March 2025

Beaten to a pulp

How the EU's forests are being burned for energy by the pulp & paper industry

biofuelwatch

Environmental Paper Network

A logging site in Sweden. *Marcus Westberg*

Altri's biomass plant at the Biotek pulp mill, Portugal. *Biofuelwatch*

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Summary

This investigation aims to quantify the scale of primary woody biomass burning for energy generation associated with the pulp industry in the European Union (EU). It includes case studies on the EU's top five pulp producers, and assesses the impacts of the extraction of wood from forests and plantations for energy use.

The report's main findings include:

- Pulp-producing companies are the **dominant force in biomass electricity generation in four of the five top pulp-producing countries in the EU**. They are responsible for over a fifth of the primary woody biomass burned for energy in those countries.

- On average, **for every tonne of pulp produced in the EU's top pulp-producing countries, one cubic metre (m^3) of primary woody biomass is burned for energy generation**. On an EU-wide level, pulp-producing companies could therefore be responsible for up to 45 million cubic metres of wood being burned. This is equivalent to **16% of all the primary woody biomass burned for energy in the EU in 2021**.

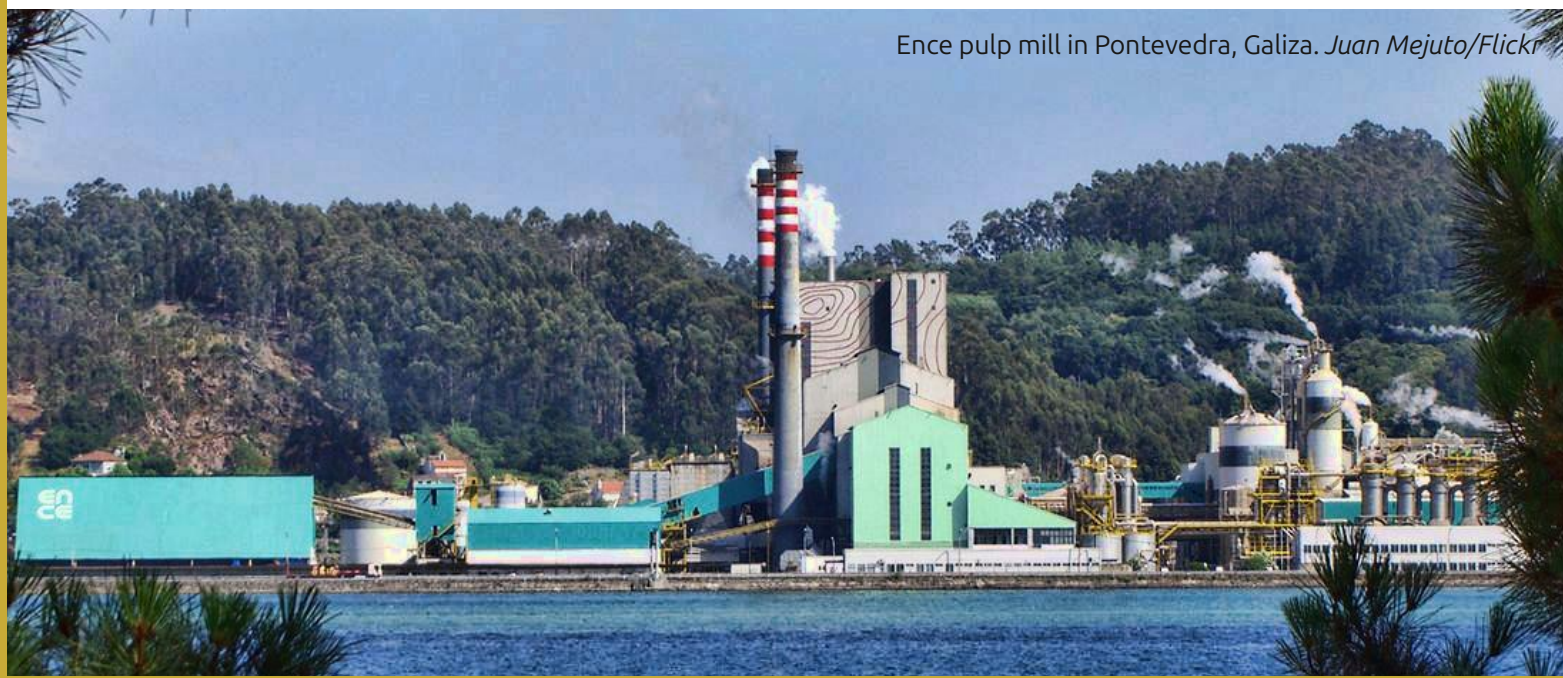
- Rather than being a sustainable, low-carbon and efficient use of biomass, **increasing biomass energy capacity at pulp mills throughout the EU results in more and more wood being extracted from forests and plantations**, which increases carbon emissions and impacts soil health and other aspects of forest ecosystems. The increasing use of primary woody biomass and woody by-products that have different industrial uses than energy generation increases pressure for further logging.

- Pulp companies are also **diversifying into other areas of the bioeconomy and making investments in refining woody biomass to produce fuels such as wood pellets and aviation biofuels**, which is another factor that increases the overall demand for wood for energy generation.

In terms of the impacts of primary woody biomass sourcing in the EU's top five pulp producers, this report highlights how:

- In Sweden, the "green" colonial forestry model that underpins the use of primary woody biomass for energy generation is resulting in the **decimation of the country's remaining highly-biodiverse primary forests and directly threatening the livelihoods of Indigenous Sámi reindeer herders** and the communities that they are part of.

- In Finland, primary woody biomass is the country's fastest-growing source of biomass energy. The **excessive logging linked to the increase in biomass burning in heat and power plants has resulted in Finland's land sector becoming a source of emissions** rather than a sink.



Ence pulp mill in Pontevedra, Galiza. *Juan Mejuto/Flickr*

Wood waiting to be chipped and burned for energy in Finland. *Varpu Sairinen*

- In Portugal, biomass electricity subsidies have decoupled power generation at pulp mills from by-product waste streams, whereby **more than two-thirds of the woody biomass burned for energy by the sector is now sourced directly from forestry operations**. In turn, this adds to political pressure to expand harmful eucalyptus plantations.

- In Germany, as well as pulp companies increasingly diversifying into biomass electricity, the **gradual phase-out of coal burning has precipitated a shift towards burning wood at several pulp mills**, which is of no benefit in terms of emissions and is diverting wood away from other more climate-friendly uses.

- In Spain, the pulp industry and power stations associated indirectly with it **account for over two-thirds of Spain's overall biomass electricity generating capacity, requiring over a third of all of the woody biomass used for energy generation each year**. Plans for new biomass power stations linked to pulp producers could see a 70% increase in primary woody biomass demand in coming years.

This report makes three main recommendations for EU policy-makers:

- State subsidies and support mechanisms are the driving force behind new biomass energy developments associated with pulp mills or pulp producers, particularly for electricity generation, and the extraction of wood from forests and plantations for energy generation is also heavily incentivised in some countries. Because of this, **subsidies, tax exemptions and public finance for biomass energy and perverse incentives for logging must cease**.

- Accurate and up-to-date information on the type and origin of biomass feedstocks used across industrial sectors in EU Member States and the results of monitoring and verification by public bodies, is hard to come by. Consequently, **there must be increased transparency and information disclosure to the public about supply chains and biomass feedstocks linked to pulp producers and other industries**.

- The main use of biomass energy generation associated with pulp mills in the EU is to satisfy the enormous electricity and heat demands of producing pulp and paper products. Efforts must be made to **drastically reduce production levels, particularly of short-lived products such as disposable packaging, as the most efficient way of reducing the demand for energy by the pulp and paper industry** and the scale of the demand for primary woody biomass.

Glossary

Biomass electricity: Electricity generated through the combustion of biomass, including woody biomass and black liquor.

Dedicated/electricity-only biomass power station: A power station that burns biomass and generates electricity, put where the heat produced is not utilised for another purpose.

Combined heat and power (CHP) power station: A power station that produces electricity and utilises the heat generated for an industrial process, or for heating and cooling supplied to a district heat network or individual customers.

Woody biomass: Solid plant-based material with a high lignin content, such as woodchip, roundwood, bark or sawdust. Black liquor is not included in this definition.

Primary woody biomass: Any plant-based biomass that is sourced directly from felling or removal operations. This includes roundwood and logging residues from forests and tree plantations, as well as wood sourced from municipal operations in urban areas, for example. Also referred to as energy wood in some EU member states.

Secondary woody biomass: By-products and residues of wood processing industries such as pulp mills and sawmills.

Residual biomass: Plant-based material that is leftover from or a by-product of forestry or agricultural operations. This includes residual logging/forestry residues, black liquor and bark.

Residual woody/forest biomass: The "left-over" plant-based woody biomass resulting from forestry and other tree-removal operations including branches, tree tops and stumps.

Industrial by-products: Processing residues that result from industrial processes. In pulp mills these are predominantly black liquor and tree bark.

Black liquor: An aqueous solution of lignin residues and other material that is extracted during the pulping process, when pulpwood is converted to paper pulp. It is usually burned in a recovery boiler to produce steam and electricity for pulp mill operations.

Altri's Biotek pulp mill in Portugal. *Biofuelwatch*

Introduction

The pulp and paper sector globally is increasingly turning its attention towards biomass electricity to take advantage of renewable energy subsidies and to fulfil its climate targets, at least on paper. Pulp mills have traditionally produced their own heat and electricity through burning black liquor and bark, two of the main by-products of the pulping process. However, lucrative incentives for burning biomass are encouraging the industry to burn ever greater quantities of wood in far greater amounts than can be met by industrial by-products.

