installation fuelled with woody biomass in Poland is the "Green Block" Power Plant Połaniec, which burns approximately 1.1 million m^3 of forest biomass per year.

Woody biomass harvesting for energy purposes

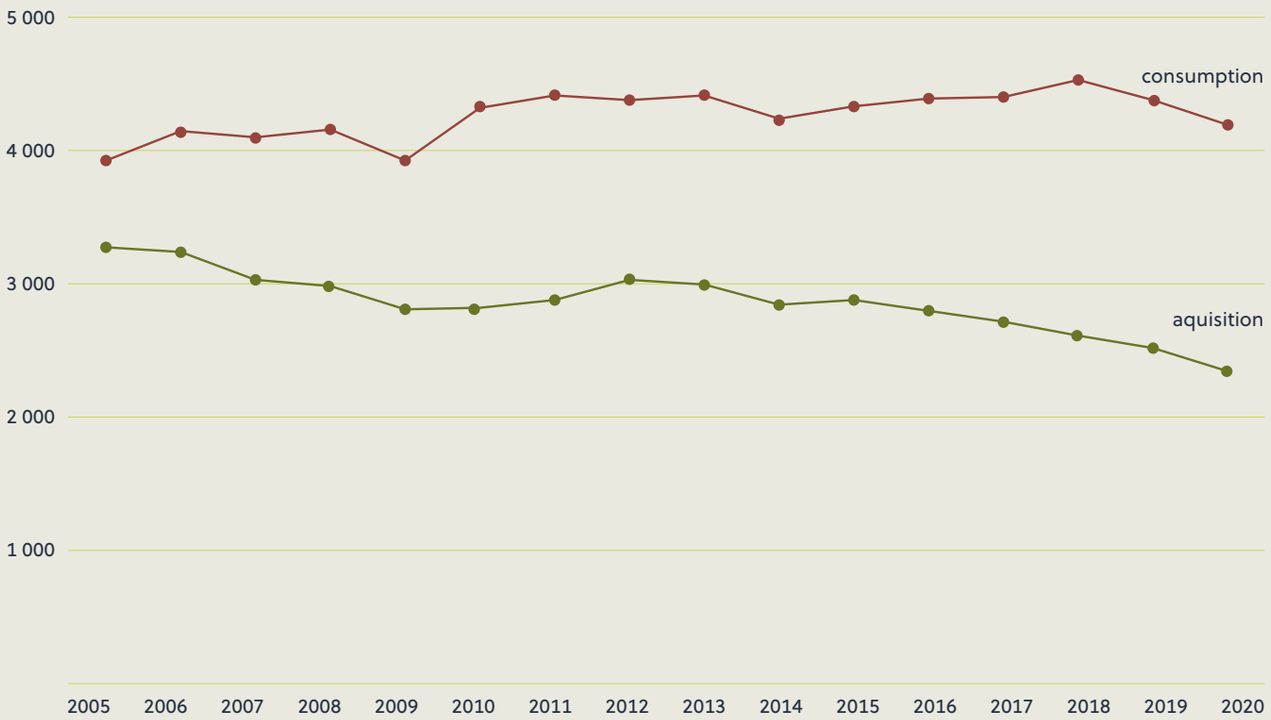
It is very difficult to calculate the amount of primary woody biomass harvested for energy production in Poland. Even state administration authorities with access to all public data have difficulties with providing accurate data.

Aquisition (upper graph) and consumption (lower graph) of energy carriers in Poland in 2005-2020

Report on Primary Energy Balance 2005-2020,
Ministry of Climate and Environment, Energy Market Agency S.A.



Aquisition and consumption of primary energy in Poland (in PJ)



Source: Report on Balance of primary energy in 2005-2020, Ministry of Climate and Energy Market Agency S.A.

S2 TIMBER GROUP – according to the Polish classification medium-sized timber in the second thickness class, i.e. with a diameter of 25–34 cm, measured at log mid-thickness. The S2 group of wood is called utility pole timber.
→ p. 109

The information published by the Energy Market Agency, the Central Statistical Office and the Ministry of Economy are contradictory. This is confirmed by the following statement in the National Renewable Energy Action Plan developed by the Ministry of Economy, one of the few publicly available documents that attempts to estimate the amount of woody biomass for energy production: "[...] even a rough estimation of the wood raw material designated for energy purposes is very difficult".[79]

However, the Ministry of Economy attempted to estimate the amount of harvested woody biomass used for energy production in 2006. In order to calculate the primary woody biomass yield, they summed up the annual yield of firewood, some of the medium-sized timber (Polish classification S2 timber group), which is most often used as energy biomass besides firewood, and the estimated amount of wood waste from forestry works (all these biomass categories are forest biomass), and then this value was increased by the wood from tree plantations and green areas management (non-forest biomass).

And so, according to these estimates, in 2006 10.7 million m^3 of primary forest biomass was harvested in Polish forests for energy purposes, with the total amount of forest wood harvested in 2006 being 32.3 million m^3.[80]

79 Ministry of Economy, National Action Plan for Renewable Energy, Warsaw 2010.

80 Central Statistical Office, Forestry 2017, Warsaw 2017.

This would mean that one third of the wood harvested in Polish forests in 2006 was destined for direct burning for energy generation. As regards non-forest woody biomass, the Ministry estimated that in 2006 a total of 1.85 million m^3 of such biomass was harvested, including 340,000 m^3 from municipal greenery maintenance and 1.5 million m^3 from tree plantations. When estimating the amount of secondary forest biomass for energy production for 2006, the Ministry based its calculations on consultations with the Institute of Wood Technology (ITD) and the Polish Economic Chamber of Wood Industry. **The Ministry of Economy estimated that in 2006, 5.91 million m^3 of secondary woody biomass, mostly industrial wood waste, were allocated for energy production.**

If the estimates of the Ministry of Economy are to be trusted, in 2006 about 18.45 million m^3 of woody biomass from domestic resources was burned in Poland to produce energy, including 10.7 million m^3 (58%) of primary forest biomass, 1.85 million m^3 (10%) of non-forest woody biomass and 5.9 million m^3 (32%) of secondary woody biomass. This amount is considerably higher than that reported by the Energy Market Agency (ARE), which estimated the total amount of wood (woody biomass) from domestic resources transferred to energy production in 2006 at 14.3 million m^3.

To sum up, the estimates of the Ministry of Economy compared with Energy Market Agency data are 29% higher, which proves inconsistency of the data published by different public institutions, and confirms the inefficiency of the system for monitoring the use of forest biomass for energy generation in Poland.

Currently, four types of timber are harvested in the Polish forests for energy production. Two of these, S4 (medium-sized firewood) and M2 (small-sized firewood), are sold at retail outlets. The other two, S2AP (medium-sized general-purpose wood) and M2E (so-called logging residues), are sold on the market, which in practice means that the main purpose of their acquisition is to satisfy the demand for biomass in the bioenergy sector. All these types of wood are classified as "forest biomass" in accordance with the Regulation issued on 27 April 2021 by the Director General of State Forests.

In the last three years (2018–2020), the total wood harvest of these four types was approximately 7.5 million m^3/year. In 2020, a total of 7.4 million m^3 of forest biomass was harvested, including 4.4 million m^3 of retail firewood, 2.1 million m^3 of general medium-sized wood and 800,000 m^3 of felling waste.

According to the information provided by Poland in the interim reports on implementing the NREAP in Poland in 2015-2018, presented to the European Commission, the direct supplies of woody biomass from Polish forests and other wooded areas amounted to more than 21 million m^3/year. Again, such a large difference between the declared amount of wood destined for

energy production (7.5 million m^3/year) and the declared amount of primary woody biomass used for energy production (21 million m^3/year) indicates the lack of a reliable monitoring system, both as regards the destination of wood harvested in forests and the origin of biomass used for energy production. This diagnosis is confirmed by the Ministry of Climate and Environment in the most recent interim report on NREAP (2020), stating the unavailability of data on indirect supply of woody biomass for energy production. A similar statement was made in the first interim report prepared in 2012. Despite the fact that almost ten years passed, Poland still fails to have a system for collecting reliable data on the origin of woody biomass used for energy production.

Over the past 15 years, many new installations powered with woody biomass have been built in Poland and the amount of wood (primary and secondary woody biomass) from domestic sources for energy production increased between 2006 and 2019 by 47.6% (from 14.3 million m^3 to 21.16 million m^3, according to Energy Market Agency.[81] During this period, the total volume of wood harvested in Poland also increased (by 30%), as did the production output of the wood and paper industry and, consequently, the volume of post-production wood waste. In addition to the biomass harvested in forests, these are mostly responsible for the supply of woody biomass used for energy generation.

Woody biomass in the bioenergy sector

The last 15 years have seen a dynamic development of the bioenergy sector in Poland. As recently as in 2005, the total capacity of biomass-fired installations amounted to less than 190 MW, increasing sevenfold (by 697%) to 1512 MW by 2020. During that period, the consumption of primary energy from solid biomass, biogas, biofuels and biodegradable municipal waste also increased significantly (by 88%), as did the share of bioenergy in the total primary energy consumption in Poland (from 4.6% in 2005 to 7.6% in 2020). Throughout this period, bioenergy accounted for the vast majority of primary energy consumption from renewable sources, but the share of bioenergy in primary energy consumption from renewable sources decreased steadily from 94% in 2006 to 81% in 2019.

Woody biomass is the main fuel for the Polish bioenergy industry therefore the development of this sector has led to its higher use.

In 2019, woody biomass was responsible for 65% of the use of primary energy from solid biomass, biogas, biofuels and biodegradable municipal waste (almost 80% of solid biomass used in the energy sector is woody biomass). In the same year, woody biomass combustion

81 Energy Market Agency, ***Bilans energii pierwotnej w latach 2005-2020***, Warsaw 2021.

was responsible for 52% of primary energy consumption from RES, and 5% of total primary energy consumption in Poland. The increase in the consumption of woody biomass in bioenergy is primarily related to the construction of biomass units in existing power plants and combined heat and power plants.

Woody biomass use in power plants

Four fully biomass-fired boilers currently operate in Polish power plants. The largest installation that produces energy from biomass is the "Green Block" of the Połaniec Power Plant with a capacity of 230 MWe, fuelled with a mixture of 61% forest woodchips and 39% agricultural biomass.[82] According to the information provided by the Połaniec Power Plant, **between 2014 and 2016 the Green Block burned approximately 1.8 million tonnes (Mt) of biomass per year, including approximately 1.1 Mt of woodchips.** The second most powerful all-biomass-fired unit operates at the Konin Power Plant and is fired with a mixture of 80% woody biomass and 20% agricultural biomass. The unit has a capacity of 50 MWe, and a second twin unit is planned to be connected to the power plant in 2022.

Annual biomass consumption at the Konin Power Plant can be as high as 0.5 Mt per year (0.4 Mt woody biomass).[83] In addition, two power plants owned by the Tauron Group in Poland, Jaworzno and Stalowa Wola, burn up to 0.5 Mt of woody biomass per year.[84]

The total power capacity of biomass fuelled units in the power station is 385 MW.

The Green Block in the Połaniec Power Plant

In 2012, GDF Suez Energia Polska S.A. commissioned a 225 MWe fully biomass-fired power unit at its Połaniec Power Plant located in Zawada, Świętokrzyskie Voivodeship. At the time, it was the world's largest biomas powered unit.[85] Since 2017, the power plant has been owned by ENEA S.A. According to the power plant owner, the Green Block has the potential to burn about 2 million tonnes of biomass per year. In 2013–2016, the fuel origin structure was as follows:

- forest woodchips 61%,
- agricultural biomass 39%[86].

Between 2014 and 2016, the Green Block reached an output potential close to its maximum and burned almost 2 Mt of biomass per year. During this period, the

82 Adam Kwiatkowski, *Ekoinwestycje Enei Elektrowni Połaniec [Enea eco-investments in Połaniec Power Plant*] Energetyka June 2020, pp. 257–259, Katowice 2020

83 13 October 2021, Drewno.pl, https://bit.ly/3jM2ku4

84 Data collected from analysis of documents issued by energy companies, technical specifications of energy installations, information provided by companies to the press, municipal renewable energy development plans, companies' investment plans, and information about biomass installations provided by the media and online biomass industry journals.

85 17 September 2021, Echodnia.eu, https://bit.ly/3pOIulP

86 ENEA S.A., *Biomasa w GK Enea – możliwości, doświadczenia, badanie jakości i certyfikacja* [Biomass in Enea CG – opportunities, experience, quality testing and certification], presentation 2017

The Green Block in Połaniec Power Station

The whole Puszcza Białowieska forest would be burned in the Green Block within

20 years.

Green Block Parameters

Capacity: 225 MWe

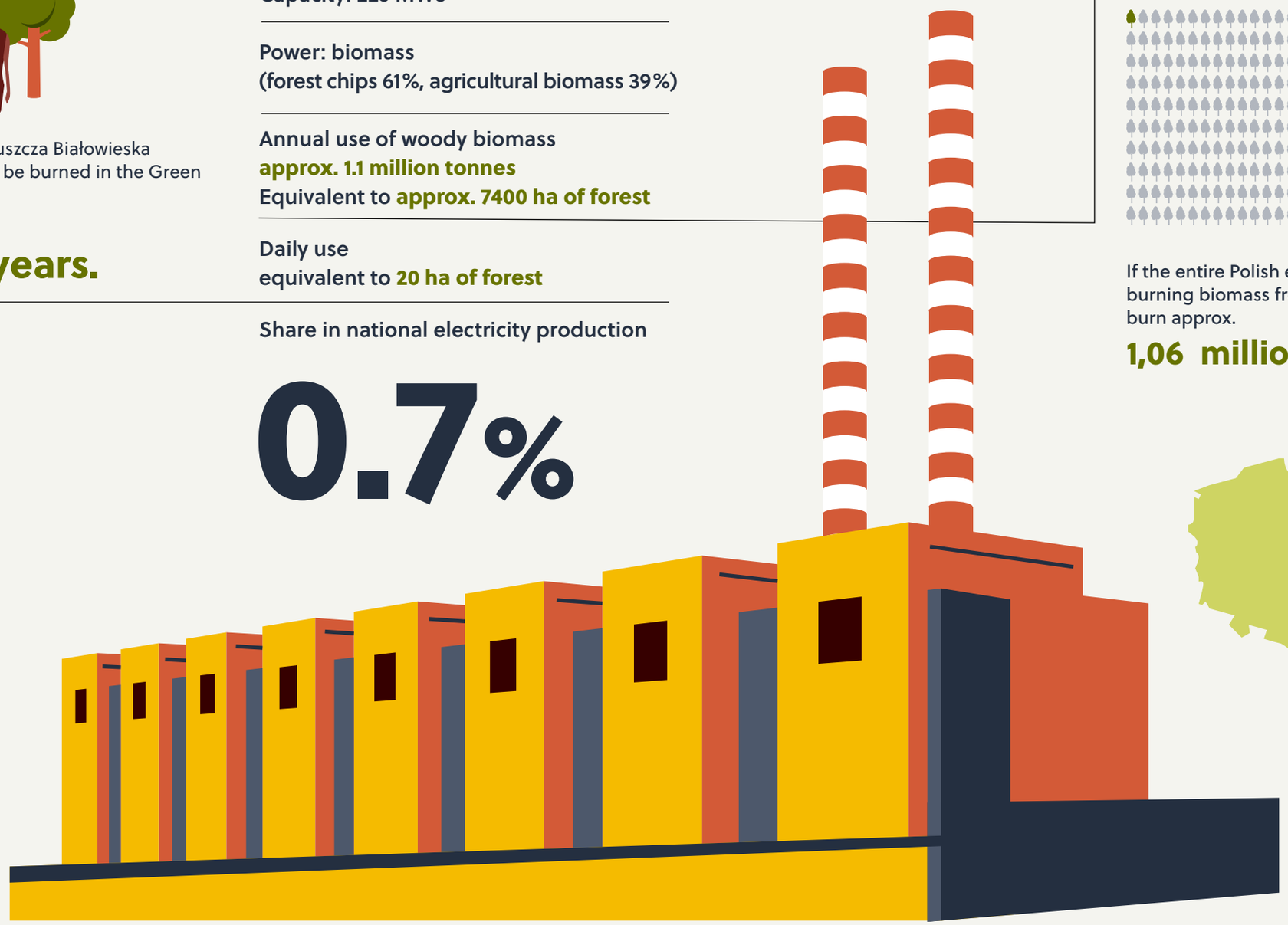
Power: biomass
(forest chips 61%, agricultural biomass 39%)

Annual use of woody biomass
approx. 1.1 million tonnes
Equivalent to **approx. 7400 ha of forest**

Daily use
equivalent to **20 ha of forest**

Share in national electricity production

0.7%



The Green Block burns about

7400ha of forest annually

If the entire Polish energy sector switched to burning biomass from Polish forests, it would burn approx.