This requires wood to be brought in from outside pulp mills, usually in the form of primary woody biomass (i.e. wood taken directly from forestry operations), which increases overall logging volumes, or from other wood processing industries such as sawmills, which diverts wood residues that could be used for less polluting purposes than burning for energy.

Increasingly, stand-alone and over-sized biomass power stations are being built within pulp mill complexes that export some or all of their electricity to the public grid and depend on wood taken directly from forests and tree plantations. Recent investigations by Environmental Paper Network (EPN), Global Forest Coalition (GFC) and other groups have highlighted the impacts of these kinds of biomass electricity investments at pulp mills and the incentives that have driven them in Valdivia in Chile, and Ngodwana in South Africa.

Another trend is for fossil fuel (usually gas) combined heat and power (CHP) plants at pulp mills to be replaced with new biomass CHP plants, or for biomass to replace coal (and often peat) as a fuel in existing CHP plants. These are usually also oversized and require additional biomass to what the pulp mills produce in by-products. On top of this, pulp-producing companies are often vertically integrated, meaning that they have forestry subsidiaries that harvest and sell wood for energy generation to other users and often also have shareholdings in biomass energy infrastructure that is indirectly connected to pulp mill operations.

EU-wide statistics on biomass energy use in the pulp and paper sector are hard to come by, but the Confederation of European Paper Industries (Cepi) publishes data for its member countries, which include the five countries featured in this report and account for three-quarters[1] of European pulp production. In the

[1] 35 million tonnes of pulp requiring 146 million m^3 of wood (Europe total = 46 million tonnes).

Eucalyptus wood destined for energy generation in Galiza, Spain. *Salva la Selva*

Lack of transparency is endemic throughout the pulp industry

The case studies in this report used publicly available information and, where this was insufficient, contacted pulp-producing companies directly to request further information. The information published by the companies themselves is, generally speaking, incomplete and vague and, on a national level, government statistics bodies do not publish or, in many cases, even collect industry-disaggregated data on the types and quantities of biomass feedstock used for energy generation. Of the more than 100 companies and power plant operators contacted during the research carried out for the case studies in this report, only two responded with useful additional information. The vast majority simply ignored the requests, and around six responded that if the information requested wasn't already in the public domain, then it wasn't for public disclosure. Transparency, full disclosure of environmental data and a willingness to cooperate with civil society actors should be a minimum requirement for these companies.

pulp and paper sector in Cepi countries, the fraction of biomass in total fuel consumption in 2021 was 61%, making it by far the most significant energy source. In terms of primary energy consumption, biomass combustion for energy has nearly doubled over the past two decades.

However, there is no disaggregated data for the different fractions of biomass used by the pulp industry in the EU, which are primarily black liquor, bark and primary woody biomass. Even on a national level, such disaggregated data is not published, although a few companies publish it for individual mills.

On an EU-wide level, 550.8 million m^3 of woody biomass were burned for energy in 2021. Almost half (239.5 million m^3) was roundwood harvested in the EU's forests, including 52.3 million m^3 of industrial roundwood. Overall, 50% of the woody biomass burned for energy production was primary biomass from forests, the remaining being forest-based industry co-products (37%, including bark burned by pulp mills), processed wood-based fuels (8%, mainly wood pellets) and post-consumer wood (5%).

In general, the pulp industry claims that the primary woody biomass it burns is entirely residual, i.e. leftover or waste wood from forestry operations once the higher value wood has been extracted. According to data for the EU, at least 23 million m^3 of the primary biomass burned for energy in 2021 was in the form of branches, tree tops and stumps, which would be considered as residual primary woody biomass. However, reporting the amount of branches, treetops and stumps burned is not mandatory, and this figure reflects the amount of this type of biomass burned by nine countries, which together account for 38% of total woody biomass consumption for energy purposes in the European Union. In these countries, branches, treetops and stumps accounted for only 20% of the total woody biomass burned for energy purposes, while trunk wood accounted for the remaining 80%.

In addition to being heavily dependent on biomass energy, the pulp sector is also a major source of Europe's demand for wood. The 141 pulp mills in countries with Cepi members consumed 145 million cubic metres of primary wood in 2022, equivalent to 30% of the EU's total roundwood harvest. Although the pulp and paper industry tries to draw a clear distinction between the wood it uses for pulp production and what it burns for energy by claiming that only residual biomass is burned and that alternative uses of this wood result in greater emissions, the two are inextricably linked. The impacts of one must be considered in the context of the other. Furthermore, there are many clear examples of roundwood being burned for energy in countries with Cepi members.

At the EU level, little is known about the overall extent of energy generation linked to biomass burning at pulp mills, and important questions such as how much wood is being burned each year, what its impacts are and what the threat of future expansion remains unanswered.

This investigation looks at Europe's top five pulp producers —Sweden, Finland, Portugal, Germany and Spain— which together accounted for 59% of the pulp produced in Europe in 2022 (totalling 27 million tonnes). It also includes a case study about the largest pulp mill in Slovakia, operated by Mondi. There is little published information about the biomass electricity capacity linked to the pulp sector in these countries, how much primary woody biomass is being burned at pulp mills and the threat posed by new developments. Detailed case studies on these five countries and Mondi's pulp mill in Slovakia aim to help to build a global picture of the extent to which the pulp sector is driving developments in forest biomass power generation.

EU statistics on wood use for energy - can they be trusted?

In 2023 the European Commission launched a mandatory data collection drive for member states to report on the types of biomass used for energy generation in 2021, published as the Supply of biomass - annual data dataset. The availability of this kind of disaggregated data on types of biomass use is vital to accurately assess what is going on in each member state and in the EU as a whole. However, so far only data for 2021 has been released, and there are so many inconsistencies, inaccuracies and missing values that the value of it is seriously undermined. Issues with it include the following:

- No values are given for "branches and tree tops" in Finland, when the Finnish government reports these figures itself annually.
- Data for black liquor consumption in Portugal is reported with the incorrect units and is three orders of magnitude different from figures reported by the Portuguese government, leading to a significantly lower value being reported in the dataset.
- There is no data for Hungary.

Furthermore, Member States are only required to report on the total amount of the different types of woody biomass used for energy generation in their economies, meaning that the database lacks information on consumption by different categories of users. Such information is essential for conducting reliable assessment of the factors contributing to the increased demand for wood in the EU. This problem is partly addressed by the pending Forest Monitoring Law which, according to its current draft text, will require EU Member States to report on woody biomass consumption by commercial energy producers, autoproducers, households and other sectors. .

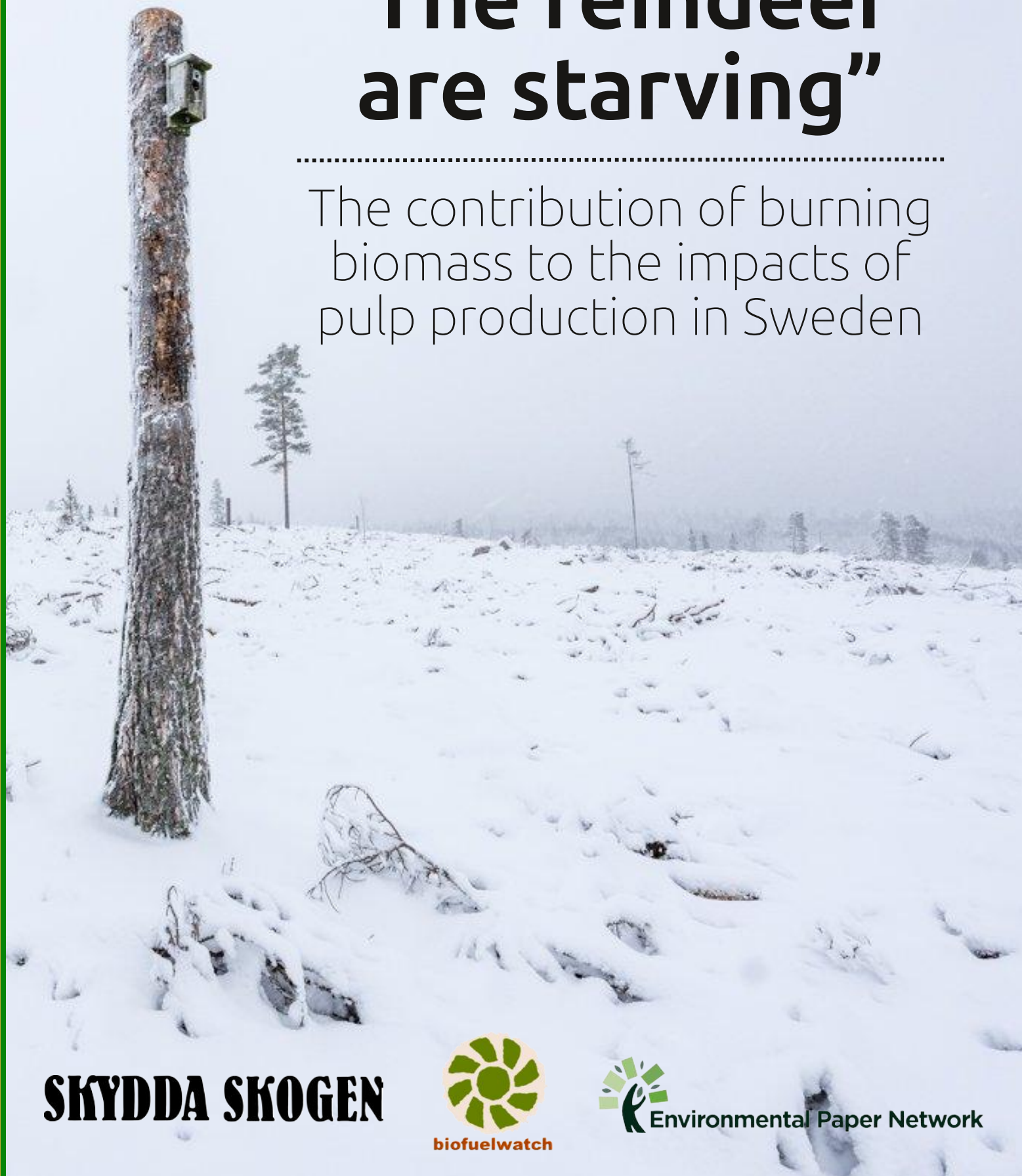
Logging site in Sweden. *Marcus Westberg*

A logging site in Sweden. *Marcus Westberg*

March 2025

“The reindeer are starving”

The contribution of burning biomass to the impacts of pulp production in Sweden



SKYDDA SKOGEN

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Logs piled up at a logging site in Sweden. *Marcus Westberg*

Introduction

Sweden produced around 12 million tonnes of pulp in 2022, accounting for over a quarter of Europe's total pulp production and making it Europe's largest producer. Bioenergy is Sweden's largest energy source and accounts for almost a third of total energy supply. Almost 60% of final energy use in the industrial sector is bioenergy, and the pulp and paper industry accounts for much of this.

The two main consumers of bioenergy are the district heating sector and forest industries, and pulp-producing companies play a substantial role in both. The Swedish Energy Agency (SEA) calculates that in 2021 the pulp and paper industry consumed 73 TWh[1] of energy, 75% of which was from bioenergy.[2] Sweden's total energy consumption is around 355 TWh, meaning that the pulp and paper industry is responsible for a fifth of the country's total energy use.

Primary woody biomass accounts for around a third of the biomass burned in Swedish power stations, and includes so-called forestry residues as well as roundwood, which also frequently includes centuries old dead trees, as well as deciduous trees, which are vital for biodiversity. Primary woody biomass was used to generate 13 TWh of energy in 2020, not including firewood burned domestically. Figures for fuel production are slightly higher, with Swedish Energy Agency figures indicating that a total of 17 TWh of primary woody biomass fuels from forestry operations (excluding firewood) were produced in 2022, compared to 31 TWh of woody biomass fuels from industrial byproducts such as bark and sawdust.

As in other parts of Europe, many of Sweden's pulp mills generate excess heat and electricity to sell to external customers, such as municipal district heating networks and the public electricity grid. They are also increasingly selling lignin, bioethanol, tall oil, bark, wood chips and wood pellets.

It is often claimed that the forestry industry's most important product is timber and that all other products, such as paper, packaging and bioenergy, are a result of the efficient utilisation of residual biomass. However, timber only accounts for 20% of the export value of the forestry industry in Sweden, whereas other products that are classified as residual, such as biomass used to generate energy, account for the majority of what raw forest materials are turned into. According to Svenska Cellulosa Aktiebolaget (SCA), one of Sweden's largest pulp producers, 30% of everything that is harvested from their forestry areas is converted into energy or products such as wood pellets that are destined to be burned.

This case study aims to assess the Swedish pulp industry's overall contribution to the demand for primary woody biomass for energy generation and place this within the context of the impacts of Sweden's intensive forestry model.

State support and subsidies for burning biomass

The pulp and paper industry receives up to 600 million Euros a year in renewable energy subsidies for the biomass electricity it produces, some of which is produced by burning primary forest biomass and industrial by-products that could be put to alternative, lower-emission uses. The pulp and paper industry also does not pay carbon tax, nor does it have to buy emission rights for the approximately 18 million tonnes of CO_2 it emits each year, which is another financial incentive, equivalent to 1.7 billion Euros a year.

Pulp producers have relied on these electricity related tax breaks for many years, as they protect the highly energy intensive industry from the costs of high energy prices. Pulp and paper company Stora Enso, for example, has underlined this by threatening to move its mills abroad if the Swedish government were to consider reforming these subsidies. Stora Enso receives more subsidies for generating electricity than any other company in Sweden, followed closely by SCA.

More generally, in the last year for which there is publicly-available information (2019), seven out of the top 10 most heavily-subsidised companies in Sweden were pulp producers, and this trend persists today. More public money was spent in 2019 on subsidising these highly-polluting companies than on Sweden's entire budget for climate change mitigation measures. In 2021, Protect the Forest (*Skydda Skogen*) calculated that the electricity-related tax breaks received by the forest industry in just two to three years—which incentivises the logging of highly biodiverse forests—would be enough to pay for the protection of the entire and unique chain of mountain forests in Sweden.

Logs piled up at a pulp mill in Sweden. *Marcus Westberg*

SCA's Munksund pulp mill. *Marina Ilaria*

Primary woody biomass burning at pulp mills in Sweden

As part of this case study, every pulp-producing company in Sweden was contacted for further information on their use of biomass for energy generation. Only three responded, all refusing to provide the information specifically requested, reflecting a significant lack of transparency in wood sourcing throughout Sweden's forest industries.

Without company provided data, estimates of biomass use have been made using the limited available information found in online searches of of annual company and environmental repots and websites, as well as media articles. Eight pulp-producing companies operating in Sweden were identified as having recently burned primary woody biomass to generate energy and/or providing it from their forestry operations to other energy generators. Between them, we estimate that they burn the equivalent of 4.5 million m^3 of woodchip directly from logging operations a year and deliver around one million m^3 to other energy users. This is equivalent to almost a third of the total primary woody biomass burned for energy each year in Sweden.

Company	Pulp mill(s)	Estimated primary woody biomass consumption (m^3)	Estimated primary woody biomass delivered to other energy generators (m^3)
Billerud	Gruvön, Gävle, Frövi/ Rockhammar, Karlsborg and Skärblacka	100,000	
Metsä	Husum		100,000
Nordic Paper	Bäckhammar	30,000	
SCA	Obbola, Munksund, Ortviken and Östrand	1,660,000	750,000
Stora Enso	Fors, Skoghall and Skutskär		194,000
Södra Cell	Värö, Mönsterås and Mörrum	2,500,000	
Sylvamo	Nymölla	240,000	
	Total:	**4,530,000**	**1,044,000**

Table 1: Pulp-producing companies and their estimated contribution to the use of woody biomass for energy.

Billerud's Gruvön pulp mill. *Marina Ilaria*

Billerud

Billerud is a Swedish pulp and paper company which operates five pulp and paper mills in Sweden, one in Finland, and three in the USA. According to the company, around 75% of the wood used in their Scandinavian pulp mills comes from Sweden, the rest mostly from Norway, Finland and the Baltic States. Wood comes directly from forests as well as from 90 different sawmills. Billerud co-owns and manages around 350,000 hectares of forests and plantations in central Sweden, some of which are within Sápmi, the traditional territory of the Indigenous Sámi People.

Of all the pulp mill operators in Sweden we contacted, Billerud is particularly non-transparent. They responded to a query as to how much energy is generated in Billerud's pulp and paper production and how much of this is primary woody biomass (i.e. comes directly from forestry operations) by saying, *"Unfortunately this is not information that we share."* The only publicly available information about the primary woody biomass that Billerud burns is from its latest Annual Report, which states that it uses forestry biomass residues internally produced in Sweden as a part of its heat and power production. We estimate that around 100,000 m^3 of primary woody biomass is burned by Billerud each year in its Swedish mills.[3]

Metsä Group

Metsä Group operates one pulp mill in Sweden, in Husum. The mill mainly burns black liquor and bark to generate energy, and similarly to Metsä Group's pulp mills in Finland, it appears unlikely that primary biomass is burned for energy. However, according to Metsä Group's 2023 Annual Report, Metsä Forest, the Group's forestry subsidiary, delivered a total of 30.4 million m^3 of wood, and its operations procured 29 million m^3 of wood. It is possible that the difference between these two figures is energy wood, which would mean that in 2023, 1.4 million m^3 of primary forest biomass were delivered to other operators in the power sector (such as CHP plants providing district heating) or to other Metsä Group mills that burn primary woody biomass (such as sawmills). Given that 7.3% of the wood Metsä Group uses comes from Sweden, we estimate that 100,000 m^3 of the wood it procured directly from forestry operations in Sweden was delivered to other operators as energy wood, although it should be stressed that the company has refused to confirm if this estimate is accurate.

It should also be noted that other Metsä Group operations, such as sawmills and panelboard factories, may well burn primary woody biomass to generate energy, but that this is outside the scope of this study. In addition, Metsä Group has faced much criticism from civil society groups due to the company's logging practices and the huge amounts of wood required by its new "bioproduct mills" (pulp mills), some of which are covered in more detail in the Finland case study.

Nordic Paper

Nordic Paper is a Norwegian paper company operating five mills, three of them in Sweden. Only one of the Swedish mills is an integrated pulp and paper mill, whereas the other two are pure paper mills. The Swedish pulp and paper mill is located in Bäckhammar, Värmland County. According to a 2022 Environmental Report, the mill has a recovery boiler and a solid biomass boiler. Although the Bäckhammar mill sold around 90 GWh worth of bark that year, it also burned 23.9 GWh worth of wood purchased externally. The company has ignored requests for more information about the type of externally purchased wood. However, there is no sawmill nearby, and the company states that in 2023, a certain amount of fuel wood was consumed. Given the lack of more detailed publicly-available information and the company's refusal to provide it, we estimate that up to 30,000 m³ of primary woody biomass could be being burned at the mill each year.