1,06 million ha of forest...

which means that Poland's forest cover would be enough for

<10 years.

consumption of forest woodchips was 1.0–1.2 Mt per year. According to the director of the plant's production department, the main fuel is "[...] forest biomass harvested by State Forests as part of their sanitation cuttings".[87] Assuming that forest woodchips with a moisture content of 30% have the density in the loose state of 543 kg/m3, the Połaniec Power Plant burns from to 1,841,620 to 2,209,944 m^3 of woodchips per year.

According to the Forest Data Bank, in Poland the average wood resources per 1 ha in the forests under the administration of State Forests are 274 m^3/ha.[88] The annual wood consumption by the Połaniec Power Plant's Green Block is therefore equivalent to the volume of forest growing over 6721–8065 ha (according to further estimates approx. 7400 ha). This means that the blocks of Połaniec plant consumes the equivalent of 20 ha of forest per day, which translates to 0.83 ha of forest burned per hour. According to the company's reports, in 2016, 47% of the raw material was sourced domestically and 53% was imported.

The Połaniec Power Plant as a whole supplies around 6% of the country's electricity production with a total installed capacity of 1882 MW.[89]. The Green Block alone provides 11.95% of the plant's generating capacity, so it can be assumed that it satisfies about 0.7% of the national electricity consumption. This means that approximately 7,400 ha of forests are burned in order to satisfy 0.7% of Poland's annual electricity demand. If all the electricity produced in Poland were to be supplied by installations such as Green Block, about 1.06 million hectares of forests would have to be cut down annually. Poland's forests cover an area of 9.46 million hectares[90], which means that a power plant based entirely on biomass combustion would clear all of the country's forests in less than 10 years.

Woody biomass in heat and power cogeneration

At present, there are at least 11 units operating in Poland's commercial heat and power (CHP) plants that use woody biomass as their sole or main fuel. These include two plants owned by **the Veolia Group: EC Dalia Łódź[91] and EC Karolin in Poznań.** The owner of the plants reports that these installations burn 80%/20% mix of woody biomass and agricultural biomass respectively.

87 Adam Kwiatkowski, ***Ekoinwestycje Enei Elektrowni Połaniec*** [Enea's eco-investments in the Połaniec Power Plant], Energetyka, June 2020, pp. 257–259, Katowice 2020

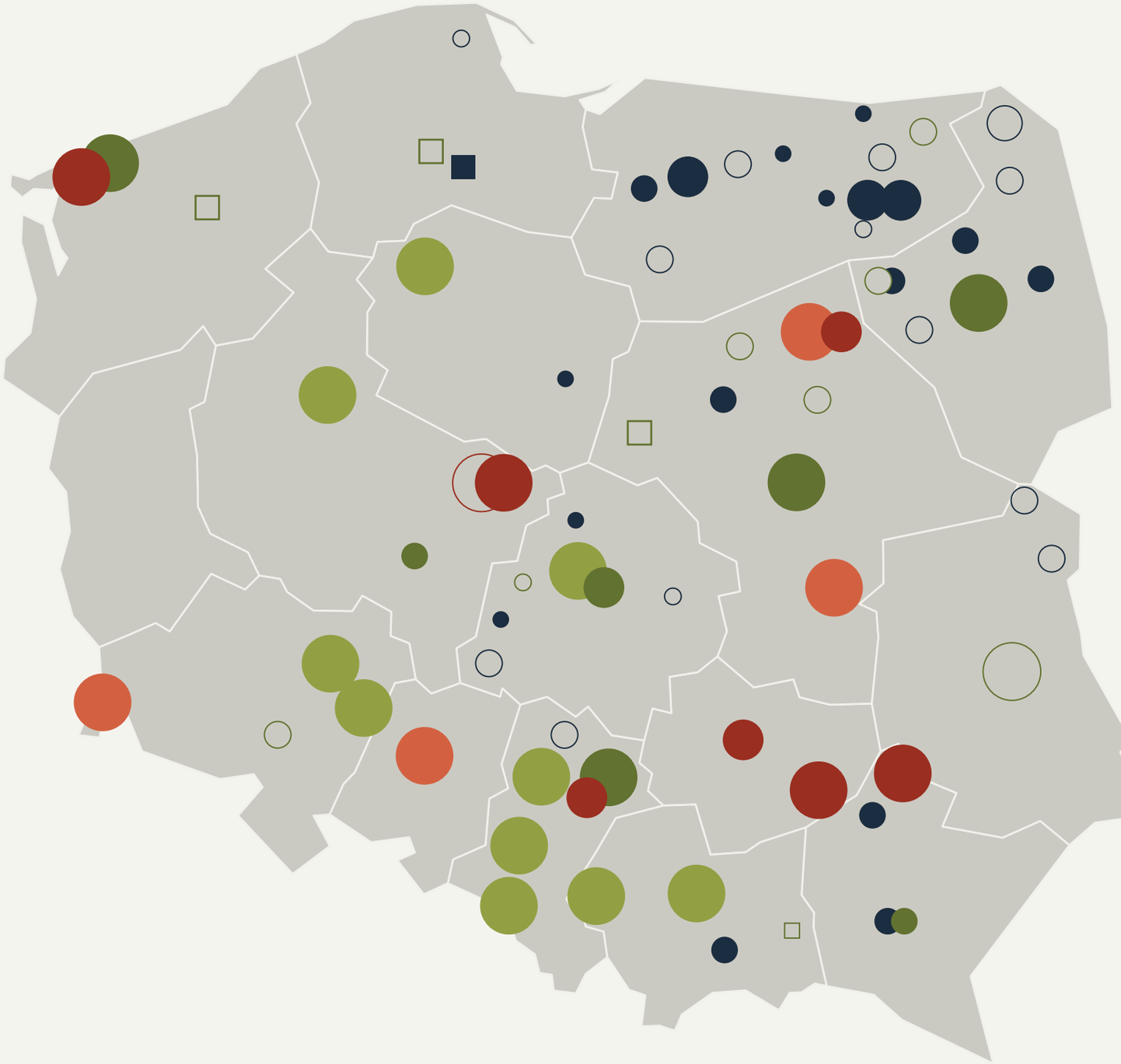
88 Forest Data Bank, ***Krótko o Lasach Państwowych*** [A Brief on State Forests] https://bit.ly/3GARp0n

89 ENEA S.A. Group, ***Information about the company; Introduction***, https://bit.ly/3pP8oWA

90 Central Statistical Office, Forestry Statistics 2020, 2020

91 Veloia, https://bit.ly/3pPslfS

Woody biomass-fuelled power and heating plants



Capacity

- +50 MW
- 20–50 MW
- 5–20 MW
- 0–5 MW

Type of installation

- power plant
- coal-biomass co-firing power plant
- combined heat and power (CHP)
- plant co-firing coal with biomass
- heat plant
- installation in a wood processing plant
- existing installation
- installation under construction

The total woodchips consumption in 2017 at Veolia's installations was 0.27 Mt.[92]

Another large unit operates in Elektrociepłownia Białystok, with its majority owner ENEA Wytwarzanie sp. z.o.o. Group. The Białystok CHP plant is equipped with a double unit, fired with woody biomass and bituminous coal, burning up to 0.5 Mt of biomass and 0.12 Mt of bituminous coal in the two boilers annually.[93] When the second boiler was commissioned, it was reported that ¾ of the biomass (0.375 Mt/year) would come from forestry and the rest from agriculture.[94]

A large biomass-fired unit is also in operation at PGNiG Termika's Siekierki CHP plant in Warsaw. A boiler adapted exclusively for biomass burning was commissioned there in 2015. According to the owners, the main fuel is woodchips from thinning, sanitary logging and forestry residues (so-called fresh woodchips or branch wood), and sawmill woodchips. These account for 78% of the fuel, which is topped up with agricultural biomass. The annual total biomass consumption is about 0.35 Mt, i.e. 0.28 Mt is primary and secondary forest biomass.

The Tychy CHP that belongs to Tauron burns 0.25 Mt of woody biomass per year and the equivalent figure for Elbląg CHP owned by ENERGA Kogeneracja is 0.1 Mt.[95]

The three CHP plants owned by PGE ENERGA S.A., Szczecin, Czechnica and Kielce, burn a total of up to 0.6 Mt of woody biomass annually (0.42 Mt and 0,130.07 respectively). In addition, woody biomass-fired units operate at Elektrociepłownia Ostrołęka A, owned by ENERGA, and CHP Saturn operated by Polenergia.

Woody biomass in municipal and district heating plants

In Poland there are 16 municipal and district heating plants fired solely with biomass. Their total thermal power capacity amounts to 130 MWt. The largest system of this type with a thermal capacity of 25 MWt is operated in Olsztyn, with the annual consumption of 55,000 tonnes of woody biomass. 15 out of 16 of these installations, quote woody biomass as their fuel. Only one installation reported mixing woodchips with agricultural biomass.

92 https://bit.ly/3cug5tq

93 Teraz Środowisko, https://bit.ly/3CtGGCr

94 Gram w Zielone.pl, https://www.gramwzielone.pl/bioenergia/2153/drugi-kociol-na-biomase-w-elektrowni-bialystok

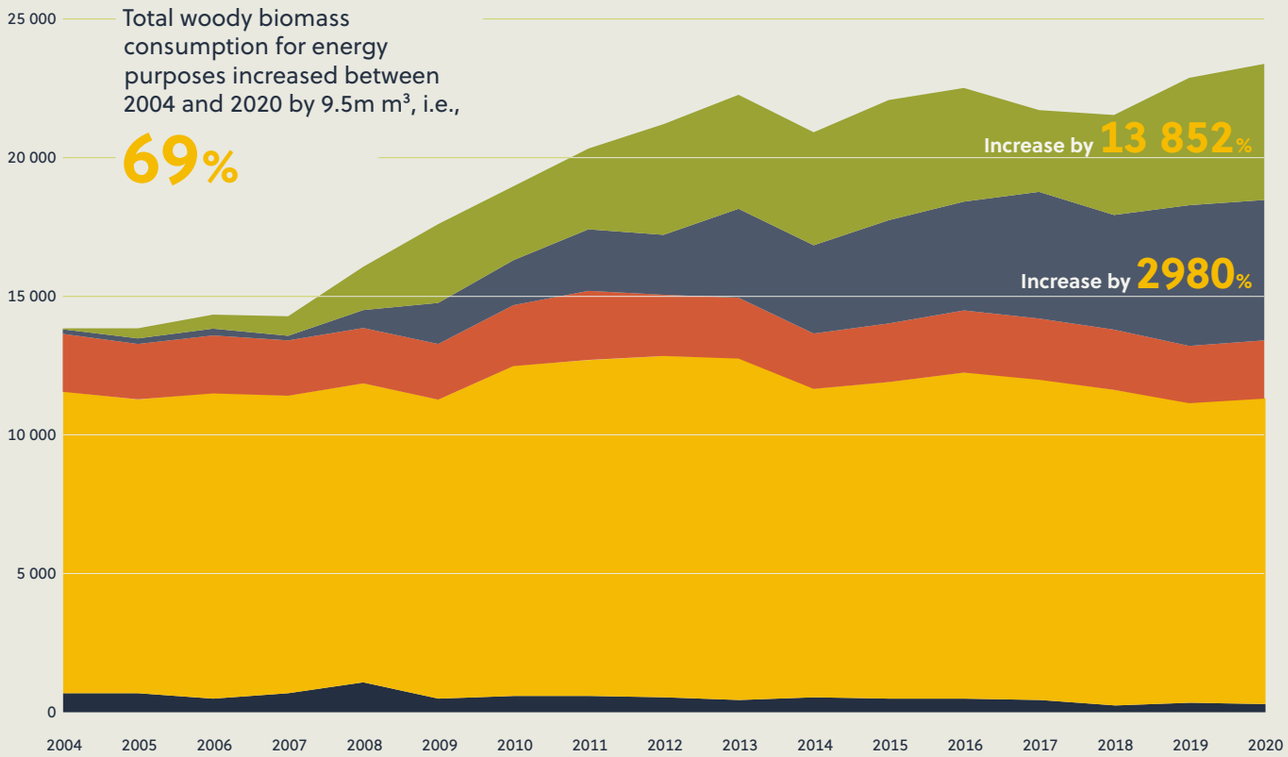
95 PGNIG TERMIKA, BIOMASA W EC SIEKIERKI PGNIG TERMIKA HTTPS://BIT.LY/3GZ7NIG

Woody biomass use in the energy sector

Between 2004 and 2020, the consumption of woody biomass in the energy sector had increased by almost 140 times (by 13852%) from 35,000 m^3 in 2004 to 4.9 million m^3 in 2020. The importance of woody biomass consumption in this sector in relation to the total consumption has also increased significantly. In 2004, the energy sector consumed less than 1% of total woody biomass burned to produce energy in Poland. **In 2020, the figure rose to 21%.**

Over the past 16 years, the increase in the use of woody biomass in the energy industry has been mostly caused by the rapidly growing use of woody biomass in power plants, district heating plants and combined heat and power plants. As recently as 2004, only 33.700 m^3 of woody biomass was used in this sector (all of it in commercial heating plants), while in 2020 it was already 4.3 million m^3. Almost all of the woody biomass (97%) consumed in the energy sector is burned in power plants and CHP plants and commercial heating plants. The rest is consumed by municipal heating plants. Most of the woody biomass in commercial energy facilities (2.7 million m^3 in 2020, 62%) is used to produce electricity; the rest (1.6m^3 in 2020, 38%) is used to produce heat. The importance of woody biomass consumption for heat production has been growing rapidly in recent years. In 2014, 19% of woody biomass consumed for

Woody biomass consumption for energy production in Poland (in thousand m^3) 2004–2020



- Use of woody biomass for energy production in **commercial** power generation (installations producing energy for sale) and **industrial power generation** (installations at industrial sites producing energy primarily for the needs of the site), in all types of installations (power plants, combined heat and power plants and district heating plants).
- Consumption of woody biomass by **wood processing, pulp and paper and furniture industries.**
- Use of woody biomass for energy production **in agriculture**
- Direct consumption of woody biomassfor **household** energy production
- Other woody biomass consumers for energy production in sectors other than i wood processing and paper industries (e.g. food and beverage production), transport and non-commercial heating plants

Data based on CSO (Gospodarka Paliwowo-Energetyczna, issues 2006-2020)

energy production in commercial power generation was used to produce heat, in 2020 it was already 38%.

A significant increase in the consumption of woody biomass for energy production was also recorded between 2004 and 2020. In 2004, industrial power plants and combined heat and power plants consumed only 1,500 m^3 of wood biomass. Over 16 years, this amount increased by more than 600 000 m^3 and in 2020 these installations already burned 606,000 m^3 of woody biomass, mostly for producing electricity (501,000 m^3, 83%) and for heating purposes (105,000 m^3, 17%).

Woody biomass use by individual households and agriculture

A significant share of woody biomass used in Poland for energy production is consumed directly by households. Burned as firewood, pellets or briquettes, woody biomass is one of the key heat sources in Polish homes, used by 30% of Polish households.