Nordic Paper's Bäckhammar pulp mill. *Marina Ilaria*

Svenska Cellulosa Aktiebolaget (SCA)

Svenska Cellulosa Aktiebolaget (SCA) is a vertically integrated Swedish forest industry company that produces pulp, packaging paper, sawn timber, wood pellets and transport biofuels, generates energy and conducts logging operations. It operates two pulp mills, Ortviken and Östrand, and two pulp and paper mills, Obbola and Munksund, which produced almost one million tonnes of pulp in 2023. In 2022, SCA's production facilities used 10.3 million m³ of wood, 94% of which was sourced from Sweden and 58% from forests and plantations managed by SCA. Almost all of the wood sourced by the company was from northern Sweden, falling within Sápmi.

In 2023, SCA produced 11.1 TWh of bioenergy, 9.3 TWh of which was used in SCA's mills and 1.8 TWh was delivered to external customers. Of the external deliveries, 0.7 TWh was wood pellets, 0.6 Twh was unprocessed biofuels such as bark, sawdust and primary woody biomass from logging operations, and 0.5 TWh was district and waste heat. SCA describes itself as *"one of the largest suppliers of forest-based biofuels in Sweden, including unrefined by-products from the forest and industry, as well as refined fuels in the form of pellets."*

In terms of deliveries of primary woody biomass to other users, one study describes how SCA's forestry division, SCA Skog, delivers around 40,000 tonnes (130,000 m³) of logging residues annually to the Lugnvik CHP plant and Strömsund district heating boiler, and purchases a large share of logging residues from the private forest owners in the Östersund area. SCA has not responded to specific requests for information relating to the types and proportions of woody biomass the company burns to generate energy. However, using the information available, we estimate that the company delivers up to 750,000 m³ of primary woody biomass to energy producers from its own operations,[4] and burns up to 1,700,000 m³ of primary woody biomass to generate energy in its own power plants.[5]

SCA is also increasingly investing in pellet and liquid biofuel production, which will significantly increase its need for biomass. In the case of its pellet production, it is using sawmill residues which could otherwise have other uses, including panelboard production, which from a climate perspective is preferable to being burned. The competition for sawmill residues also drives up the total demand for woody biomass, and therefore logging pressures in the region.

Producing transport biofuels from pulp mill by-products and primary woody biomass

SCA is co-investing in a biofuel refinery being built jointly with the oil company ST1 in Gothenburg, with a total annual production capacity of approximately 200,000 tonnes of liquid biofuel. The refinery, which is under construction, is meant to be capable of producing biofuels for road vehicles and aviation. SCA claims its 25% ownership *"corresponds to 50,000 tonnes, equivalent to the total fuel requirements of domestic flights in Sweden."* SCA will supply tall oil, which is a by-product of pulp production. Using tall oil for biofuels is very concerning because it is in high demand by the chemical industry. If tall oil is used for energy generation purposes instead, the chemical industry will most likely replace the tall oil it had been using with fossil fuels. According to a 2017 study, these significant indirect greenhouse gas emissions mean that using tall oil as a fuel is even worse for the climate than using fossil fuel equivalents.

SCA is also trying to develop transport biofuel production from *"solid biomass, such as sawdust and bark"* at its newly expanded Östrand pulp mill. They admit that the technology for using solid biomass for transport biofuels is still under development (and research suggests that technical success is unlikely any time soon, if ever). Nevertheless, SCA is trying to open up a big new market for transport biofuels that will create more demand for tall oil and solid biomass.

In 2020, Södra announced the opening of the world's first bio-methanol plant at Mönsterås, supplying methanol to a biodiesel producer.[6] It has a capacity of 5,250 tonnes a year, and the methanol is made from woodchip. Södra sells methanol as part of its "Liquid Forest" brand. Its other Liquid Forest products are turpentine and tall oil. Both are now routinely produced from pulp mill byproducts around the world. However, Södra is also a partner and shareholder in SunPine, a company that produces drop-in biofuels (i.e. hydrocarbons from biomass which have similar chemical properties to fossil fuels)[7] from tall oil. Tall oil is already used in biodiesel production, and using it to produce drop-in biofuels would open up an even larger market.

Stora Enso

Stora Enso is the world's fourth-largest pulp and paper company and the largest one in Europe. In Sweden, Stora Enso operates the Skutskär pulp mill, as well as two paperboard mills, a plant producing paper products for packaging and two sawmills. Stora Enso also describes itself as *"one of the largest private forest owners in the world,"* owning and leasing more than two million hectares of tree plantations and forests worldwide. Of those, around 1.14 million hectares are located in Sweden.

Similarly to its Finnish mills, Stora Enso's Swedish pulp mill is unlikely to burn primary forest biomass due to company policy. However, the company's forestry division is also a major supplier of energy wood to external energy producers. According to its 2023 Annual Report, 300,000 m^3 of wood for energy generation was harvested from its forestry sites across all of the countries it operates in. If this value is extrapolated to third-party forestry lands, the figure rises to 843,000 m^3. It is therefore likely that, in Sweden, the company delivered around 194,000 m^3 of energy wood from primary sources to third-party customers in 2023, most likely customers in the industrial heat sector.[8]

Stora Enso also has a 16% shareholding in Pohjolan Voima, which is one of Finland's largest users of primary woody biomass for energy, discussed in more detail in the Finland case study.

Stora Enso's Skoghall pulp mill. *Marina Ilaria*

A logging truck in Sweden carrying pulp wood. *Marina Ilaria*

Södra

Södra operates three pulp mills in southern Sweden: in Mönsterås (Kalmar County), Mörrum (Blekinge County) and Värö (Halland County), as well as seven sawmills. It describes itself as *"a forest industry group that processes the forest products delivered by its 53,000 owners."* Södra and its members own and manage around 2.8 million hectares of land, mostly spruce and other conifer plantations, in southern Sweden. The vast majority of these are not biodiverse forests but even-age monoculture plantations. According to their quarterly report in December 2023, they took "nature conservation measures" on just 2,010 hectares. In addition, Södra manages 16,000 hectares of forests in Estonia and ships Estonian wood to its pulp mills.

Södra reports having produced 1,885 GWh of electricity in 2023, of which 432 GWh were sold to the grid. According to its latest Annual Report, 54% of the solid biofuels burned in Södra's power plants, equivalent to almost 2,000 GWh of energy, comes directly from forestry operations, compared to 46% mill by-products such as bark. This is equivalent to around 2.5 million m^3 of woodchip.[9] Södra's biomass electricity generation attracts generous subsidies: they state that they are *"one of the largest producers of green electricity eligible for green electricity certificates in Sweden."*

Syvalmo

Syvalmo is an international pulp and paper company based in Tennessee, USA. In January 2023 they acquired the Nymölla pulp and paper mill, located in Skåne County in the southeast of Sweden, from Stora Enso. In 2022, prior to the takeover, the mill burned 632,000 tonnes of biomass. According to the mill's Environmental Report for the same year, 93% of the mill's energy is produced from biofuels, and 100 GWh of surplus heat a year is supplied to district heat networks in Bromölla and Sölvesborg. The plant has a recovery boiler and a solid fuel boiler, which burns woodchip alongside pulp mill residues such as bark and sludge. The company provides no information about the origin of the woodchip, nor the quantities of different feedstocks, and has ignored requests for further information. However, it indicates in its Environmental Report that primary woody biomass is used, referred to as "fuel chips." There is no adjacent sawmill, which makes it more likely that the woodchip is made from primary woody biomass. It is therefore possible that up to 70,000 tonnes (240,000 m^3) of woodchip from primary woody biomass are burned for energy each year.[10]

Wood pellets. *Oregon Department of Forestry*

Sawmill residues: Wood pellet production and burning sawdust for energy

As well as burning primary woody biomass for energy, Sweden's pulp industry is also burning large quantities of sawmill residues such as sawdust and offcuts, or turning them into pellets. This diverts these by-products away from alternative uses such as panelboard production and other more durable wood products, which would have a lower climate impact. Using sawmill residues for energy generation drives up the total demand for woody biomass and therefore increases logging pressures on forest ecosystems.

Examples of pulp producing companies that burn sawdust include ATA Timber, which describes in a 2022 Environmental Report for its Waggeryd Cell pulp mill that its solid fuel boiler "mainly" burns sawmill residues, alongside pulp mill by-products (bark and sludge). Arctic Paper's upgraded biomass boiler at its Grycksbo mill will also mostly burn sawdust. Another example is Holmen, a forestry company which owns three pulp and paper mills in Sweden, and one in England. It uses sawmill residues to produce electricity and heat for its pulp mills, such as its Braviken pulp mill, which is co-located with a company-owned sawmill. Its operators reported in 2018 that the mill's solid fuel boiler was burning large quantities of sawmill residues.

A number of Sweden's pulp-producing companies are also building or have recently built new wood pellet mills. SCA has the largest production capacity, and its five fully or partially-owned pellet mills can now produce up to 340,000 tonnes per year. In 2023, a new pellet plant adjacent to its Rundvik sawmill began operating in order to supply the recently replaced lime kilns at the Obbola and Munksund pulp mills, which run on wood pellets instead of fossil oil. This requires around 38,000 m^3 of wood pellets (or 26,000 tonnes).

Two of SCA's largest pellet mills are certified by the Sustainable Biomass Partnership (SBP), indicating that the pellets are produced for industrial and not domestic use. According to the Supply Base Audit for the 180,000 tonne capacity Härnösand pellet plant, sawmill residues are sourced from up to 10 sawmills using wood from Sweden, Finland and Norway. SCA holds 9% of shares in and supplies the wood to a pellet plant operated by Luleå Energi, with an annual capacity of 100,000 tonnes. According to the mill's Supply Base Report, it uses sawmill residues from up to 12 sawmills, which receive wood from Sweden and Finland.