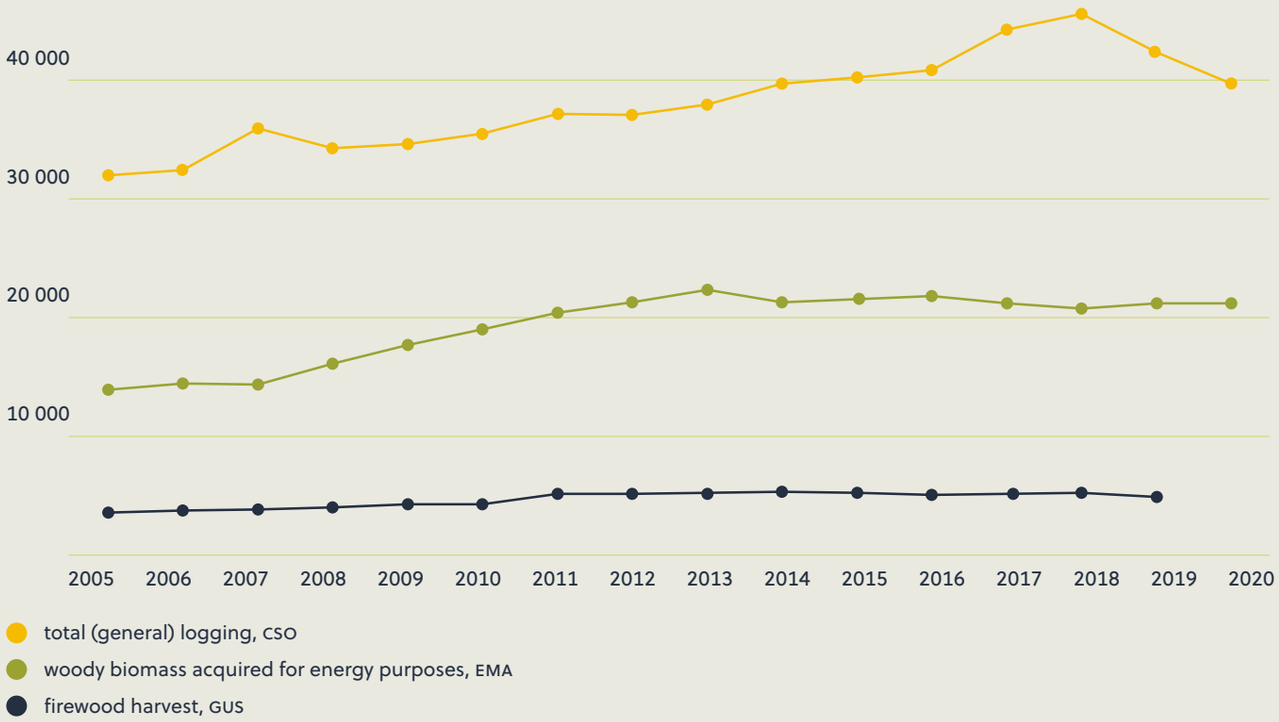
However, the household consumption of woody biomass is characterised by low dynamics, having remained at a similar level in the past 16 years (between 10.6 million m^3 in 2005 and 12.3 million m^3 in 2012 and 2013). In 2020, the household consumption of woody biomass was only 1% higher than in 2004. Due to the rapid increase in the use of woody biomass for energy production in other sectors (energy and industry), the importance of household consumption is declining. In 2004, it accounted for 79% of total energy consumption in Poland, while in 2004, it was only 47%. As in the case of households, the amount of woody biomass consumed in agriculture did not change in any significant way between 2004 and 2020. Throughout this period, it remained at a level between 2 million m^3 and 2.5 million m^3 (in 2011). The share agriculture in the total woody biomass consumption in Poland decreased from 15% in 2004 to 9% in 2020.

Woody biomass use in wood and paper industry

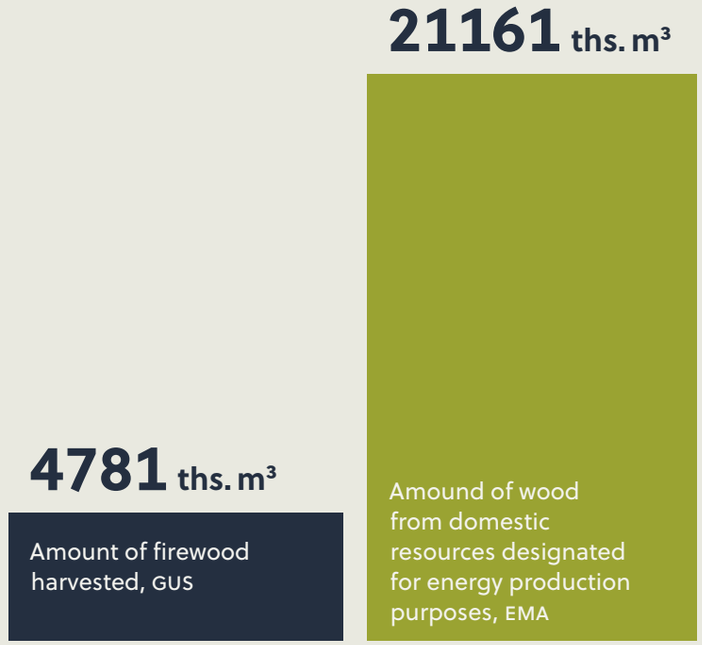
A significant proportion of woody biomass burned for energy production is consumed in industrial processing plants, particularly in the wood and paper industry, which mostly utilizes post-production waste. In 2020, about 5 million m^3 of woody biomass was used in this type of industrial plants to produce energy, which accounted for 22% of all woody biomass used for energy production in Poland in that year. **The consumption of woody biomass for energy production in the wood processing and paper industry increased by nearly thirty times (by 2980%) between 2004 and 2020.**

Logging in Poland (in thousand m³)

2005–2020



2019



The total consumption of woody biomass in energy production

In the period between 2004 and 2020, the total consumption of woody biomass for energy production increased in Poland by 9.5 million m³ (69%) from 13.8 million m³ to 23.4 million m³.

Woody biomass harvest for energy purposes in the National Forestry Accounting Plan (NFAP)

Estimates of the Ministry of Economy concerning woody biomass harvesting for energy purposes in Poland in 2006, and the calculations of the current harvest based on these figures, as well as data published by the Ministry of Climate and Environment together with the Energy Market Agency are much higher than the values presented by Poland in the National Forestry Accounting Plan submitted to the European Commission (NFAP – see Part III). The NFAP contains, among

others, the following information on the volume of timber harvested in forests for energy purposes in the period 2000–2009, as well as the projection of annual harvest for 2019–2025. **According to the NFAP projections, the wood harvested for energy purposes was to amount to 3.56 million m³ in 2019 but according to the Statistical Yearbook of Forestry of the Central Statistical Office (CSO), in that year the harvesting of firewood only amounted to 4.78 million m³. According to the estimates presented above, the harvesting of energy wood in 2019 was approximately 7.5 million m³, i.e. over twice as much as the figure projected in NFAP.**

The reason for this discrepancy in data may be that the State Forests, the largest supplier of timber to the domestic market (over 90% of all timber harvested), fails to keep the record of their customers' business profile, and has no influence on the destination of the raw material purchased. According to the spokesman for the State Forests, approximately 800,000 m³ of wood waste generated during forest maintenance (other than firewood) could have been used for energy purposes in 2020 alone. It cannot be ruled out, he said, that some other sort of wood (e.g. S2AP general-purpose medium-sized timber) is also used in the energy sector.

Officially, State Forests does not sell wood directly to energy companies. Biomass is supplied to large energy companies by firms that specialise in biomass trading, which are often subsidiaries of energy sector giants, such as Bioeko Grupa TAURON sp. z o.o. or Enea Bioenergia sp. z o.o. These companies buy the raw material from State Forests and other suppliers and then convert it to fuel that meets the technical requirements of power and heating plants. The main fuel in biomass burning systems is woodchips, which is not offered by the State Forests in the amount required by the power industry (in 2019 the State Forests sold only 255,000 m³ of woodchips), so it is definitely purchased by companies in the energy sector from other firms specialising in biomass trade.

The reason for the discrepancies in the data may be that the State Forests, the largest supplier of timber to the domestic market (over 90% of timber harvested), fails to keep the record of their customers' business profile, and has no influence on the destination of the raw material purchased.

03 Imports

Woody biomass imports to Poland

Imports of woody biomass to Poland is on the increase, as a result of the introduction of the first RED Directive in 2009. The importance of Belarus as an exporter of energy wood has been growing rapidly since 2012. **In 2013, imports from Belarus exceeded 50% of Poland's total woody biomass imports, and by 2020 they reached 79.6%. Currently 87.9% of the imported woody biomass comes from Belarus, Ukraine and Russia** – the countries known for their low standards of nature conservation in forests.

Imports of woody biomass used for energy purposes are growing. According to CSO and Eurostat data, woody biomass imports increased ninefold between 2010 and 2020. **In 2010, Poland imported 0.21 Mt of woody biomass for energy purposes, and in 2020, the figure reached 2.19 Mt, which was an increase of 917%.**[96]

96 Based on data quoted by CSO in June 2021, downloaded from globaltimber.co.uk

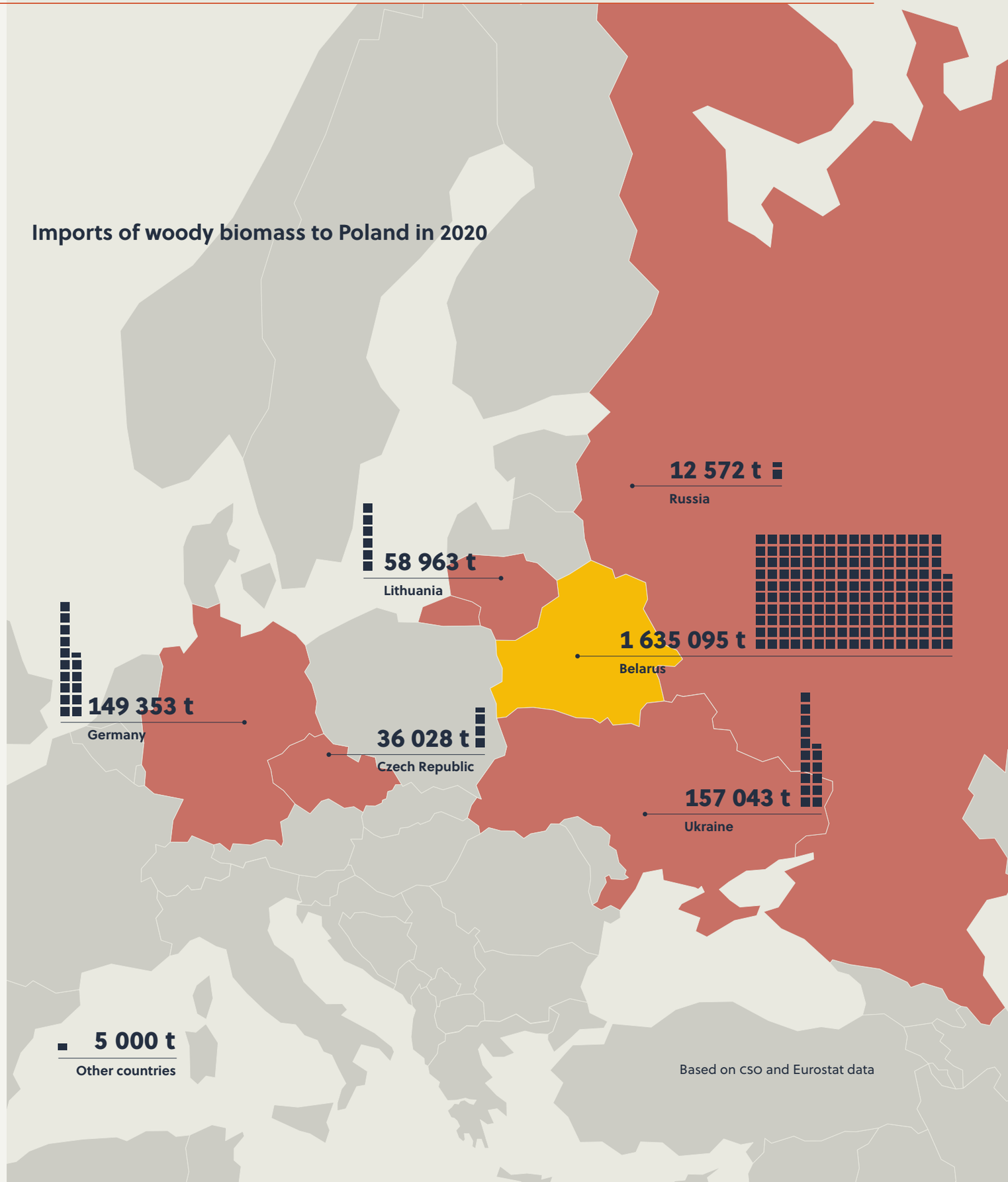
2021 will certainly be another year of intensified imports, as indicated by the results for Q1 2021 (0.94 Mt). 2019 was a record year, with Poland having imported 2.44 Mt of woody biomass.[97] The **rapid increase in the imports of woody biomass for energy purposes is due to the adoption of the RED Directive by the European Union in 2009, which recognises wood as a zero-emission, renewable source of energy** and sets as an objective of an increase of biomass consumption and the mobilisation of new sources of biomass, also from outside of the EU.

Poland's CSO does not provide information on woody biomass imports with a breakdown into forest and agricultural biomass. Yet we can assume that in the case of Polish imports it is practically all forest biomass (primary and secondary), because the countries that export biomass to Poland (with the exception of Germany) hardly have significant energy tree crops, and their wood trade is based on extensive forest management over large forest areas (e.g. Belarus, Russia, Lithuania).

Poland imports the majority of its woody biomass from outside the European Union. **In 2010-2020, 82.2% of all imports came from three countries: Belarus (67.4%), Ukraine (13.7%) and Russia (1.1%). In 2020, the share of these three countries in Poland's biomass imports reached 87.9%.** At the same period woody biomass

97 Global Timber UK, https://bit.ly/2zGq3vR

Imports of woody biomass to Poland in 2020



was imported from Germany (7.9% of total imports), Lithuania (4.6%) and Slovakia (1.7%). In the period from 2010 to 2020, total imports from the EU amounted to 17.4%. The share of imports from other countries was negligible.

Imports of forest biomass from non-EU countries have been growing strongly in recent years. Total imports from outside the EU increased by 1255.3% in 2010–2020. Imports from the EU countries increased by 38.0%. **In 2010, Poland imported 57.5% of woody biomass for energy purposes from outside the EU. In 2020, it was as much 87.9%.** Unlike other European countries (e.g., UK, Denmark or the Netherlands[98]), Poland does not import significant amounts of forest biomass from outside of the European continent. In fact the majority of woody biomass is imported to Poland from its neighbours.

In the recent years, the imports of forest biomass from non-EU countries have risen sharply. The total import from non- EU countries increased by 1255.3% in the period 2010-2020. The import from the EU countries has risen by 38%.

The forms of woody biomass imported to Poland

Poland primarily imports woody biomass in the form of coniferous and deciduous woodchips (60.0% on average in the whole period analysed and 74.7% in 2020). In the last decade, there has been a significant increase in the share of woodchips in Poland's woody biomass imports. In 2010–2012 they accounted for up to several percent of total import figures, and in 2013 they became the main form of imported biomass.

Their share in the imports for the period of 2010–2020 had been relatively stable at around 70% of the total import figure. The second most popular form of woody biomass (average share 23.7%) was sawdust and waste from wood processing in various forms (including briquettes), followed by wood pellets (7.6%), charcoal (6.4%) and firewood (2.3%). In 2010-2012, sawdust and wood waste were the main imported wood raw material.

In 2010-2020, almost all woodchips was imported to Poland from Belarus. In this period, 86.9% of biomass in this form was imported from Belarus (increasing from 45.6% in 2010 to 92.6% in 2020). Wood pellet was mainly imported (73.9%) from Ukraine (68.4% in and 2010 and 75.5% in 2020). **Total import of woodchips increased by 416% and of pellets by 328% during the period under review.** Sawdust and wood processing waste are losing their position in the Polish imports of forest biomass. They showed the lowest (53%) growth in the analysed period of ten years, nevertheless, they remained the

98 6 November 2020, Euractiv, *EU should support efforts in Denmark and Netherlands to stop wood¬ burning*, https://bit.ly/3vUKyKe

second most important forms of woody biomass imported during that period.