Stora Enso also operates two pellet plants in Sweden, each with a capacity of 100,000 tonnes per year. They are co-located with the company's Gruvön and Ala sawmills, making it likely that the wood used comes from sawmill residues. Arctic Paper is another pulp-producing company expanding into the wood pellet market, and is constructing a pellet plant with a capacity of 50,000 tonnes a year at its Grycksbo site. It expects to commission the plant in 2025, and the pellets are destined to be sold rather than used internally. Södra is also diversifying its manufacture of wood-based fuels, and operates a pellet mill with a capacity of 40,000 tonnes a year at its Väro mill, and another with a capacity of 45,000 tonnes a year next to its sawmill in Långsjö.

Sweden produced 1.8 million tonnes of wood pellets in 2022, meaning that at full capacity pulp-producing companies would account for around 50% of Sweden's pellet production. The vast majority of the feedstock used for pellet production associated with the pulp industry is sawmill residues, equivalent to around 1.4 million tonnes of wood.

Pulp industry lobbying for large increases in primary woody biomass combustion

Sweden's Bioenergy Association (Svebio), representing several large pulp producers, including Arctic Paper, SCA and Södra, is advocating for a massive increase in the amount of primary woody biomass burned for energy each year. It claims that 148 TWh of forestry residues are left in managed forests annually, whereas only 10 TWh is collected and used for energy. According to the group, an increased harvest of 60 TWh of residues is possible while complying with EU Renewable Energy Directive's sustainability criteria.

In making this claim, Svebio is ignoring the scientific evidence around the key problems involved in burning primary woody biomass: first of all, pulp producers are logging forests that should not be logged at all. In addition, they log biodiverse forests via a harmful logging method: the FSC-certified so-called regeneration forestry (otherwise known, and in this report referred to as clear cut logging). . Which in effect results in monoculture tree plantations due to the fact that forestry companies had been replanting clearcut areas with single species plantations. Therefore, all types of primary woody biomass from these practices are unsustainable.

Today, clear cut logging is the most common harvest method in Sweden, and accounts for 97% of all logging operations. Given that boreal forest ecosystems store an enormous amount of carbon, these logging operations release large amounts of the carbon stored in forests and soils. Put together, the trees, plants, soils and peatlands common to Boreal ecosystems store more carbon than the world's tropical forests. Boreal forests are the single largest terrestrial carbon stock on the planet, and most of the carbon is stored in soils, making clear cutting particularly harmful for the climate.

It has also been established that in Sápmi, approximately 40% of today's clear cut operations are likely to take place in forests that the EU wants to protect (the last remaining forest that never been clear cut). In addition, across the whole of Sweden, current logging plans in forests with confirmed high conservation values amount to 40,179 hectares. Already intensive logging rates coupled with existing low levels of protection will threaten Sweden's last remaining old-growth forests, meaning that virtually all unprotected natural forests in non-mountainous areas are projected to be lost in the coming decade.

Logging site in Sweden. *Marcus Westberg*

Sámi reindeer herders. *Michiel van Nimwegen/Flickr*

Today, only 6% of Swedish forests are formally protected. The Swedish Forestry Agency's 2024 annual review of its environmental objectives states that *"There is a negative trend regarding the state of the forest. At present, there are insufficient measures to ensure that forest biodiversity is preserved and that forest ecosystem services are maintained over time."* In addition, government data shows that 14 out of 15 forest habitats have an unfavourable conservation status, and the conservation status of 10 out of 11 woodland-living priority species is also listed as "bad". On top of this, about 2000 forest species are red-listed in Sweden according to the Swedish Species Information Centre, who state that *"Three out of four red-listed forest species are declining because of the conversion of natural forest with a long continuity into tree plantations. Swedish forestry methods, in particular clear-cutting, therefore have a strong negative impact on forest species."* To highlight how wide-spread these impacts are, it is estimated that 39% of the important biologically-sensitive habitats in Sweden were negatively affected by harvesting during 2014-2017.

This systematic conversion of irreplaceable forests into environmentally-harmful tree plantations is also threatening the rights of Indigenous Sámi communities. The reindeer that their indigenous culture rest upon have survived the harsh arctic climate for time immemorial, but after only 60 years of Sweden's prevailing clear cutting forestry model, 71% of lichen-rich forests in Sweden - crucial for the survival of the reindeer and indigenous culture - have disappeared. Sámi communities are sounding the alarm and letting the world know that "*the reindeer are starving*," and hae sent an open letter to the government.

Sweden's FSC-certified forestry model is therefore a guarantee of increased emissions, a continual loss of biodiversity and a systematic violation of Indigenous Peoples' rights. Halting the destruction and fragmentation of forest ecosystems as well as restoring and protecting more forests is fundamental; not least for strengthening the resilience of ecosystems during a period of extreme climate change. At a time when reducing emissions and safeguarding every possible carbon sink and carbon storage is critical, FSC-certified regeneration forestry (otherwise known as clear cutting) continuously moves large amounts of carbon out of the forest stock and into the atmosphere via its logging methods and end-products.

The important question therefore is not how many TWh of bioenergy is produced by burning so-called forestry residues left behind during logging operations each year, but whether pulp producers can guarantee that the biomass does not stem from these destructive logging practices, which they cannot.

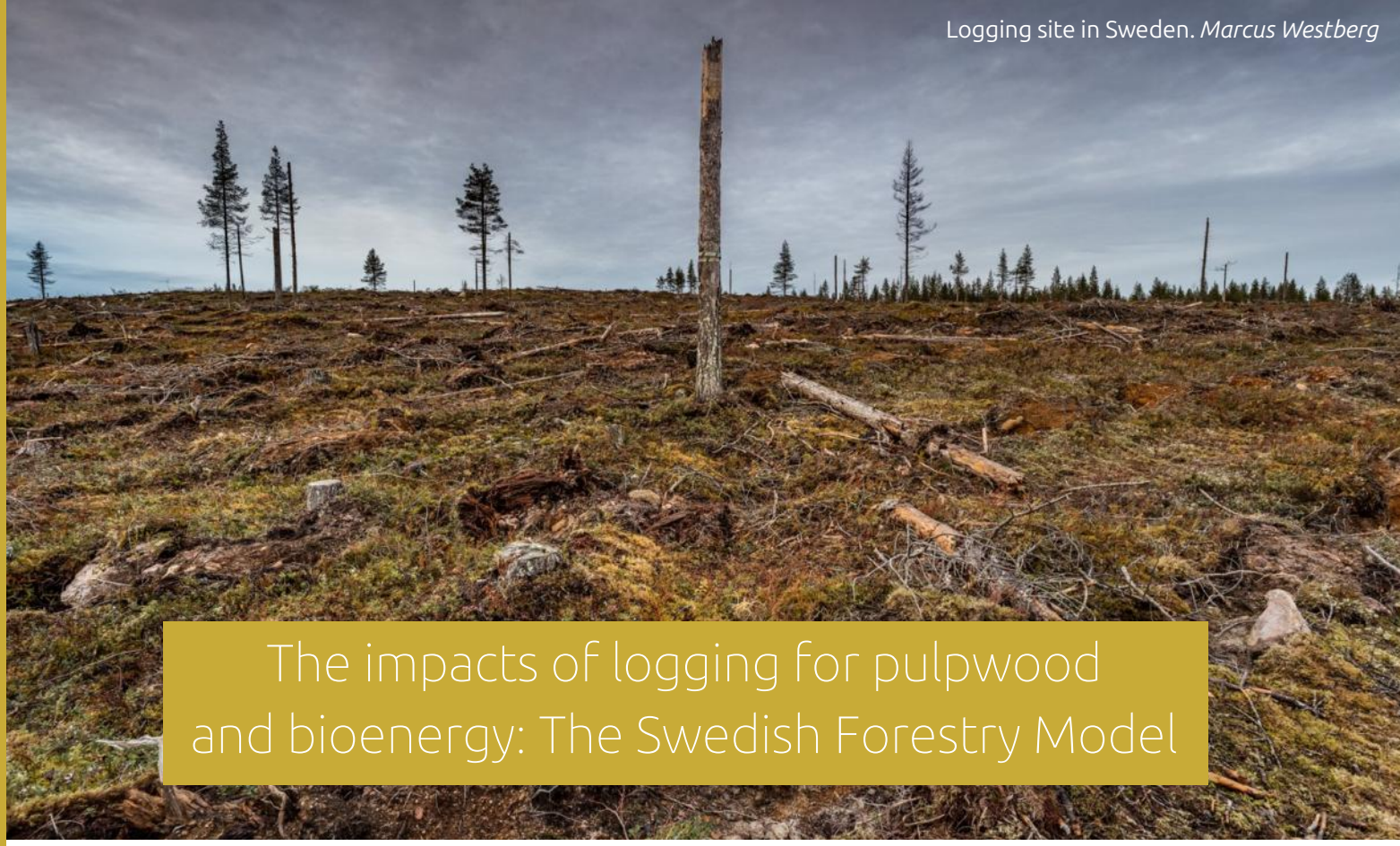
Climate impacts in the Swedish context

Sweden has experienced a sharp decline in its forest carbon sink (25% decline over a decade between 2011 and 2021[11]) in recent years despite claims that its forestry practices are sustainable. Data from the Swedish Environmental Protection Agency highlights a *"substantial reduction"* in the forest and land carbon sink due to recent declines in tree growth and high logging levels and acknowledges that *"The sharp decline in net storage may mean that Sweden will find it difficult to reach the EU's common climate goals linked to the land use sector."* Any increase in the biomass extraction rate from Sweden's forests would, therefore, clearly further reduce the ability of forest land to act as a carbon sink.