Ukraine was the largest exporter of firewood to Poland (40.9% of the total export figure), followed by Germany (37.5%), Belarus (8.9%), Slovakia (6.2%) and the Czech Republic (4.8%). **The imports of firewood to Poland increased by 143% in 2020 compared to 2010.**

Import of energy in the form of woody biomass

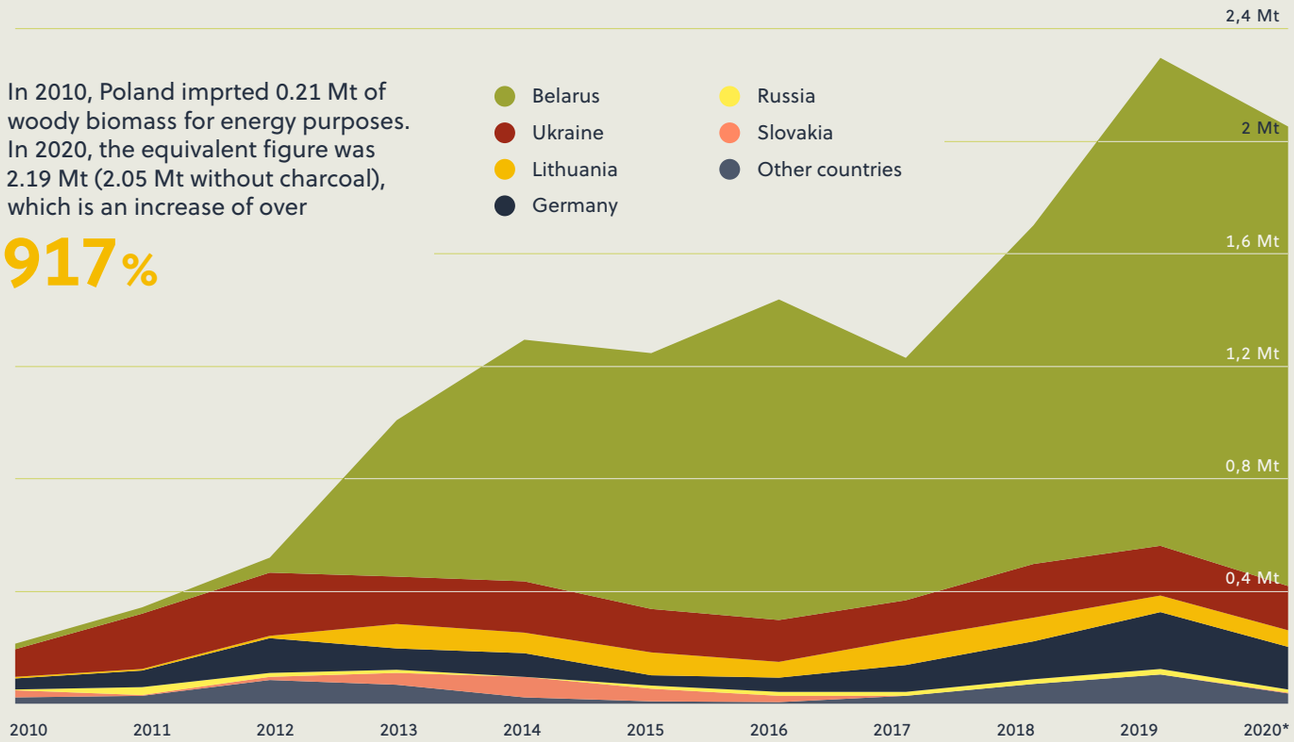
In order to compare different sources, fuels and carriers of renewable energy, the mass or volume of the raw material is often converted into energy units – terajoules (TJ). For our calculations, we used the energy density of one kilotonne of woodchips equal to 12.5 TJ, wood pellets 17 TJ, firewood 15 TJ, sawdust and wood waste 12,5 TJ,[99] and charcoal 31 TJ.[100]

In 2020, Poland imported 30,411 TJ of energy in the form of woody biomass. This is an increase of 956% compared to 2010. The main energy carrier in the period 2010–2020 was woodchips with an average share of 60.2%, followed by sawdust and waste (12.7%), pellet (10.1%) and finally firewood (2.7%). Poland imports energy mainly in the form of unprocessed biomass (woodchips and firewood), whose share amounted to 62.9% in the analysed period. Processed biomass (pellets, charcoal) accounted for 25.1% of Poland's imports. The remaining 12% of energy was imported as sawdust and waste. **The importance of woodchips as an energy carrier is clearly increasing. In 2020, as much as 67.1% of energy was imported in this form.** The share of pellets, sawdust and waste, and firewood is decreasing (8.2%, 9.6% and 2.0% respectively in 2020).

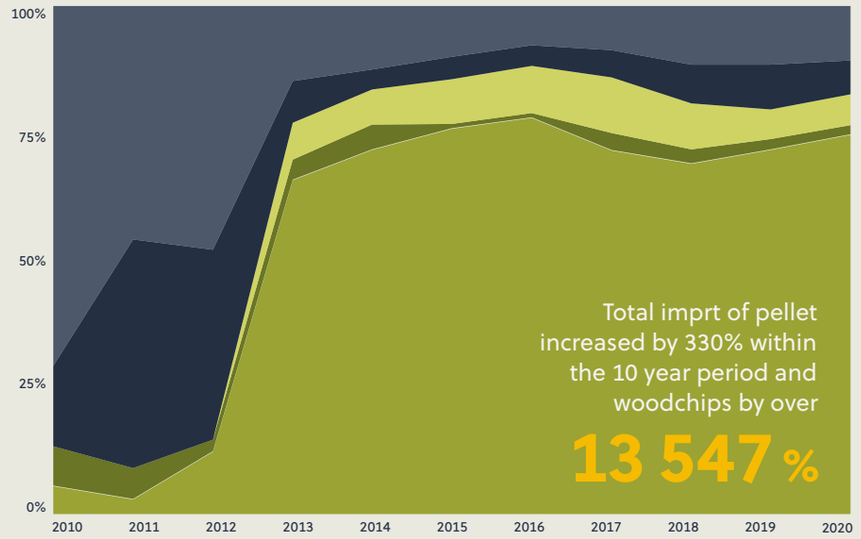
99 Forest Research, https://bit.ly/3nDoSeR
100 FAO, https://bit.ly/3mmJxr8

Imports of woody biomass to Poland (2010-2020)

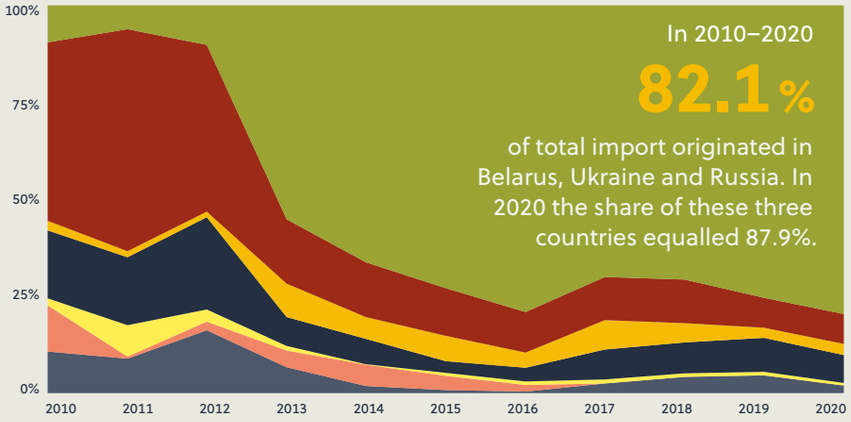
Volume of imported woody biomass (excluding charcoal) by country

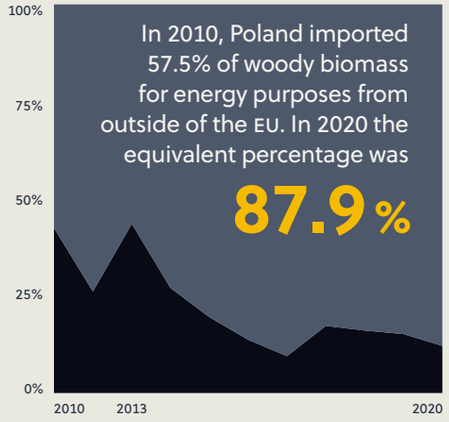


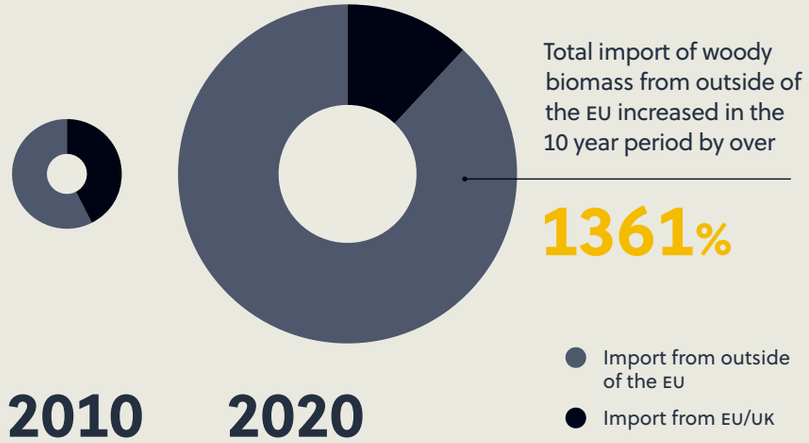
The form of imported biomass



The share of individual countries in woody biomass imports







* Data for 2010-2012 (Eurostat), 2013-2020 (CSO).

04 Exports

Woody biomass exports from Poland

The volume of forest biomass exported from Poland for energy production has increased over the past 10 years. Modernisation of the biomass sector, which has been underway since Poland's accession to the EU, has led to an increase in the significance of processed woody biomass sales. Wood pellets are becoming an increasingly popular export commodity compared to less-processed forms of biomass (firewood or woodchips). The main buyers of Polish woody biomass are Western European countries, especially Germany, Italy and Denmark.

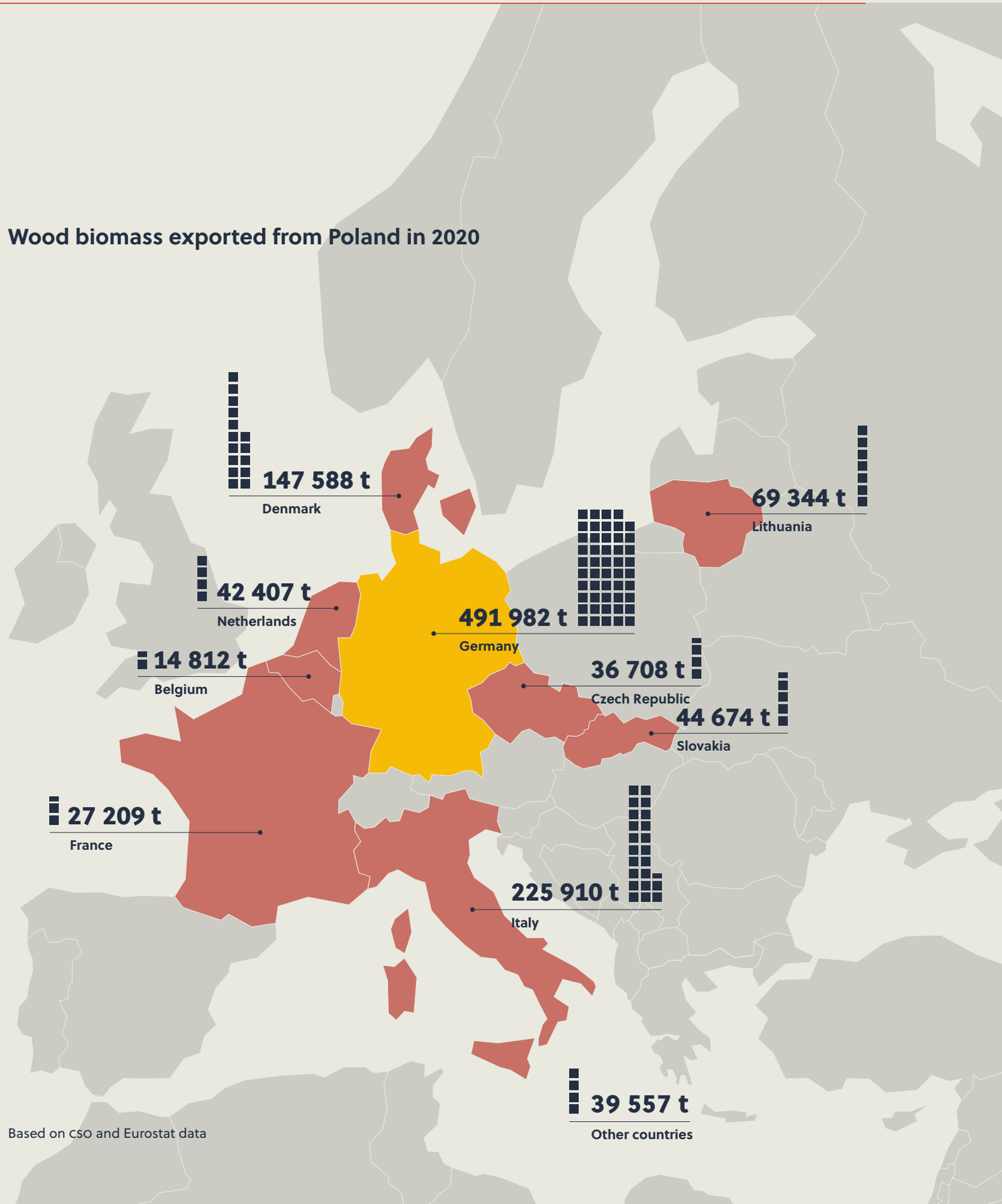
Notably, Poland's exports of forest biomass are growing more slowly than imports. **In 2010, Poland sold 0.52 Mt of forest biomass and in 2020, 1.14 Mt of biomass, which represents an increase of 119%.** The record year in the analysed period was 2018,when 1.49 Mt of woody biomass was exported from Poland.

Importers of woody biomass from Poland

Polish exports of forest biomass are almost entirely focused on EU member states. Between 2010 and 2021, the share of exports to the countries inside the EU and the UK averaged 99.2%, without falling below 99% in any given year. 97% of biomass is exported from Poland to the nine EU countries.

The largest recipients of Polish biomass were Germany (55.6% of total exports in 2010–2020), Italy (13.3%), Denmark (12.7%), the Czech Republic (6.0%), Slovakia (4.0%), Lithuania (2.1%), Belgium (1.4%), France (1.3%) and the Netherlands (1.0%). Looking at the share of individual countries in exports in the period under review, the total export to Germany increased by 56.1%, while the share of Germany alone fell from 60.7% to 41.1% in 2020. Exports to Italy are marked by dynamic growth. In 2010, Poland exported 5.2% of its raw material to Italy, and by 2020 the equivalent percentage was 20.2%. In fact total exports to Italy have increased by 737% over a period of 10 years. Biomass export to Slovakia is also growing fast (increase by 3116%), although it does not account for a large share of the total. The share of exports to Denmark, which imported 24.5% of Polish woody biomass, fell by half, and in 2020 it amounted to only 12.5%.

Wood biomass exported from Poland in 2020



Based on CSO and Eurostat data

Exports by form of woody biomass

The structure of woody biomass exports changed noticeably in 2010–2020. The share of firewood and waste decreased in favour of processed biomass. The share of woodchips remained at a similar level. The export of sawdust and wood-processing waste dominated in 2010 (63.3%), followed by firewood (20.7%), woodchips (15.6%) and finally pellet (0.43%). **Pellet became the main form of exported woody biomass with a share of 44.9% between 2010 and 2020.** The share of sawdust and waste decreased to 36.3%. The export share of firewood increased in the analysed period, however, in the in 2020 in terms of its volume the figure was the same as in 2010. The exports of woodchips (total increase of 67%) and sawdust, wood processing waste (42%) are also on the increase, but their share is dropping in favour of wood pellets.

In 2010, Poland exported 0.096 Mt of firewood, and in 2020 the figure was 0.095 Mt, but in-between exports were higher and reached 0.166 Mt in 2013 and 0.166 Mt in 2019. Germany was the top importer of firewood from Poland (96.6% in 2010–2020), followed by Denmark (7.9%), Italy (3.1%), the UK (2.8%), France (2.4%) and Slovakia (2.1%). The exports to Germany fell from a 70% in 2013 to 50% in 2009. The highest growth in exports in 2010–2020 was recorded in Slovakia, the United Kingdom, Italy and France.

The structure of forest biomass exports changed noticeably between 2010 and 2020. In 2010, the export of sawdust and wood processing waste (63.3% share) dominated, followed by firewood (20.7%), woodchips (15.6%) and finally pellet (0.43%). In the 2020, pellet became the main export raw material with a share of 44.9% from to2010), while the share of sawdust and waste dropped to 36.3%.

The total exports of woodchips increased from 0.07 Mt in 2010 to 0.12 Mt in 2020 (an increase of 66.6%). The structure of exports has also changed rapidly over the decade. The main customers for this type of biomass were Germany, the UK, Lithuania, Italy, Denmark and the Czech Republic. Most woodchips were sold to Germany (17.2% of the total sales figures) while exports to Lithuania are growing dynamically. In 2010 Poland exported 1.4% of woodchips to Lithuania and in 2020 it was 40.7%.

Wood pellets are the fastest growing type of forest biomass exported from Poland and largest in volumes. In 2010, Poland sold only 0.002 Mt of pellets, and in 2020 it was 0.51 Mt. The structure of exports had been changing; in 2010–2012, Denmark was the largest importer of pellets from Poland, then in 2013–2017 it was Germany, and in 2018–2021 it was Italy that became the main buyer of pellets. These three countries received a total of 89% of Polish pellets in the analysed period. Their share in 2020 was respectively 36.2% Italy, 23.0% Denmark and 21.4% Germany. The fastest import growth was noted by

the Netherlands, which in 2010 was still importing pellets from Poland in insignificant quantities but in 2020 it bought 7.8 % **of all exported pellets.**

Sawdust and wood processing waste were the most important form of forest biomass exported from Poland, although their share is decreasing in favour of pellets. In 2010, it amounted to 0.29 Mt and in 2020 it was 0.41 Mt (increase by 45%). Germany was and still is the largest importer of this type of raw material (61.5% in 2010–2020). Other top importers of Polish sawdust and wood waste were Italy (9.8% share), the Czech Republic (9.3%), Slovakia (7.9%), Denmark (4.7%), Lithuania (1.8%) and Belgium (1.7%).

These data show that Poland is increasing its exports of processed biomass, primarily in the form of pellets. The boom for wood pellets in Europe is also boosting exports of woodchips, sawdust and waste, which are the raw materials for their production.

Poland's energy exports in the form of woody biomass

Poland's export volumes of energy contained in woody biomass is increasing. In 2010, 7001 TJ of energy was exported from Poland, and in 2020 it was already 16 790 TJ, an increase of 140%. 2019 was a record year, with energy export reaching TJ20958.

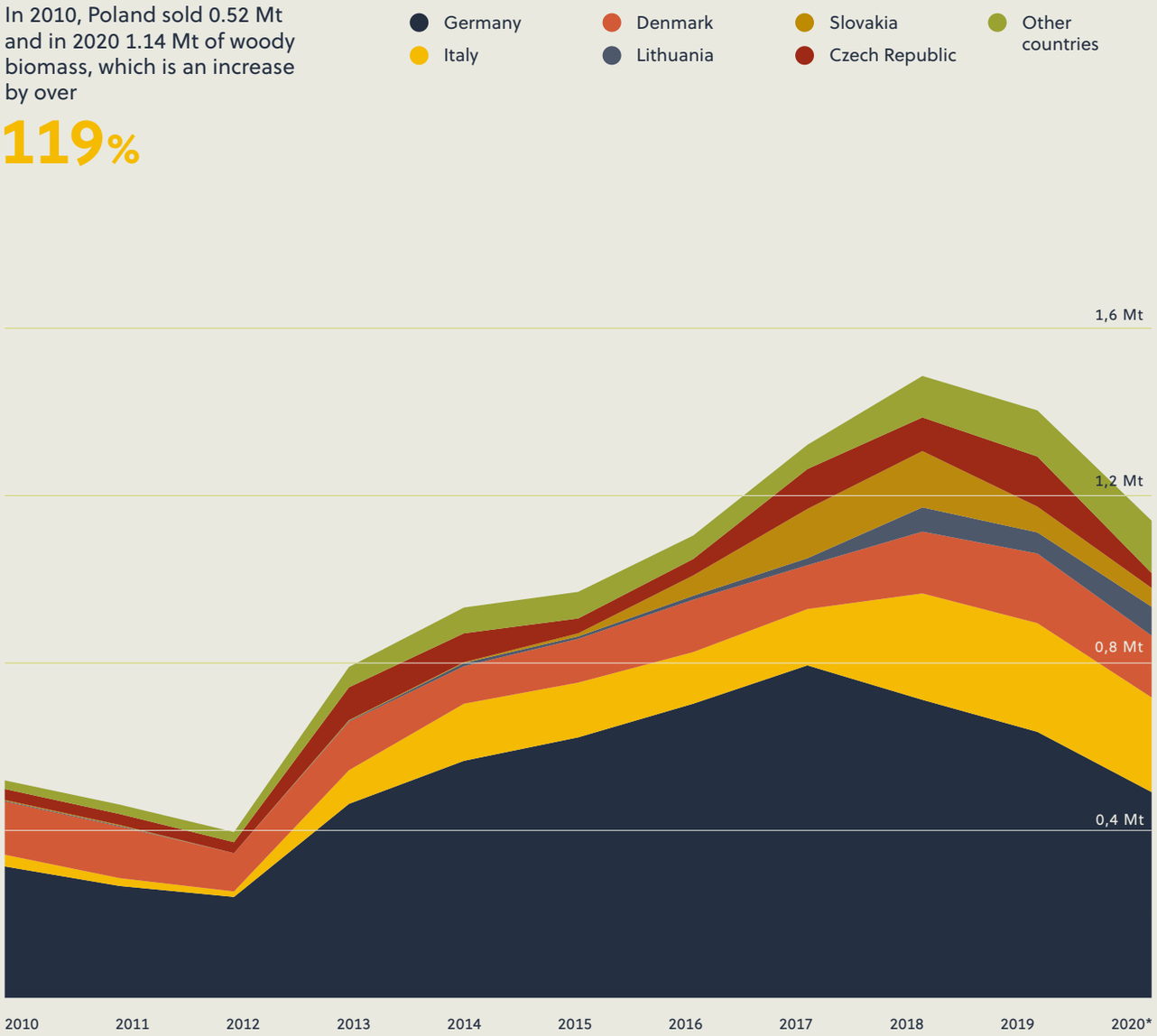
Most energy was exported from Poland in the form of sawdust and wood waste (44.8%), followed by pellet (32.7%), firewood (14.1%) and woodchips (8.4%). Energy export in the form of pellets is growing fastest (761.0% increase between 2010 and 2020), followed by woodchips (66.6%) and waste (41.6%). The export of energy contained in firewood decreased by 1.1% in the analysed period, but kept growing between 2010 and 2019.

Woody biomass export from Poland (2010-2020)

Volume of woody biomass export by country

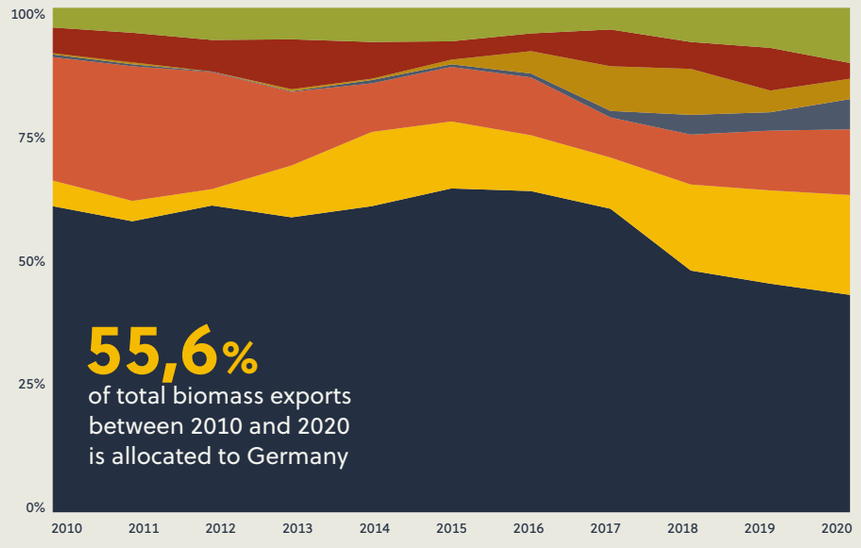
In 2010, Poland sold 0.52 Mt and in 2020 1.14 Mt of woody biomass, which is an increase by over

119%

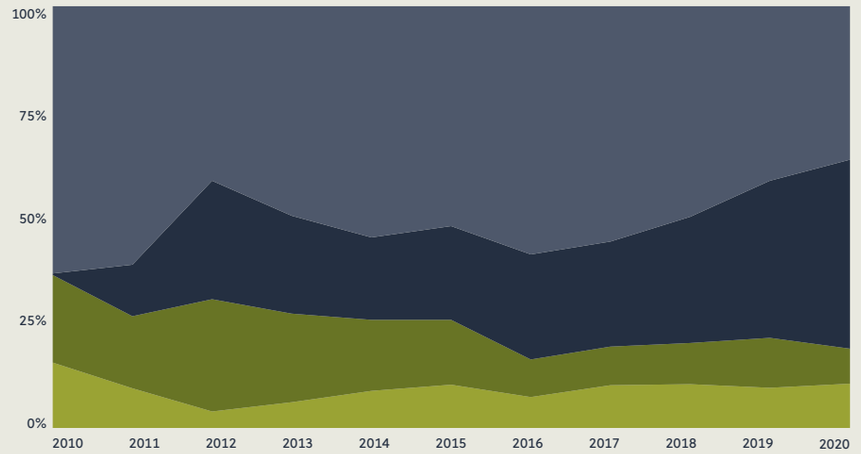


* Eurostat data

The share of countries in woody biomass export



The form of exported woody biomass



Primary biomass:
- firewood
- woodchips

Secondary biomass:
- sawdust and wood waste
- wood pellet

05

Financial support for biomass

Grants and other financial support mechanisms for biomass energy generation

Poland's accession to the European Union opened the way for the use of EU funds for modernisation of its economy. One of the key objectives of the EU is to increase the share of RES in the European energy mix, both in the commercial, municipal and household energy sectors. As biomass is classified as a renewable energy source, the related projects can count on EU subsidies. Between 2003 and 2021, more than 600 projects related to biomass combustion received funds of total value PLN 2.8bn (including 912m from EU funds).

EU subsidies for harvesting, production and use of woody biomass for energy purposes 2003–2021

Poland keeps a register of all projects that have received European funding since 2003, i.e., from the pre-accession period. The register contains over 600 energy biomass projects. Not all of the project descriptions state whether they involve forest or agricultural biomass, but most state the use of woody biomass as their objective. The total amount spent on these projects was approximately PLN 2,803 m, including the EU co-financing of PLN 912 m. The EU funds were transferred under the following programmes:

- Operational Programme Infrastructure and Environment
- Regional Operational Programme
- Integrated Regional Development Operational Programme,
- Operational Programme Innovative Economy
- Intelligent Development Operational Programme
- Operational Programme Human Capital
- Sectoral Operational Programme Restructuring and Modernization of the Food Sector and Rural Development
- Improvement of the Competitiveness of Enterprises Programme.

The largest EU funding was allocated to the construction of new commercial power plants, heat plants and CHP fueled by woody biomass, the co-firing of woody biomass with coal, and the modernisation of coal-fired boilers for combustion of biomass. The money came from the Operational Programme Infrastructure and Environment (2007–2014 and 2014–2020), and from the Improvement of the Competitiveness of Enterprises Programme (2004–2006). Municipal CHP companies dominate among the projects. Co-financing has been granted to 38 investments, 24 of which are still in the implementation phase. Only one project (heat and power plant in Ełk) clearly specifies agricultural biomass (straw) as its fuel. Other projects identify woodchips or forest woodchips as their fuel, which means that it is a safe assumption that **37 of the supported installations are and will be burning woody biomass.** Four projects concerned modernisation of boilers and biomass co-firing installations, another five involved connecting new electricity generation capacity.

In 2004–2021, the total expenditure for these projects was PLN 2015 m, including PLN 477 m of EU co-financing. About 625 MW of new generation capacity was connected as part of these investments. Most of the co-financed projects related to replacing boilers fired with coal with those fired with wood pellets in farmsteads, individual households and public utility buildings, such as schools, nurseries, nursery homes and local governments facilities. The beneficiaries were mainly local municipalities, striving to improve the air quality in their area. Farmers

COGENERATION, HIGH-EFFICIENCY COGENERATION – simultaneous generation of heat and electricity in a single technological process, which increases energy efficiency. The effectiveness of high-efficiency cogeneration installations can reach up to 90%. → p. 106

EU programmes

- → Operational Programme Infrastructure and Environment
- → Regional Operational Programme
- → Integrated Regional Development Operational Programme,
- → Operational Programme Innovative Economy
- → Intelligent Development Operational Programme
- → Operational Programme Human Capital
- → Sectoral Operational Programme Restructuring and Modernization of the Food Sector and Rural Development
- → Improvement of the Competitiveness of Enterprises Programme

also constituted a large group of beneficiaries. Most of these projects offered a choice of switching from coal to biomass or gas, so it is difficult to determine exactly how much money was spent on biomass alone. Between 2003 and 2021, PLN 567 m was spent on projects concerning the installation of boilers and modernisation of boiler plants, of which PLN 346 m came from EU funds. The main source of grants was the provincial operational programmes for regional development, with co-financing rates as high as 99% if the project aimed at improving air quality in the municipality.

The second largest group of beneficiaries in terms of the number of co-financed projects included the producers of wood pellets, woodchips and briquettes, who received funds to purchase biomass harvesting machinery, woodchippers and production lines. Approximately PLN 221 m, including PLN 89 m from EU funds was spent on these projects. Among the co-financed projects were grants for the production of pellet boilers and innovations in boiler design, improvement of biomass combustion processes, and innovative methods of pellet and briquette production.

Funds for these purposes were allocated both to the private and public sector companies, e.g., for the development of an improved method of biomass burning in a research and educational unit. PLN 59 m, including PLN 29 m of the EU funding, was earmarked for these purposes.

The 'Clean Air' Programme

An important source of subsidies for energy biomass is the Clean Air programme, run by the Warsaw based National Fund for Environment Protection and Water Management as part of the Good Air Quality measure. The programme began in September 2018, and since then 264,603 heat sources have been replaced in individual households throughout Poland. **51,544 of these new heat sources are biomass boilers, i.e., primarily wood pellet fired boilers** (as of August 2021).

Good Air Quality: Stop Smog programmes, Improvement of air quality in the most polluted municipalities (pilot), Improvement of air quality through replacement of heat sources in multi-family buildings (pilot).

Other programmes, similar to Clean Air are Stop Smog, Improvement of air quality in the most polluted communes (pilot) and Improvement of air quality through replacement of heat sources in multi-family buildings (pilot). These programmes aim to improve air quality in municipalities by replacing high-emitting solid fuel cookers with biomass boilers, gas boilers or by connecting individual consumers to a district heating network. They targeted municipalities and allowed for the change to a pellet boiler if the building was not connected to a district heating or gas network.

Good Air Quality: Regional Heat Supply Programme

Another programme included in the Good Air Quality is the Regional Heat Supply Programme, which aims to decarbonise heat production and improve air quality through investment in renewable energy sources. A call for applications is currently underway. The programme is addressed to capital companies that produce heat for municipal and household purposes, which have 50% share of local government units. The entry condition is that the total installed capacity of the equipment owned by the company does not exceed 50 MW. The companies may apply for funds for modernisation of their installations together with their connection to the network. Biomass will probably be the most popular fuel, as new units that are gas fuelled are excluded from the co-financing. The entire programme has been allocated PLN 500 m, of which PLN 150 m is in the form of non-repayable grants and PLN 350 m as repayable loans.

Energy Plus Programme

Another ongoing programme of subsidies for investments in RES, including in woody biomass, is the ***Energia Plus*** programme aimed at enterprises, scheduled for 2019–2025. According to the National Fund for Environment Protection and Water Management, the aim of the programme is to reduce the negative impact of enterprises on the environment, including improvement of air quality. Enterprises will be able to benefit from subsidies for the installation of additional generation capacity from RES and highly efficient co-generation of energy from RES. It targets larger enterprises that plan to install at least 50 MW of new capacity. The programme's budget amounts to PLN 4 bn and is based primarily on repayable loans of up to PLN 3.95 bn and non-repayable grants of up to PLN 50 m. The call for applications is currently underway.

European Economic Area Financial Mechanism (EEA FM) and Norwegian Financial Mechanism (NFM) 2014–2021

The third edition of the programme Environment, Energy and Climate Change is currently implemented under the so-called Norwegian Grants and the EEA Financial Mechanism, with EUR 157 m to be distributed. The programme is divided into three sections: energy, climate and environment. The energy sector is the largest, with funds amounting to EUR 112 m. The programme is designed to finance, among others:

- development of high-efficiency industrial and commercial cogeneration
- construction/modernization of municipal heating systems and liquidation of individual heat sources
- construction of installations for the production of fuel (pellets) from agricultural and forest biomass[101].

This is another mechanism, apart from EU and national funds, which can support investments into forest biomass for energy purposes.

101 NFOŚiGW, https://bit.ly/3pP9tO8

06

Planned investments

Planned investments into woody biomass energy in the energy sector

The National Energy and Climate Plan for 2021–2030 provides for rapid development of the bioenergy sector in Poland. By 2030, the consumption of solid biomass for energy production is to increase by 53% compared to the consumption in 2015. The net installed capacity of electricity sources using biomass is to more than double from 658 MW to 1531 MW, while gross electricity generation from solid biomass is to increase from 9.6 TWh (2020) to 11.6 TWh (2030). Over the next ten years, between 2020 and 2030, PLN 10.5 bn is to be invested in the production of electricity from biomass. The implementation of these plans will require the construction of at least several large biomass-fuelled power units.

In August 2021, the ZE PAK S.A. Group signed a contract for the connection to the network of two power units fuelled with woodchips in the Konin Power Plant which belongs to the ZE PAK. The total installed capacity will equal 100 MW. The first boiler of 50 MW capacity will

be launched in October 2021. The investment is to be completed by November 2022 at a cost of PLN 212.8 m.[102] Once the new boilers are in place at the Konin Power Plant, Poland's commercial biomass-fuelled electricity generation capacity will increase by 10.5%.[103]

New investments in heat generation and high-efficiency cogeneration

24 new woody biomass fuelled heat and power plant projects are currently under construction; 19 of these are new municipal heat and power plants. The capacities of the new municipal CHP plants vary from a few to several megawatts of thermal power (MWt) and several megawatts of electrical power (MWe). The total installed capacity of most of the individual projects does not exceed 20 MW. This means that these installations will not have to meet the criteria of greenhouse gas emission or the efficiency criteria of energy generation from biomass resulting from the RED II Directive (in its current form). This does not mean that the newly created installations are outdated, high-emission or low-efficiency, but that they are exempt from the need to invest in the latest technologies available.