In addition, over a 50-100 year perspective, burning woody biomass has a higher climate impact than fossil fuels and emits more CO_2 per unit of energy. Studies also show that using primary woody biomass for energy production can increase carbon emissions by around 40% compared to fossil fuels, if losses of soil carbon during harvesting are taken into account.

The science is clear: society urgently needs to reduce all greenhouse gas emissions, including from burning forest biomass, while simultaneously and rapidly scaling up forest protection and restoration. Burning forest biomass does the opposite however, and over the all-important future years and decades, it will both increase emissions and decrease forest carbon stocks, moving enormous amounts of CO_2 from forests into the atmosphere. Scientists are also clear: in 2018, close to 800 scientists signed a letter to the European Parliament with a clear warning to parliamentarians that burning forest biomass will worsen our climate impact in the coming decades. The European Science Advisory Council (EASAC) has also emphasised that the burning of forest-based products could increase CO_2 emissions in the EU.

Logging site in Sweden. *Marcus Westberg*



Logging site in Sweden. *Marcus Westberg*

The impacts of logging for pulpwood and bioenergy: The Swedish Forestry Model

Sweden has the largest area of tree cover in the EU, at 23 million hectares (non-mountainous areas), and about 50% of Sweden's total land area falls within Sápmi, the traditional lands of the Indigenous Sámi People. Logging rates are constantly increasing due to the competing demands from forest industries to produce timber, pulp, paper, bioenergy, biofuels and other products, with more than half of Sweden's annual wood harvest being turned into pulp or used for energy generation.

The Swedish Forestry Model is based on the clearcutting of older forest stands, natural and near-natural forests, and replacing them with planted tree-stands. The model exists for the benefit of large industries, and allows forestry companies to police their own practices, thereby simultaneously adhering to standards of conservation and carrying out highly-destructive and extensive clearcutting predominantly of old growth forests, since most of the country's plantations are still too young to harvest.

In practice, only a few small islands of trees are retained for conservation purposes after forest clearcuts. These logging practices are contributing to biodiversity loss and the decline of vital forest ecosystem functions, such as water quality and other essential elements that life requires in order to flourish.

The model of forestry carried out by Sweden's pulp and paper industry is part of a green colonial paradigm which exploits the traditional lands of the Sámi, causing deep fractures in the Sámi's way of life and a mosaic of oppressions created by the industries, politics, policies and institutions that uphold the model. The Sámi have traditionally lived through reindeer herding, hunting, fishing, trading and *duodji* (arts and crafts), but their livelihoods have been severely affected by many colonial exploitations such as forestry. The Swedish state has systematically forced the Sámi from their lands, forbidden them to speak their languages and practise their culture and spirituality.

Sweden's forestry practices have been described as *"a disaster for the Sami, biodiversity, the countryside's development, the small-holding land owners, and the nature tourism industry."* Reindeer in particular rely on older and lichen-rich forests, which are often the forests that the forestry companies are now logging. Sweden has lost over three-quarters of its old growth forests since the 1950s, and the remaining pockets of relatively intact forest ecosystems are being logged at an alarming rate. The Council of Europe's Committee of Ministers have even published a resolution sharply criticising Sweden's treatment of the Sámi, and specifically calling on the Swedish government to protect their cultural practices on their traditional land, particularly reindeer herding.[12]

Sweden's state-owned forest company sells more than half of its annual harvest to the pulp and paper industry

Sveaskog is a state-owned forestry company that is Sweden and Europe's largest forest land owner, with 3.9 million hectares. According to the company, 68% of those overlap with reindeer herding areas (Sápmi). Sveaskog supplies pulpwood to around 20 pulp and paper mills, equivalent to 5.5 million m^3 of wood in 2022, which was 51% of the total volume sold by the company. It also supplied 0.45 million m^3 of primary woody biomass for energy generation to around 50 customers in Sweden in 2022, equivalent to 1.2 million m^3 of woodchip.[13] According to National Geographic Explorer Staffan Widstrand, *"most of the clearcut logging on Sámi land is carried out by Sveaskog, and often at a direct loss. So we can say that the Swedish taxpayer is actually continuously subsidizing the deforestation of Sámi lands, for the good only of the privately-owned industry giants."*

Sveaskog claims that its *"biofuel is a by-product from felling and consists of branches and tree tops that would otherwise be left in the forest after felling. The natural decomposition process releases the same amount of CO_2 that is emitted during controlled combustion with heat extraction in a heating plant,"* but offers no scientific reference for this claim and contradicts studies showing that significant amounts of carbon remain locked in forest soils as biomass decomposes. It also describes how *"The customers for Sveaskog's biofuels are power and heating plants as well as the energy-producing forest industry...Sveaskog felt that the consumption of biofuel generally increased as a result of several co-generation plants having increased electricity production compared to previous years,"* showing how electricity generation and therefore state-funded incentives are directly driving increased use of primary woody biomass for energy generation.

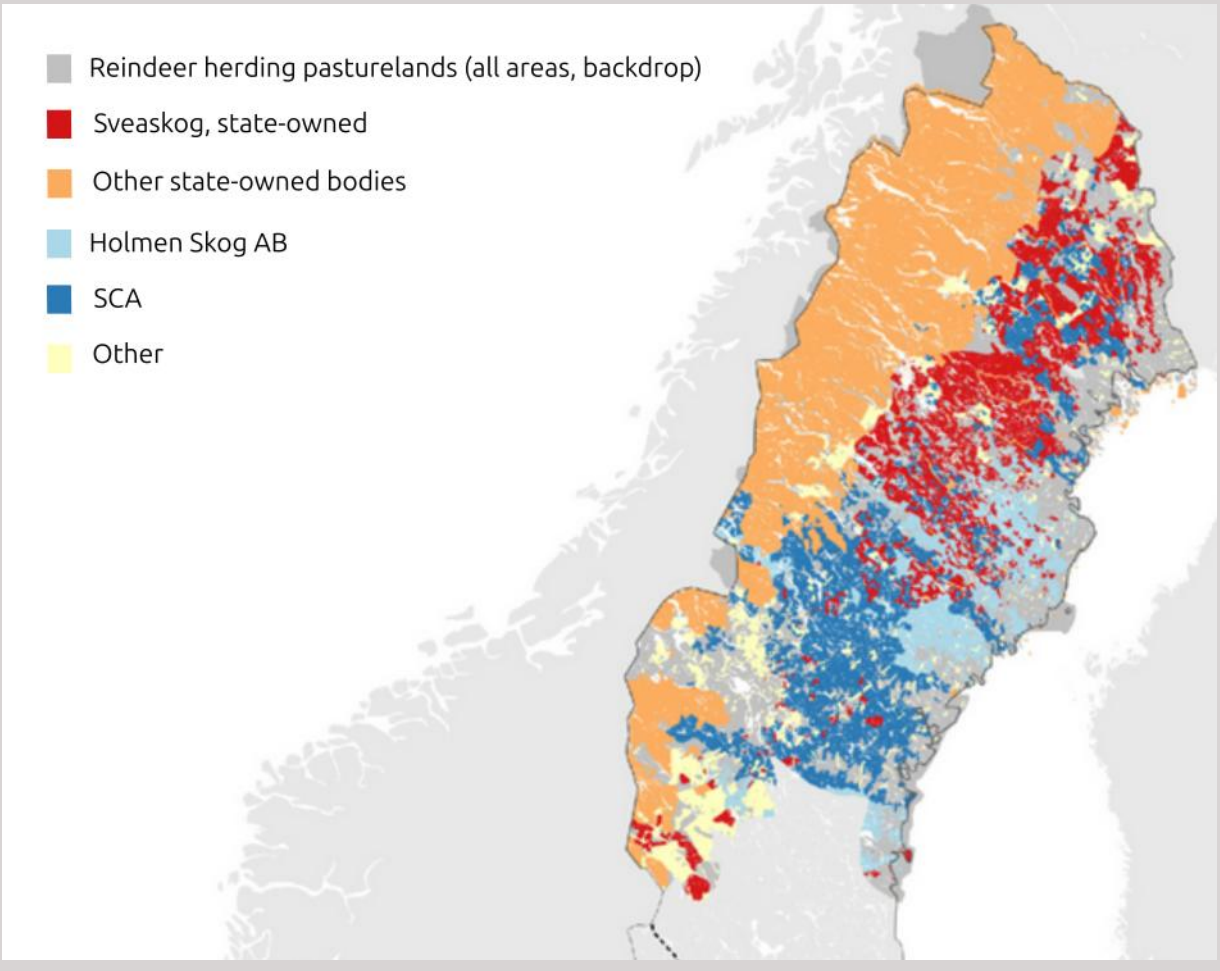


Figure 1: Map of large forest property owners in Sweden within reindeer herding areas.
Adapted from: David Harneskinland (2022)