The largest investment among these municipal CHPs is underway in Lublin, where ME- GATEM EC-Lublin Sp. z o.o. is building a thermal power plant with a heating capacity of 40 MWt and 12 MWe of electricity. The project will cost PLN 219 m, of which PLN 42 m will be co-financed from the Operational Programme Infrastructure and Environment 2014–2020. Forest woodchips (90%) and willow (10%) are to be used as fuel. The installation will burn approximately 140,000 tonnes of fuel per year.

A 12 MWt heating plant is also being built in Tarnowskie Góry by a private company, Veolia. The company has declared that the installation will burn 22,000 tonnes of woodchips per year. The total cost of the installation amounts to PLN 27 m, and the subsidy from OPI&E 2014–2020 will come to PLN 10 m.

Other investments include three large biomass-fired boilers on the premises of large wood-processing plants. These plant-based boilers are designed to have a capacity of several MW, which is the equivalent to that of a district heating plant supplying heat to a small town.

102 18 August 2021, Biznes Alert, https://bit.ly/3mpRlbs
103 Own calculations based on ERO, Information on investment plans in new generation capacities in 2020–2034, 2021

PART III

Forest biomass in European law

The Directive on the promotion of the use of energy from renewable sources (The RED Directive)

In the European Union, the use of forest biomass for energy purposes is regulated by the directive ***on the promotion of the use of energy from renewable sources,*** called the RED II directive. It contains regulations concerning the use of biomass for energy purposes, use and production of biofuels, and it also sets the targets for bioenergy production from these energy carriers in the timeframe 2021–2030. RED II was published in December 2018 as a revision of the first RED Directive 2009, which had determined the targets and activities of the EU in the scope of renewable energy until 2020.

The RED Directive of 2009 aimed at increasing the use of renewable energy sources, reducing greenhouse gas emissions and meeting the provisions of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC).[104] Its goal was to reach a 20% share of renewable energy sources in the energy mix of the European Community by 2020. As a result of the adoption of the directive, the production and consumption of biomass and biofuels by the EU Member States has increased rapidly, which has resulted in a number of threats to the environment and the climate. The direct effect of accepting RED was, and still is, an increased pressure on the world's forests (which have become one of the sources of biomass for the European energy sector), and a destruction of south-east Asian rainforests, cut down for plantations of oil palms for biofuel (RED accepted the target of 10% biofuel share in transport by 2020). The main reason for these problems is the fact that the directive recognized biomass and biofuels as renewable, zero-emission sources of energy, despite the reports from the world of science which questioned that approach. The RED regulations have been implemented into the Polish legislation (see Part II of the report). However, the first RED directive of 2009 does not contain any criteria or guidelines which would ensure that the acquisition of biomass has no negative impact on forests and the climate. Moreover, it clearly indicates the need to "mobilise new biomass resources" (including those from outside of the EU), which – together with the lack of adequate legal safeguards – has led to the destruction of large areas of the world's forests, including the extremely valuable natural forests, for the needs of the European bioenergy market.

104 Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance)

RED II Directive

Nine years after the adoption of the first directive, the second (RED II, 2018.) was announced, aimed at eliminating the deficiencies of the previous directive, and setting new targets for the production and use of bioenergy. **RED II established the EU goal of achieving 32% of renewable energy sources in the energy mix by 2030, and increased** the target for the share of biofuels in transport. RED II also includes the criteria which must be met by installations that burn forest biomass, as well as regulations concerning sustainability of forest biomass harvesting, and regulating the control and reporting on the level of carbon dioxide absorption by forests.

The provisions of the RED II directive have not been yet implemented into the legislation of all Member States (as of the date of publishing the report), although they had until 30 June 2021 to do so. Despite the fact that the implementation of RED II is still in progress, the European Commission is already working on its revision. Since the moment of its publication, many scientists and organizations for the protection of nature and climate, argued the weakness of the provisions of the directive, which were supposed to guarantee that the production of bioenergy will not have a negative impact on nature and the climate, and that it will not lead to increased emission of greenhouse gases. Forest biomass is one of the most controversial topics addressed in the ongoing legal work on the RED II revision.

Criteria regarding forest biomass in Red II provisions

The most important change relating to forest biomass in RED II adopted in 2018 are the four criteria for bioenergy installations and forest biomass harvesting:

- efficiency criteria,
- GHG criteria,
- sustainability criteria, and
- land use, land use change and forestry (LULUCF) criteria.

Meeting all these criteria makes companies/organisations legible for public financial support. At the same time the energy produced by an installation that meets these criteria can be counted towards the target share of energy from renewable sources in the energy mix of the Member State concerned.

Efficiency criteria

The energy efficiency criteria are applicable to installations burning (woody) biomass for electricity, heat or cogeneration (high-efficiency cogeneration). The criteria also applie to installations co-firing biomass with fossil fuels, provided they are not the main fuel.

This criteria applie only to units with total power above or equal 50 MW. Its purpose is to ensure the highest possible energy efficiency of biomass combustion, and prevent the construction of new, low-efficiency installations.

New installations between 50 and 100 MW, operating in high-efficiency cogeneration or producing only electricity, must have an efficiency of at least 33.5%. Plants with a capacity of more than 100 MW must achieve at least 36% efficiency. Exempted from this are units already in operation and those using BECCS technology.

As it stands, the efficiency criteria are very weak for two reasons. Firstly, they do not cover smaller units below 50 MW, which represent the majority (in terms of numbers) of installations providing municipal heat and electricity. Secondly, the required efficiency ceilings are unambitious and, in fact, fail to set any additional requirements for newly built installations, as it is in any case not worthwhile for investors to build installations with lower efficiency anyway. For example the "Green Block" of Połaniec Power Plant achieves efficiency of 39%[105] and small cogeneration units have efficiency exceeding 80%. This means that the current efficiency criteria do not provide an impetus for the bioenergy sector to improve its technology or search for newer, better solutions. The minimum efficiency of 36% for large installations should not be seen as progress. Most of the currently operating coal-fired units achieve higher efficiency, e.g., the coal-fired units of Połaniec Power Plant reach up to 38% and the units of Bełchatów Power Plant, from 38% to 42%.[106]

GHG criteria

The GHG criteria applied to all new installations above 20 MW, thus covering more installations than the energy efficiency criteria. However, in Polish conditions, they will not apply to most municipal heating plants. The GHG criteria set the acceptable greenhouse gas emissions expressed in grams of CO_2 per MJ of energy produced. Importantly, the emissivity factor per MJ does not express the actual emissions produced by the installation, but the emissions linked to a partial life cycle of biomass. According to the RED II Directive, biomass is counted as RES, and thus the assumption is that its burning does not cause emissions. It is only the emissions produced during biomass acquisition, its processing, transport and other greenhouse gases produced during its combustion that are counted. These criteria implie that emissions related to the production and supply of biomass will be reported in the energy sector and not, for example, in the transport sector. This is important

105 ENEA S.A. Stable energy production from biomass – modern technology and experience of long-term operation, 2018.

106 PGE GIEK S.A. Bełchatów Power Plant, https://bit.ly/3w4I9g8

for processed biomass, especially in the form of pellets, the production of which is energy-intensive (it is a common practice to dry pellets using fossil fuel).

To qualify as a RES, an installation generating electricity must demonstrate emission reductions (compared to an installation burning fossil fuels) of:

- at least 70% if it is launched after 2021.
- at least 80% if it is launched after 2026. The emission reductions are calculated from the perspective of biomass life-cycle (LCA, see Part I). For installations producing only electricity, a value of 183 g CO_2eq/MJ (183 g CO_2 equivalent per 1 MJ of energy produced) was adopted. A new installation has to demonstrate a 70% and 80% reduction in emissions, i.e., and 54.9 and 36.6 g CO_2eq/MJ respectively. For heat production the reference value is 80 g CO_2eq/MJ. For heat producing installations for which a direct physical substitute for coal can be identified, the reference value is 124 g CO_2eq/MJ.

Similarly to the energy efficiency criteria, the GHG criteria do not provide an impetus for change in the bioenergy sector, as most units (even those burning high-emission pellets) already reach the required values. The most significant gap, however, is linked to the fact that CO_2 emissions are not counted from biomass burning alone. In this situation, the actual amount of CO_2 emitted from working installations is ignored. In addition, due to lower energy density of biomass, the emissions are higher than those from burning fossil fuels.

The exclusion of units with capacities below 20 MW from the GHG criteria means that, in case of Poland, it will not apply to the majority of installations burning high-emission pellets (i.e. usually small boilers with capacities up to 10 MW) and tens of thousands of individual consumers.

The sustainability criteria

The third set of criteria for forest biomass installations are the sustainability criteria for biomass harvesting. They aim to ensure that forest biomass is sourced from countries which have adequate legislation and systems in place to monitor and enforce legislation on ensuring the legality of timber harvesting; protecting areas secured by national and international law; and regenerating managed forests. These also aim to ensure that forest management that harvests wood for energy has a minimal impact on soils and biodiversity and that it will sustain or enhance the productive capacity of forests.

If a country has not introduced the above-mentioned regulations or monitoring and enforcement systems, RED II permits the harvesting of forest biomass if the country in question has a “management system,” i.e. an authority which exercises control over forest management. RED II permits the harvesting of biomass in

protected areas, if "the production of that raw material does not interfere with those nature protection purposes".

The sustainability criteria are weak. They only state that harvesting of forest biomass is permissible if the country in question has regulations specifying forest management methods aimed at minimising damage to nature. Such regulations may be very general – the criteria do not provide any guidelines on how forest management should be carried out, or explicitly indicate practices that are dangerous to nature or the climate, and which should not be allowed. For example, if a country allows clear-cutting or the removal of stumps on clearcuts, it will meet the criterion of sustainable harvesting as long as such activities are in accordance with national forest management regulations. The criteria of sustainable harvesting lack clear standards to minimise the impact on nature.

Moreover, this criteria allow the import of forest biomass to the EU from countries that do not have legislation protecting nature from the negative effects of forest management, as long as there is a relevant authority or system in place. As a result, it is actually permissible to use forest biomass from any source, as long as it is legal. Allowing logging from protected areas in criteria may have a negative impact on these areas, among others, by limiting the amount of deadwood present there.

As with the first two sets of criteria, the sustainability criteria apply only to installations above 20 MW, excluding most municipal and private CHP and heat plants.

The land use, land use change and forestry (LULUCF) criteria

The LULUCF criteria state that harvesting biomass for energy purposes should not reduce the CO_2 absorption capacity of forests. Emissions resulting directly from the burning of forest biomass are not reported in the energy sector (i.e. the consumer), but in the forestry sector (i.e. the producer). The consequence of the LULUCF criteria was the publishing in 2018 by the European Parliament of the ***Regulation on greenhouse gas emissions and removals from land use, land use change and forestry in 2030 climate and energy framework*** [...], (the LULUCF Regulation[107]), requiring Member States to develop National Forestry Accounting Plans (hereinafter NFAPs) to ensure that Member States meet the LULUCF criterion.

107 Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals resulting from activities related to land use, land-use change and forestry in the climate-energy policy framework by year and 2030amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (Text with EEA relevance)

The RED II Directive revision

The European Commission, the European Parliament and the Council of the European Union are currently working on a revision of the RED II directive, whose aim is, among others, to adjust it to the goals set out in the European Green Deal policy.

The European Green Deal assumes, among other things, that the share of renewable energy sources in the EU's energy mix will rise to 40% by 2030. As the bioeconomy and bioenergy are to be an important part of the new EU strategy, bioenergy production from forest biomass is expected to increase. The new EU climate targets may therefore become another factor in increasing pressure on forests.

The RED II directive revision proposal presented by the European Commission includes provisions consolidating the sustainable development criteria concerning the production of energy from biomass, and is supposed to adjust it to the assumptions of the Biodiversity Strategy 2030. It should be remembered, however, that the EU has not met the targets of the previous biodiversity strategy yet. The new strategy assumes, among other things, that 30% of the EU area will be covered by protected areas, including 10% of strictly protected areas. In the RED II revision, sustainability criteria for forest biomass have been consolidated. Since, at present, wood constitutes 59% of the EU RES, the EC makes it no secret that in this respect the RED II revision concerns mainly the acquisition of biomass from forests. The newly proposed criteria exclude certain harvesting practices which are harmful to forests, such as the harvesting of biomass from primary forests and forests with high biological diversity. They also disallow the harvesting of stumps and roots, which contributes to soil destruction and release of the carbon bound in it.[108]

European Commission wants to prevent high-value round wood from being used for energy purposes. Member States are to be obliged to develop schemes for cascade use of biomass, ensuring that only by-products or waste wood are used for bioenergy production. The EC also wants to stop supporting the practice of burning forest biomass in installations producing only electricity, due to the low efficiency of this process.[109] The new sustainability criteria will apply not only to new but also to existing installations. The minimum capacity of an installation subject to the criteria is to be reduced from 20 MW to 5 MW, which should ensure that the municipal sector, as well as larger private installations, will be subject to the guidelines.

The proposal to revise the sustainability criteria is a step in the right direction, but it is not enough. **It**

108 14.July 2021, European Commission, Commission presents Renewable Energy Directive revision, https://bit.ly/3vYkCxp

109 Even in the most modern conventional power stations more than half of the energy is irretrievably wasted, as their energy efficiency is around 40%.

should be supplemented with a ban on the harvesting of biomass through clear-cutting, the exclusion of all protected forest areas (including Natura 2000) from harvesting of forest biomass and ensuring that an adequate amount of deadwood is left in forests. Moreover, the the sustainability criteria should include individual private installations, as they are a significant and fast-growing consumers of wood in the EU.

However, the new goals of the European Green Deal and the current proposal to revise RED II create a situation in which more and more forest biomass will be imported from outside the European Union. If the criteria do not ensure that wood from outside of the EU is sourced responsibly, without any harm to the environment, the imported raw material will be more competitive than European, and thus its inflow will increase. This, in turn, will lead to increased pressure on forests outside of the EU.

The LULUCF REGULATION[110]

Emissions from biomass burning are accounted for in the *Land Use, Land Use Change and Forestry* (LULUCF) sector. The LULUCF mechanism was developed by the International Panel on Climate Change (IPCC) as a result of the Kyoto agreements. LULUCF was designed to ensure that agricultural land, forests and other areas remain a net carbon sink, despite the extraction of biomass from them and emission of the related greenhouse gases to the atmosphere. The signatories to the UNFCCC and the Kyoto agreements, in accordance with generally accepted methodology, count and report the amount of carbon sequestered by land in their countries. The amount of carbon sequestered by the growing aboveground and underground biomass (in roots) and carbon deposited in soils is counted. This value is increased by the carbon absorbed by newly afforested land. The amount of carbon absorbed is reduced by natural emissions, such as from deadwood decay. In this way, the annual amount of carbon absorbed by land and forests (expressed as a negative number) is calculated. The amount of carbon in harvested biomass and the amount of carbon lost through e.g. deforestation or land degradation is subtracted from this value to give the total annual LULUCF

110 The full name is Regulation on inclusion of greenhouse gas emissions and removals from land use, land use change and forestry into the 2030 climate and energy framework

emissions balance. UNFCCC signatory countries commit to the LULUCF balance remaining negative, i.e., land and forests will be a net emissions sink and carbon stocks will grow.

Emissions resulting from the harvesting of wood raw material and energy forest biomass are reported by the producer, not the consumer. This is known as the production model of emissions. It allows for control whether the biomass harvesting in a given country does not exceed the CO_2 absorption capacity of forests. In the case of non-energy wood, such a model allows emissions to be accounted for unambiguously, as such wood, after being harvested, may in its life-cycle pass through many sectors of economy and many countries, which makes indicating the place where the emission actually happened difficult. The same production model, however, applies to energy biomass – even though it is very easy to pinpoint exactly where it was burnt.

Reporting emissions from the LULUCF sector

Under LULUCF, countries that import biomass for energy do not account for emissions associated with its burning. It is the responsibility of the biomass producing country to account for emissions from biomass used for energy purposes in its LULUCF sector. Emissions taking place in Poland should be in fact reported by countries exporting biomass for energy purposes (e.g. Belarus, Ukraine or Lithuania). For energy biomass, a different model of calculating emissions can be used, i.e., the so-called emission transfer model, in which emissions from combustion are reported by consumers of the raw material, not by its producer. This would be closer to reality and would not be affected by double counting (emissions would not be reported twice, once in the LULUCF sector and again in the energy sector). Many climate and nature conservation organisations promote this approach, but the European Commission is reluctant. If this method of counting emissions were used, the European Union would have to start recording emissions from the burning of imported forest biomass, and thus the achievement of the EU's climate goals could be jeopardised. It would also turn out that the EU's success in reducing carbon emissions to date is to some extent due to offsetting them outside Europe. In such a situation, achieving the goal of reducing emissions by 55% by 2030 would require much firmer action than has been taken so far. Introducing the emissions transfer model would make a strong case for accelerating energy transition and moving away from fossil fuels more quickly.

REPORTING EMISSIONS – gathering information on greenhouse gas emissions for information purposes. The reported emissions do not have to be included in emission reduction targets. → p. 106

ACCOUNTING EMISSIONS – calculating and collecting information about the greenhouse gas emissions of a country or region. The accounted emissions count towards meeting the emission reduction targets → p. 105

Introduction of the LULUCF Regulation

In 2018, the European Union adopted ***a regulation on greenhouse gas emissions and removals from activities related to land use, land use change and forestry in the 2030 climate and energy policy.***[111] This was, among other things, the EU's response to the allegations of unaccounted for emissions from biomass burning. According to the European Commission, the new regulation should ensure that the forestry sector (which accounts for the largest share of LULUCF) also contributes to achieving the EU's climate and GHG emissions reduction targets by 2030.[112] Between 2013 and 2018, in Europe carbon sequestration by the LULUCF sector decreased by 20%[113], with European Comission citing increased wood harvesting as one of the main causes.[114]

The LULUCF Regulation is intended to address this issue and integrate the LULUCF sector into EU climate policy. The LULUCF commitments under the Kyoto agreements ended in 2020, so the EU passed its own legislation to extend the system to 2021-2030. The regulation divides the current decade into two five-year periods 2021-2025 and 2026-2030 – Member States will account for their LULUCF emissions in these periods.

The LULUCF Regulation introduced new rules for monitoring emissions from the sector and new emissivity indicators for individual type of activities. The LULUCF sector was extended to land other than forests (from 2021), including wetlands (from 2026). The zero balance principle has been adopted, according to which each Member State must ensure that their GHG emissions from land-use activities were fully offset by the atmospheric uptake of CO_2 in that sector. The regulation required that the Member States develop their National Forest Accounting Plans (NFAPs), which will show the carbon sequestration of forests and emissions from the forestry sector.

111 Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals resulting from activities related to land use, land-use change and forestry in the climate-energy policy framework by year and 2030amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (Text with EEA relevance).

112 European Commission, ***Regulation on Land Use and Forestry 2021-2030***, https://bit.ly/2ZKTeXt

113 European Commission, Questions and Answers – The Effort Sharing Regulation and Land, Forestry and Agriculture Regulation, https://bit.ly/3mEfZWo

114 European Commission, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Regulation (EU) 2018/841 as regards the scope of application, the simplification of compliance provisions, the definition of Member States' targets for the year2030 and the commitment to collectively achieve climate neutrality by the year2035 in the land use, forestry and agriculture sectors and Regulation (EU) 2018/1999 as regards improved monitoring, reporting, tracking of progress and review COM/2021/554 final

Joint reduction effort and flexibility mechanism

The LULUCF Regulation introduced a new flexibility mechanism as part of Europe's collective efforts to meet its greenhouse gas emissions reduction target. It aims to provide an incentive for countries to reduce emissions from this sector by allowing excess removals to be redirected to other sectors of the economy. Each member country whose LULUCF sector has negative emissions (negative net emissions) generates a so-called "credit" that can be used in another sector of the economy not covered by the ETS (the ETS system covers energy, heating and industrial plants) in 2021–2025 or retained for a second five-year period. The total emission pool for all countries for the period 2021-2030 is Mt 280 eq for the whole 10-year period.[115] Member States can sell saved emissions among themselves to encourage the efforts to increase the absorption capacity of the LULUCF sector.

Under this mechanism, Poland may, between 2021 and 2030, transfer or sell up to 1.2%[116] of its negative GHG emissions from the LULUCF sector, calculated on the basis of 2005 emissions (accepted by the EC Executive Decision as 192.5 Mt CO_2 eq.)[117] which is 23.1 Mt CO_2 eq. In the light of rising prices of greenhouse gas emission allowances, such a mechanism is to encourage Member States to reduce emissions from the LULUCF sector, i.e. primarily from forestry.

115 European Commission, ***Effort Sharing 2021-2030: targets and flexibility***, https://bit.ly/3mFOWtB

116 European Commission, ***Factsheet on the Commission's proposal on binding greenhouse gas emission reductions for Member States (2021-2030)***, https://bit.ly/3EJY5HQ

117 European Commission, COMMISSION EXECUTIVE DECISION (EU) 2020/2126 of 16 December 2020 on setting Member States' annual emission limits for 2021-2030 pursuant to Regulation (EU) 2018/842 of the European Parliament and of the Council (Text with EEA relevance)

HALF-LIFE OF CARBON in the raw material – an indicator used by the LULUCF forestry sector to calculate the life-cycle carbon emissions of materials and products made from wood. It assumes that, over a given period of time, half of the carbon contained in the material is oxidised and released into the atmosphere. This indicator is an artificial concept created for the purposes of estimating the life cycle of products made from wood, not representing the actual physical properties of the wood → p. 107

National Forestry Accounting Plan (NFAP)

In Poland, the balance of carbon absorption by forests and emissions from forestry is kept by the Ministry of Climate and Environment on the basis of the National Forest Accounting Plan[118], using data collected in the Large Scale Forest Inventory.[119] The State Forests National Forest Holding, as the executive body in charge of forest management, is responsible for estimating emissions from timber harvesting, both from the state and private forests.

The method for calculating emissions from forestry involves calculating the amount of carbon removed in harvested forest biomass. Emissions vary depending on the purpose for which the raw material is used. If it is intended for use by the wood processing industry, the annual emission is calculated on the basis of an assumed **"half-life of carbon in the raw material"** factor, which depends on whether the raw material belongs to any of the three product categories (paper, wood panels and sawn timber). For paper, the factor is 2 years, for wood-based panels and other wood products it is 25 years and for sawn wood 35 years. Structural timber binds carbon for quite a long time. Looking at its entire life cycle, emissions per year are small, so its half-life is long.

Products with a shorter life cycle (e.g. printer paper) have a shorter half-life and release carbon faster. In case of wood for energy purposes, the so-called **instantaneous oxidation** is used, in other words, all of the carbon contained in the harvested wood is oxidised to CO_2 in one year and counts towards the annual LULUCF balance, as if it had been burnt in its entirety.

Reference level of absorption

In their NFAPs, Each Member Country was required to accurately calculate historical forest removals and to provide historical CO_2 emissions from the forestry sector from 1990 to 2009, and also to provide an estimate of the level of removals and emissions for 2009–2025, had an analogous forest management regime been in place. In this way, each country created a baseline reference scenario, to which the annually reported net emissions in the period 2021–2025 are to be compared.

Member States had a choice of several calculation methodologies. Poland chose 2000–2009 as the period of reference and based its estimates on it. In the reference level, each country adopted a fixed ratio of timber harvesting for non-energy and energy purposes.

118 Ministry of Climate, National Forestry Clearing Plan, 2019, https://bit.ly/3GPgHaY

119 Large Scale Forest Inventory, Forest Data Bank, https://bit.ly/3EKX1U1

The reference level is crucial for each country's forestry sector because the reported emissions and removals are compared to it. It depends on their levels whether a country receives tradable emission credits from LULUCF or is charged a debit. It is important to note that the domestic forestry sector will generate emission credits even if the reported forest absorption declines over the 2021–2025 period if, despite the decline, CO_2 removals are higher than those projected in the reference level (provided forests remain a net sink). It is therefore worthwhile for the Member States to declare a reference level according to which the CO_2-absorbing capacity of forests is low and declining, which would make it unnecessary to reduce timber harvesting, or may even make it possible to increase it.

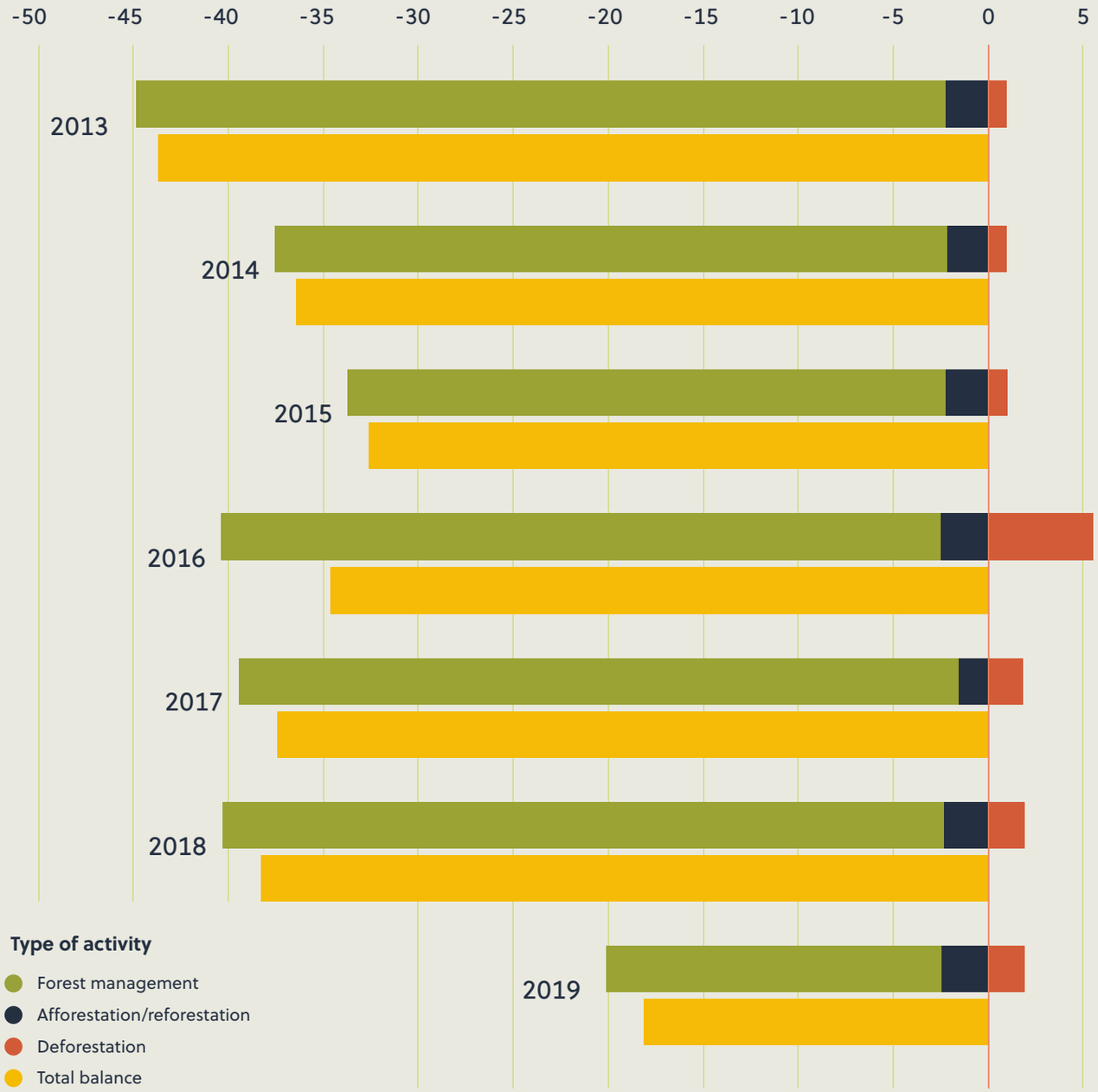
In addition to the reference scenario, the Polish NFAP 2019 includes the current scenario, in which the Ministry of Climate and Environment presented a projection of wood harvest in Polish forests by 2025, categorized into energy and non-energy wood. It was based on data of wood harvest in 2010–2019 and forecasts of wood industry development. The scenario is intended to illustrate the current forest management, taking into account the need to adapt the management model to the challenges of ecological and climate crisis.

According to this scenario, the harvesting of wood for energy purposes would decrease every year, to reach zero value in 2025. Thus, it presents the European Commission with a projection according to which energy wood (including firewood) will cease to be harvested completely in Poland. According to these projections, all wood harvested in Poland will be intended for the needs of the wood processing industry.

In reality, even looking at firewood harvesting (which is only some of the wood harvested for energy purposes), we see that, according to the CSO data for 2019, the harvesting had been increasing for years, and in 2019, it was much higher than the current level forecast in the NFAP (the forecast says 3.56 million m^3 of wood in 2019, when LP harvested 4.78 million m^3). If Poland reports its energy wood harvest in line with the forecast from NFAP 2019, its declared LULUCF emissions will be significantly underestimated.

According to the National Centre for Emission Balancing and Management, in the last 10 years the absorption of CO_2 by Polish forests has decreased by more than half, from approx. –45 Mt eq. CO_2 to approx. –20 Mt CO_2 eq. Polish forests currently absorb only about 5% of the total national emissions, while in 2010 they absorbed over 10%. The current trend indicates a further decrease in the absorption capacity of Polish forests. The forecast developed in NFAP 2019 by the Ministry of Climate and Environment (forecasting an unrealistic decrease in the harvest of wood for energy purposes to zero) may lead to a situation in which the annual absorption of Polish forests will be artificially inflated by at least several Mt CO_2

Carbon absorption and emissions of Polish forests in the LULUCF sector in 2013–2019 according to KOBIZE 2021



equivalent. In light of the continuing downward trend in the absorption of Polish forests over the coming years, there is a risk that they will become a net emitter of CO_2, although official data may not show this to be the case.

EU regulations give Member States the possibility to transfer CO_2 emissions saved in the LULUCF sector under the so-called effort-sharing scheme. By 2030, Poland may save and sell a total of approximately 23.1 Mt eq. of CO_2, worth EUR 1.8 bn today (assuming the price of a permit to emit 1 tonne of CO_2 is EUR 78 – data from 15 March 2022). It is worth noting that the price of permits is growing by leaps and bounds – at the end of 2016, it was approximately EUR 6, which gives an 13-fold increase over a six-year period. It is therefore clear that Poland's potential profits from the sale of permits may be many times higher.

Forest biomass in the Emissions Trading Scheme (ETS)

The European Emissions Trading Scheme (ETS) is one of the factors driving growth in the use of forest biomass for energy production. The inclusion of forest biomass in the list of renewable energy sources exempts energy and industrial plants using it from buying greenhouse gas emission permits under the ETS. The emissions trading scheme is becoming one of the main reasons why the energy sector is shifting away from fossil fuels,

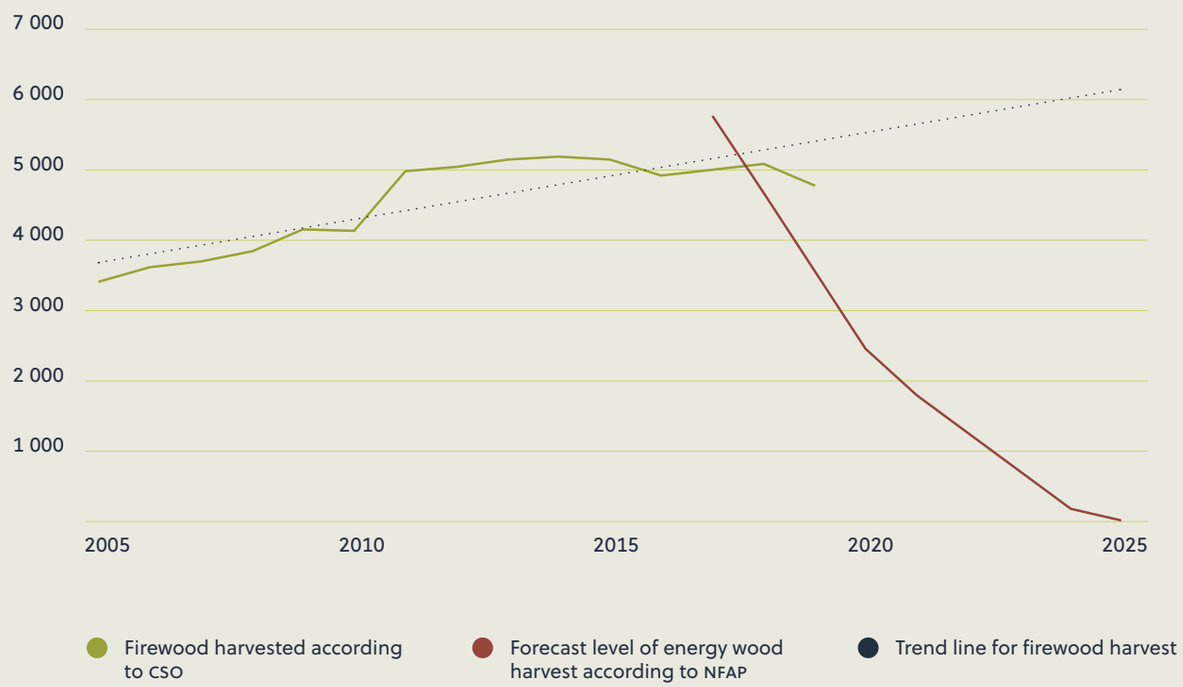
especially the high-emission coal. Prices of emission permits are growing and in the current situation, when they are also becoming an instrument of financial speculation, the Polish coal-based power industry is facing bankruptcy.[120] In 7 February 2022, permit prices have reached a record high of Euro 97 per tonne.[121]

At present, coal-fired power plants cannot compete in terms of energy price with subsidised and exempted renewable energy sources. The biggest problems are faced by small regional and municipal heating plants and combined heat and power plants run by local authorities. Many owners of municipal and communal heat plants cite the need to buy permits for biomass co-firing with coal – which does not require additional investment and can count on generous subsidies for converting boilers to forest biomass[122] fuels as a way of staying in business.