SCA: Systematic harm to irreplaceable ecosystems and Indigenous Peoples

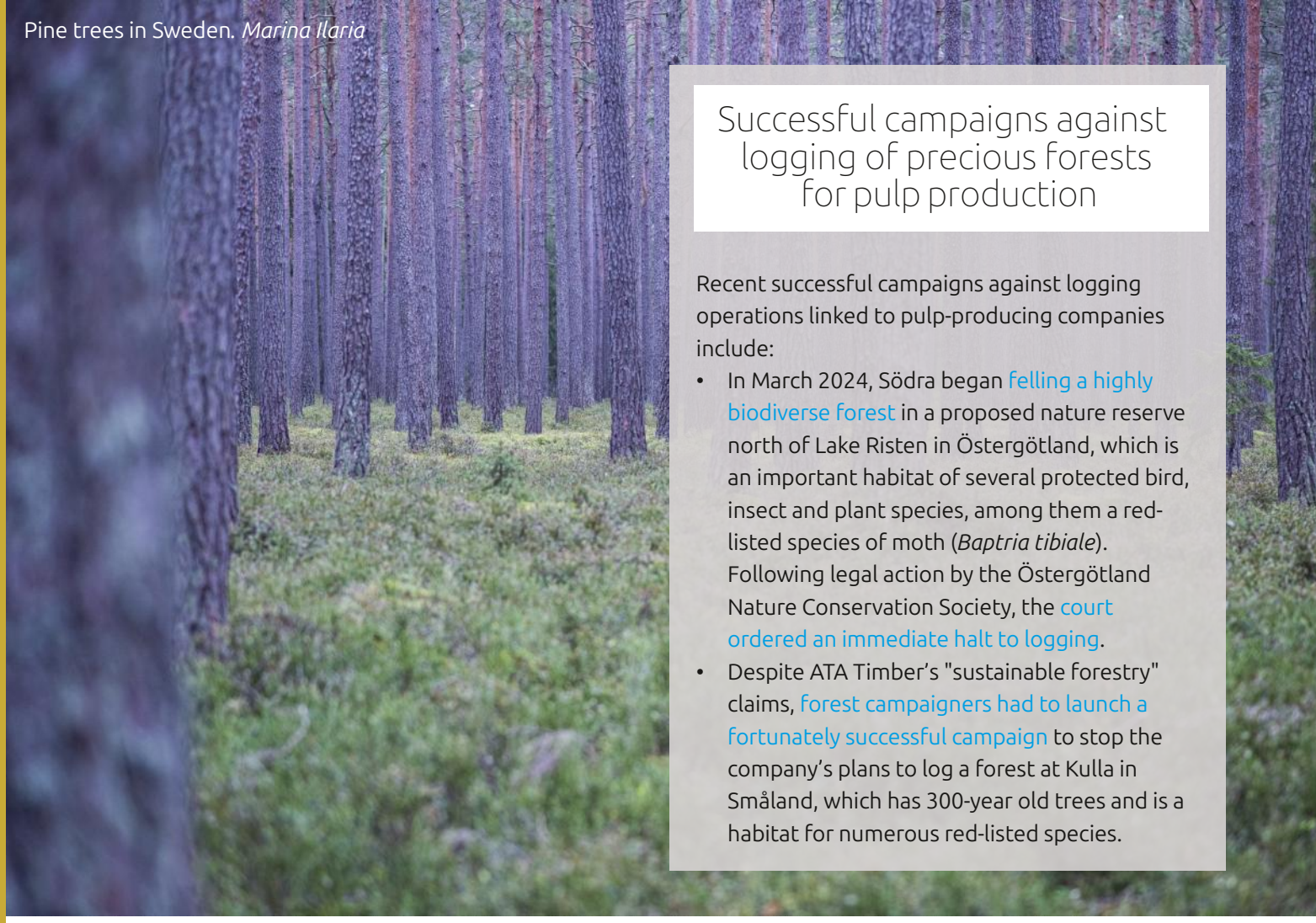
SCA is Sweden and Europe's largest private forest owner, accounting for 2.6 million hectares of forest land, much of which falls within Indigenous Sámi reindeer herding areas (Sápmi). SCA's logging practices are extremely controversial, and have attracted numerous protests from Swedish civil society groups over their extensive clearcutting of irreplaceable forests.

Protect the Forest has recently collected 500 examples showing how the company has systematically logged natural forests with high conservation values. The group also highlights the high number of similar cases that go unreported, and the many examples of biodiversity-rich forests that SCA plans to log in the near future. Another study conducted by Protect the Forest analyzed data on all forests notified for clear-cut logging by SCA, and found that more than a third (37%) consist of so-called probable continuity forests, which are forests that have never been clear-cut before. In February 2024 alone, a total of 36,802 hectares of continuity forests was notified for clear-cut logging by the company. The analysis also highlights examples of where SCA has logged its own previously set-aside areas for nature conservation, and what proportion of the forests that SCA has clear-cut have been converted into tree plantations. Essentially, these studies show how SCA is systematically converting naturally regenerating forests into tree plantations.

As another example, in 2021, SCA felled an area of ancient forest in the municipality of Arjeplog with centuries-old firs and pines, even though the site was due to form part of a nature reserve in order to protect its high biodiversity value. SCA originally requested a logging permit for 120 hectares on the Maskaure reindeer administrative association's land, which included 25 hectares of an especially rare and ancient forest type. The average age of the trees was around 180 years-old, with some as old as 300 years, and the forest had abundant lichen as well as being a habitat for 16 red-listed species. According to Amnesty Sápmi, SCA has received a number of fines for illegal logging in recent years, and in one case defied a logging ban in a reindeer grazing area on six different occasions.

SCA has also caused harm to Sámi reindeer herders due to their replacement of natural forests with contorta pine (*Pinus contorta*, also known as lodgepole pine), which is non-native. In addition, contorta spreads outside plantation areas, and has even been found on mountain areas 820 metres above sea level (on Grönfjället in Härjedalen).

SCA's Munksund pulp mill. *Marina Ilaria*



Pine trees in Sweden. *Marina Ilaria*

Successful campaigns against logging of precious forests for pulp production

Recent successful campaigns against logging operations linked to pulp-producing companies include:

- In March 2024, Södra began felling a highly biodiverse forest in a proposed nature reserve north of Lake Risten in Östergötland, which is an important habitat of several protected bird, insect and plant species, among them a red-listed species of moth (*Baptria tibiale*). Following legal action by the Östergötland Nature Conservation Society, the court ordered an immediate halt to logging.
- Despite ATA Timber's "sustainable forestry" claims, forest campaigners had to launch a fortunately successful campaign to stop the company's plans to log a forest at Kulla in Småland, which has 300-year old trees and is a habitat for numerous red-listed species.

Contorta pine was introduced on a large scale from North America in the 1970s, and its introduction is, according to the Swedish University of Agricultural Sciences (SLU) *"a large-scale ecological experiment."* Contorta plantations today cover approximately 600,000 hectares in Sweden and SCA is responsible for managing half of this area. More than 85% of contorta plantations are located on Indigenous land (Sápmi), and it is notable that the Swedish Forestry Act actually prohibits, with some exceptions, contorta pine to be planted south of the 60th parallel. Reindeer herding areas start just north of the 61st parallel, meaning that contorta pine plantations are almost exclusively allowed on Indigenous land. Studies show that reindeer avoid areas with contorta pine and that the forest industry's choice to plant them has strongly contributed to the significant loss of lichen-rich forests over the last 60 years.

Sámi communities have a zero-tolerance policy towards planting contorta pine, but SCA does not respect the Sámi communities' rights to free, prior and informed consent (FPIC). Contorta also suffers more than twice as much damage from wind and snow compared to native trees, making these dense plantations particularly difficult for reindeer to pass through. In Sweden, contorta is used almost exclusively to produce pulp, as it does not pass the standards that would allow it to be used in construction. Forestry companies prefer contorta pine as it is faster growing, can be planted more densely and is resistant to some of the diseases that can affect Swedish pine.

Other impacts of SCA's logging and plantation operations include the intensive use of fertilisers, which reindeer herding associations say harms lichen growth and reduce the amount of light that reaches the forest floor due to denser tree growth. SCA's numerous wind farm developments involving hundreds of turbines being installed on traditional Sámi lands have also been particularly controversial, as the company has pursued becoming *"one of Sweden's leading suppliers of fossil-free electricity produced by wind power."* Wind developments are another threat faced by the Sámi alongside industrial transmission lines, forestry, mining, hydroelectric and infrastructure developments.

Conclusions

Sweden's pulp and paper industry, as the central pillar of the forest sector as a whole, plays a substantial role in bioenergy generation and the combustion of primary woody biomass. Up to a third of the primary woody biomass burned each year can be attributed directly and indirectly to pulp-producing companies, with SCA and Södra playing the most prominent role.

Although Sweden's forest industries claim that the primary woody biomass they use to generate energy is residual biomass from logging operations, and that trees are not cut down specifically for energy purposes, lucrative incentives offered for burning biomass and generating biomass electricity are key to the industry's profitability as a whole. Burning biomass, of which primary biomass plays a substantial role, therefore underpins the entire viability of the pulp industry and enables the logging of whole trees and the clearcutting of forests, regardless of what fraction of a tree is used in a sawmill, pulp mill or burned for energy.

Sweden's pulp and paper companies are also responsible for a significant proportion of the sawmill residues that are burned each year, in particular through wood pellet production. Pulp-producing companies oversee around 50% of Sweden's pellet production, and almost all of the feedstock used in the process comes from sawmills. This diverts wood away from alternative uses such as panelboard manufacture, which would have a lower climate impact, and indirectly results in increased logging pressure due to the additional demand for biomass that is created.

Underpinning the use of primary woody biomass for energy generation in Sweden is a forestry model that, despite its tremendous efforts to paint itself as sustainable and socially-responsible, is resulting in the the decimation of Sweden's remaining highly-biodiverse forests, and directly threatening the livelihoods of the Indigenous Sámi peoples. The pulp industry is at the heart of the continued logging of precious forests, exemplified by the fact that more than half of the volume of wood harvested by state-owned forestry company Sveaskog (Europe's largest forest owner) goes to pulp mills, and that one of Sweden's largest pulp producers, SCA (Europe's largest private forest owner) has been fined on multiple occasions for illegally logging high-value forests both on and outside of Indigenous land.