120 11 May 2021, Dziennik Gazeta Prawna, ***Expensive CO_2 emissions. Energy-intensive companies are afraid of market speculation***, https://bit.ly/3nSAhKL
121 1 September 2021 Business, Insider, https://bit.ly/3EEP16J
122 6 May 2019 Dziennik Łódzki, https://bit.ly/3nXzSXL

Comparison of the amount of harvested firewood (with the trend) with energy wood harvest planned in NFAP (thous. m³)

Based on data from the CSO and the Ministry of Climate and Environment in the National Forest Accounting Plan 2019



If an installation burns biomass or co-fires coal with biomass (even if biomass constitutes only a few percent of the fuel), it is entitled to certificates of origin issued by the ERO, exempting it from the obligation to purchase (at least some) greenhouse gas emission permits. This is the reason why practically all coal-fired units mix coal with biomass, reducing the costs of energy production.

Most energy companies in Poland, whether state, private or municipal, have business strategies that involve increasing the use of biomass. Power companies admit that that crossing biomass out from the RES list would present a serious threat.[123] In light of the ETS, a shift in the model of accounting forest biomass burning emissions from the forestry to the energy sector would be a serious blow to the companies that have invested in moving from coal to wood.

123 ENEA Group, *RR2020 Annual Report* , 2021

PART IV

Recommendations

Recommended actions at European Union level

Stop treating primary forest biomass as a renewable energy source

Energy produced from the burning of primary forest biomass should be removed from the list of fuels qualified as RES under the Directive on the promotion of the use of energy from renewable sources (RED II Directive). Such energy should not be counted towards achieving by the European Union (and particular Member States) their targets concerning the share of RES in total energy consumption.

Only allow the use of secondary woody biomass as a renewable, zero-emission energy source

When allocating woody biomass for energy production, the principle of cascading use of raw materials should be followed without fail. This means that the only type of woody biomass that qualifies as renewable and zero-emission energy source should be secondary woody biomass, i.e. waste from the wood processing industry or post consumer wood, and only if these materials cannot be converted into durable products.

Suspend direct and indirect subsidies for producing energy from primary forest biomass

Primary forest biomass should cease to be eligible for public financial support in the recently amended Directive on the promotion of the use of energy from renewable sources (RED II). Forest biomass should also cease to be treated as zero-emission fuel in the EU Emissions Trading System (EU ETS).

Redirect subsidies for biomass to subsidies for other RES and for investments in energy efficiency

The public funding currently allocated in the European Union to bioenergy (Euro 16 bn in 2020) should be used to support the production of wind, solar and geothermal energy, as well as cleaner heating systems (e.g. heat pumps) and energy efficiency (e.g. thermal insulation of buildings).

Recommended actions at national level

Stop supporting the burning of woody in the commercial power sector

All public financial support for installations in the commercial energy sector (power plants, CHP and heating plants) burning primary forest biomass to produce energy should be stopped. All public support for firing and co-firing of any type of energy wood (forest and non-forest, primary and secondary woody biomass) in electricity-only installations should be stopped, due to their low efficiency. The construction of new electricity-only and biomass-fired units should be discontinued.

Redirect the funds supporting biomass use to support the renewable energy sources and energy efficiency

The subsidies currently provided to support the use of woody biomass for energy production (e.g., subsidies for the replacement of coal-fired boilers with biomass-fired boilers) should be redirected to support the generation of wind, solar and geothermal energy, as well as to improve energy efficiency (in particular, thermal modernisation of single-family houses and public buildings). These measures would help reduce the demand for woody biomass energy to the levels that would allow full elimination of the use of primary forest biomass in the power industry (in 2020, in Poland, wood accounted for approximately 4.7% of primary energy consumption). The aim is to reduce the total amount of energy wood harvested in Poland, which will contribute to stopping the current dangerous trend of decreasing CO_2 absorption by Polish forests.

Improve the monitoring of harvesting and use of woody biomass for energy production

The system for collecting data on the harvesting and consumption of woody biomass for energy production should be improved and standardised. Detailed data should be collected and made publicly available on the total amount of woody biomass used for energy production by installations in the commercial energy sector, divided into primary forest biomass and other types of woody biomass. The sources of woody biomass used for energy production should also be monitored (e.g. forestry, grassland management, agriculture, wood processing, post consumer wood). The amount and place of origin of forest biomass for energy production from domestic resources should be recorded in detail. The State Forest national holding, which supplies 90% of all timber for the domestic market, should bear particular responsibility for data collection.

Currently, the data collected by public institutions on domestic sources and consumption of forest biomass are incomplete and often contradictory. The Polish law lacks basic definitions of forest biomass, primary biomass and secondary biomass, which would help to organise data collection. As a result, wood and residues from forestry are often combined into a single category with wood from agriculture, city park management and other forms of biomass. Wood from forestry is sometimes treated on a par with by-products and waste from the wood processing industry. This hinders a reliable assessment of the impact of the use of woody biomass on nature and climate. At the moment, the place

of harvesting forest biomass used in the energy sector is not controlled, which makes it impossible to ensure that biomass is not harvested in high-biodiversity forests, making it difficult to assess the impact of the use of forest biomass in the energy sector on forest biodiversity.

Update the regulations governing the use of woody biomass for energy production.

As an ad hoc solution, resulting from the RES Act, quality-dimensional parameters defining energy wood should be developed immediately, so that high-quality wood suitable for the wood processing industry is not burned. As such strict parameters are missing, it is difficult to determine the amount of wood of commercial quality that ends up in the energy sector. These parameters should be specified to the effect that high-quality wood is banned from use for energy production purposes.

In addition, Poland should implement the EU RED II Directive in its national laws. So far (since 2018), the provisions of the directive have not been implemented in Poland, among others, in terms of sustainable development criteria concerning forest biomass converted for energy purposes. Polish regulations are still based on the provisions of the previous 2009 RED Directive, which protects forests from the negative effects of using forest biomass for energy production to a lesser degree.

Glossary of key terms

Accounting emissions – calculating and collecting information about the greenhouse gas emissions of a country or region. Accounting emissions count towards emission reduction targets.

Afforestation – a permanent conversion of a non-forest land to a forest through intentional planting of trees.

Amount of dead wood – the amount of dead wood is given in cubic metres per hectare [m3/ha] or tonnes per hectare [t/ha]

Bioenergy – energy generated from the remains of living organisms or products of their metabolism. *Bioenergy* can include biomass, biofuels and biogas.

Bioeconomy – a part of economy managing raw materials and energy coming from living organisms. Bioeconomy includes agriculture, food, forestry, fisheries, bioenergy, biomaterials, biocomponents and the organic waste sector. It aims to be one of the key means for the EU to build a sustainable, zero-carbon, circular economy.

Biomaterials – materials made from organic matter (e.g. bioplastics formed from sugar cane)

Biochar is another term for charcoal, produced in high temperatures by pyrolysis (dry distillation).

Briquette – heating material in the form of sawdust pressed into cubes. It is a substitute of firewood for households.

Carbon reservoir/pool – A part of the biosphere where organic carbon is bound in solid form. Carbon exchange takes place between carbon reservoirs and the atmosphere. Earth's carbon reservoirs are primarily carbonate rocks, soils, land and sea plants and other organisms. Maintaining and expanding carbon reservoirs is key to combating current climate change.

Cascading use – is the way of managing raw materials in the most effective way so that the waste generated at one level of the economy is used as raw materials at another level, etc., until its used to its full potential.

Circular economy – a model of economy in which waste becomes reusable raw material. The ultimate goal is to re-use all waste in this way. The EU has adopted an action plan 2015 for circular economy.

Climate-neutral energy source – an energy source with no net greenhouse gas emissions and no effect on greenhouse gas concentrations in the atmosphere.

Cogeneration, high-efficiency cogeneration – simultaneous generation of heat and electricity in a single technological process, which increases energy efficiency. The effectiveness of high-efficiency cogeneration installations can reach up to 90%.

Deadwood – the remains of dead or felled trees left in the forest, including standing dead trees. The term covers all types of tree debris, from stumps, branches, stubs to small twigs. Deadwood plays an extremely important role in the forest ecosystem and its quantity affects forest biodiversity.

Deforestation – a permanent conversion of forest to non-forest land (e.g. conversion of forests to farmland or clearing of forests for development). Deforestation is estimated to account for around 10% of global greenhouse gas emissions.

Energy crops – crops grown for energy purposes, i.e. heat, electricity, gas or liquid fuel.

Energy mix – a listing of energy sources present in a given country or group of countries, showing the share of specific sources in the total energy production.

Energy wood – wood for energy production from forestry, agriculture and other sources. This is a legal term, currently appearing in the Polish Renewable Energy Sources Act of 20 February 2015. It is supposed to be low-quality wood raw material unsuitable for the wood-processing industry and thus only of calorific value. This term has no equivalent in the European law and is not synonymous with forest biomass.

Reporting emissions – collecting data on greenhouse gas emissions for information purposes. The reported emissions do not have to be included in a country's emission reduction targets.

EU ETS – Emissions Trading Scheme in the European Economic Area (EEA-EFTA). It is a key element of the EU policy to fight climate change and its primary aim to reduce greenhouse gas emissions in a cost-effective way. It is the world's first and largest carbon market. https://ec.europa.eu/clima/policies/ets_pl

European Green Deal – a set of policy initiatives from the European Commission with the overarching aim of achieving climate neutrality in Europe by the year 2050 https://bit.ly/2ZZ7SdC

Extensive forest management – a way of managing forests in a non-industrial, sustainable manner that does not harm the health and integrity of the ecosystem. In extensive use, only enough wood is harvested to ensure the continuity of the forest, i.e. only individual trees are felled. The forest is also harvested at appropriate intervals to maintain the integrity of the stand. This type of forest management does not allow clear-felling or ploughing of the forest soil.

Forest die-off – decline of stands caused by a number of overlapping, mutually reinforcing, factors. An example is a decline of spruce trees in the Polish mountains, caused by the combined effects of a warming climate, lack of water and insect infestation

Forest residue – minor residues from forestry operations which are not a full-value raw material, but have a calorific value. These are branches, small branches, bark, stumps and pieces of larger logs. However, this term is not entirely identical to "logging waste" in the Polish terminology.

Forest rotation age – the period of time over which a stand is replaced by felling. Energy tree stands are characterised by a fast rotation (e.g. 30 years), while commercial timber stands have a longer rotation period (50, 60, 70 years or more).

Firewood – a type of low-quality wood harvested from forests for direct burning which can also be used to produce energy biomass. According to the classification used in forestry, firewood includes thick firewood prepared in stacks, small timber, logging waste and deadwood.

Half-life of carbon in the raw material – an indicator used in the LULUCF forestry sector for the calculation of carbon dioxide emissions in the life-cycle of materials and products made of wood. It assumes that, over a given period of time, half of the carbon in a material is oxidised and released into the atmosphere. This theoretical concept was created to estimate the life cycle of wood products and does not describe the actual physical properties of the material.

Industrial trees – species of fast-growing trees whose wood has valuable characteristics for the wood-processing industry. They are planted in single species plantations. Several species of eucalyptus are a good example of industrial trees that excellent for the production of pulp for the paper industry.

International Energy Agency (IEA) is an institution established within the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. Founded in 1974, in the aftermath of the first world oil crisis, it is one of the world's most important sources of energy strategy https://www.iea.org/

Invasive species – plants, animals, pathogens and other organisms that are not native to ecosystems and can cause damage to the environment or the economy, or have a negative impact on human health. Invasive alien species can have a particularly negative impact on biodiversity, through population decline or elimination of native species, food competition, predation, pathogen transmission, and disruption of ecosystems.

JRC – Joint Research Centre, one of the Directorates-General of the European Commission with the aim to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. JRC comprises seven scientific institutes located in five Member States, https://bit.ly/3EMzeTr

Large-scale forest stand damage – damage to stands over a large area caused by natural or anthropogenic factors. This may be, for example, damage to trees on many thousands of hectares caused by wind or damage to the assimilative apparatus of trees on a ***large*** area caused by air pollution.

Large-size wood – wood with a minimum top diameter without bark of at least 14 cm. This includes primarily trunks, logs and boughs.

Mitigation – opportunities to avoid greenhouse gas emissions by replacing high-emission with low or zero-emission sources. Such benefits include, for example, the replacement of coal-fired power plants with wind turbines.

Mtoe (Million tonnes of oil equivalent) – a unit of energy, often used when comparing different energy carriers, in which the amount of energy is converted into energy contained in tonnes of crude oil. 1 Mtoe is 41 868 gigajoules or 11 630 kWh.

Natural forest – a forest formed without human involvement, lasting as a result of natural processes of regeneration, maturing, ageing and decay. Human intervention is limited only to the harvesting of forest products, without causing any adverse changes in this ecosystem. Natural forest is characterised by high biodiversity; it is multi-species, multi-age and multi-storey and is highly resistant to potential disruptions.

Primary renewable energy – energy from renewable energy sources that has not been converted into usable energy. Primary renewable energy is, for example, the energy contained in wood, while secondary renewable energy is the electricity or heat generated from burning such wood. Primary energy is often confused with secondary energy.

Qualitative-dimensional parameters – physical characteristics of wood (e.g. diameter, length, wood defects), on the basis of which it is classified in the appropriate wood sort.

Renewable Energy Certificate (REC), also known as the Certificate of origin, "Green Certificate" – a document confirming that electricity was produced from renewable energy sources. The certificates are issued by the Energy Regulatory Office. Since July, 2016 separate *Renewable Energy Certificates* (*RECs*) have been issued for electricity generated from agricultural biogas (the so-called "blue certificates").

S2 timber group – according to the Polish classification medium-sized timber in the second thickness class, i.e. with a diameter of 25–34 cm, measured at log mid-thickness. The S2 group of wood is called utility pole timber.

Salvaged wood – wood harvested from forests damaged by natural disasters (e.g. hurricanes or insect infestations).

Saproxylic species – species that feed on or live in dead wood. The species that need dead wood to live are called *saproxylobionts*, and those that prefer dead wood are *saproxylophilic* species.

Sequestration – an activity consisting in preventing emission of carbon dioxide to the atmosphere from point sources of pollution (e.g. power plants) by capturing the emitted gas, transporting and depositing it in a place from which it cannot get to the atmosphere. Often confused with the ***absorption*** of CO_2 which is the process of capturing the gas which is already in the atmosphere.

Silviculture – all activities performed on forest land (or land temporarily deprived of vegetation) as part of forest management, with the aim of planting a new forest. Silviculture includes the cultivation of trees in nurseries, transplanting them to their final location and caring for young trees. Silviculture is a deliberate practice – the tree species are selected to achieve specific objectives (e.g. production of desired wood material or restoration of a more natural stand).

Silvicultural treatment – a silvicultural treatment aimed at creating favourable conditions for the growth and development of trees with better breeding value, the removal of useless components of the stand, and a general improvement in the environmental conditions of the stand. Silvicultural cuts include *thinning*

Traditional forests – forests providing many types of wood as raw material and services, e.g. wood for construction materials, paper industry, firewood, but also place for recreation, hunting, picking mushrooms or forest fruit. This is in contrast to industrial tree plantations which are grown for a single purpose – e.g. for paper or forest biomass.

Torrefied bio-coal – charcoal produced at low temperature. Wood pellets are sometimes processed to obtain fuel with a calorific value close to that of hard coal.

Woody biomass – biomass derived from trees and shrubs from forestry, agriculture, energy crops, municipal sector, urban greening, etc.

Wood pellets – solid fuel in the form of granulated shredded wood biomass. Used in many energy installations (including power plants and CHP plants) and in households.