A pine seedling. *Marina Ilaria*

Notes

1. Statistics were calculated by using SEA data and this converter: https://www.convert-measurement-units.com/conversion-calculator.php

2. This figure includes energy generated by burning black liquor, as well as primary and secondary woody biomass such as logging residues and bark. Source: https://www.energimyndigheten.se/forskning-och-innovation/forskning/bioenergi/biokraft/

3. Billerud has a long-term agreement to purchase one million cubic meters of wood annually from its subsidiary, Bergvik Skog Öst. If on average 10% of wood harvested from Swedish forestry operations is burned for energy (https://link.springer.com/article/10.1007/s12649-020-00947-0), that would equate to 100,000 m^3 of primary woody biomass being burned at Billerud's Swedish mills each year.

4. 600 GWh of delivered unprocessed biofuels is equivalent to 750,000 m^3 of woodchip.

5. In 2023 SCA produced 972,000 tonnes of pulp and 1,879,000 m^3 of timber and solid wood products. Its total fuel consumption from biofuels was 9,280 GWh, and pulp mills consumed 5,393 GWh from biofuels. 972,000 tonnes of pulp would produce around 194,000 tonnes of bark, equivalent to 648,000 m^3 (if one m^3 is equal to 300 kg: https://www.osti.gov/etdeweb/servlets/purl/951488), which is equivalent to 389,000 MWh (0.6 MWh/m^3). 1,409,400 tonnes of black liquor would also be produced (145t DS/ADt) = 16912800000 (12 MJ/kgDS) = 4,735,584 MWh (1j=0.00028MWh) = 4,736 GWh. 4,736+390 GWh = 5126 GWh. Equivalent to an extra 134,000 tonnes of bark. Total biomass fuel consumption other than pulp = 3,887 GWh = 4,858,750 m^3 woodchip. Waste wood produced through solid wood products = 4,697,500 m^3 sawdust and woodchip. Wood pellet production 300,000t = 450,000t wood required = 1,500,000 m^3 woodchip. Therefore an additional 1,660,000 m^3 of woodchip would be required to achieve total fuel consumption from biofuels.

6. Biodiesel is made by reacting vegetable oils or animal fats with methanol, which is almost always derived from fossil gas.

7. Hydrotreated Vegetable Oil (HVO) is chemically similar enough to fossil fuels that it can be used in combustion engines in unlimited quantities without further refining (although for use in aviation further refining is needed).

8. Stora Enso harvested "10.5 million m^3 forest cubic meters" from owned and leased forests in 2023, and delivered 10.2 million m^3 to its mills. 0.3 million m^3 (3%) was therefore energy wood. Total deliveries to all mills were 28.1 million m^3, excluding energy wood. If energy wood is harvested at the same proportion, then all energy wood is equivalent to 843,000m^3. Sweden (and Norway) represents 23% of total wood use, equivalent to 194,000 m^3 of energy wood.

9. Assuming that woodchip has an energy density of 0.8 MW/m^3.

10. If the Nymölla Mill's annual production capacity is 340,000 metric tons of pulp, this would be equivalent to around 68,000 tonnes of bark and 493,000 tonnes black liquor, or a combined 561,000 tonnes. If the total biomass use is 632,428 tonnes, then 70,000 tonnes of biomass could have been primary woody biomass.

11. National Inventory Repor, Sweden (2023). Greenhouse Gas Emission Inventories 1990-2021 Submitted under the United Nations Framework Convention on Climate Change.

12. Kuhn, G. (2020) *Liberating Sápmi: Indigenous Resistance in Europe's Far North*

13. One m^3sub is equivalent to 2.63 m^3 of loose woodchip (http://woodenergy.ie/media/coford/content/publications/projectreports/cofordconnects/ht21.pdf).

Energy wood waiting to be chipped in Finland. *Varpu Sairinen*

March 2025

Burning down Finnish forests

The scale and impacts of using woody biomass for energy by the pulp and paper industry

Ei polteta tulevaisuutta

biofuelwatch

Environmental Paper Network

Introduction

Finland is one of the most biomass dependent countries in Europe when it comes to generating energy, and 30% of the energy consumed in Finland in 2021 was produced by burning biomass, with more than half of this being woody biomass (57%). Wood-based fuels account for as much as 70% of so-called renewable energy in Finland. It has been the single largest source of energy in Finland since 2012.

Over the last two decades, the end-use of biomass for energy purposes has overtaken its use in forest products such as pulp, paper and sawn timber, such that in 2022 61% of the biomass harvested from Finnish forests was ultimately burned for energy. This increase has mainly been driven by the increased use of biomass in the industrial heat and power sector, particularly in combined heat and power (CHP) plants.

Finland's forest industries, of which pulp and paper production is a major component, accounted for 18% of all energy consumption in Finland in 2020. They produced between 50% and 70% of the energy they consumed in their own bioenergy facilities, making forest industries by far the largest users and producers of energy from biomass. The pulp and paper sector is the biggest industrial user of biomass for energy in Finland, and consumed around 56% of Finland's overall biomass energy production in 2020, much of which it generated itself. As well as generating biomass energy for its own operations, it also sells excess heat and electricity to other industries, district heating systems and the public grid.

Finland's forest sector is made up of 141 production facilities, including 13 pulp mills, 21 paper mills and 18 cardboard mills, as well as numerous sawmills, wood panel factories and biofuel refineries. The forest industries sector is also highly integrated, such that many pulp producers are part of industrial conglomerates that also operate forestry companies, paper and cardboard mills, sawmills and energy infrastructure. This makes it particularly difficult to disaggregate the exact contribution of pulp mills to overall biomass energy generation but also highlights the fact that the sourcing impacts of major pulp producers are spread far wider, across the whole forest sector.

Finland is Europe's second-largest pulp producer by a large margin and produced over nine million tonnes of pulp in 2022, equivalent to over a fifth of Europe's total pulp production. However, it is only the fourth largest producer of paper products, accounting for 7% of the total production. This reflects a shift in emphasis in recent years from exporting paper products to exporting pulp.

UPM's Kaukas pulp mill. *Ei polteta tulevaisuutta*

Wood waiting to be chipped at a Skogsreviret Nyved Ab energy wood terminal in Raasepori. *Greenpeace*

One quarter of the wood consumed in Finland ends up being transformed into paper, cardboard and wood pulp. Consequently, 86% of all the wood consumed in Finland is either burned to produce energy (61%) or used for material production (25%) by the pulp and paper industry. The economic importance of energy generation at Finnish pulp mills has also grown over recent decades, given that there is increasingly less emphasis on generating energy for paper production alongside pulp production, which in the past had a higher energy demand. There is therefore now larger amounts of excess energy available to be sold to external heat customers and the public electricity grid.

Finnish pulp mills began burning black liquor to generate energy in the early 1990s as a result of state intervention to reduce water pollution caused by the fact that the mills were previously dumping this industrial by-product into watercourses. The introduction of carbon taxes that made burning fossil fuels more expensive also encouraged the use of black liquor as a fuel. Energy generation is also partly responsible for maintaining the profitability of pulp production in Finland since modern mills produce far more black liquor than they require for their own energy needs. Another industrial by-product, bark, has grown in value as demand for so-called renewable energy generation has increased.

As is the case with all biomass feedstocks, black liquor and bark are considered renewable energy sources, and the emissions from their combustion are ignored. However, from a climate perspective, these fuels are also highly emissive. Although it may be preferable in this context for pulp mills to use these by-products as a fuel rather than fossil fuel equivalents, the point must also be made that such huge quantities of black liquor and bark result from a highly unsustainable industry with multiple supply chain impacts. In addition, these fuels can have alternative uses that don't involve combustion, and which would result in a lower climate impact. The emissions from their combustion should therefore be fully accounted for.

Almost all of the black liquor and bark produced as byproducts from pulp production is burned for energy generation in Finland. However, the extent to which the pulp and paper industry is also sourcing primary woody biomass for energy generation, and what proportion of overall primary biomass use for heat and electricity production this represents, is unknown. This case study aims to assess the scale of this contribution and its likely impacts.

What wood is being burned for energy in Finland?

Burning biomass accounted for 112 TWh of energy generation in 2021 (the last year that statistics are available for), of which 41% was black liquor and 42% was solid wood fuels like bark, sawdust, recycled wood and primary woody biomass (referred to as forest chips in Finland).

In 2023, 22.5 million m^3 of woody biomass were used as fuel in heat and power plants, and primary woody biomass (small-diameter trees from thinning operations, solid trunk wood and logging residues) accounted for almost half of this (11 million m^3). Secondary woody biomass (including forest industry by-products and recycled wood) accounted for the remaining 11.5 million m^3 burned by heat and power plants (Figure 1).

The amount of primary woody biomass burned in heat and power plants has increased significantly in the last two decades. Between 2000 and 2023, the annual consumption of solid wood fuels in this sector grew by 87%, from 12 to 22.5 million m^3. Most of this growth was due to increased consumption of primary woody biomass harvested directly from forests, while the amount of secondary woody biomass burned to produce energy remained at a similar level (Figure 2). Between 2000 and 2023, the amount of small-diameter trees used for energy increased by 6.4 million m^3 (an increase of 2218%), solid trunk wood by one million m^3 (an increase of 2900%), logging residues and stumps by 2.9 million m^3 (an increase of 760%) and secondary woody biomass (including bark, sawdust and woodchip) by only 272,000 m^3 (an increase of 2%).

A total of seven million m^3 of woodchip directly from forestry operations was burned in CHP plants in 2023, and another four million m^3 was burned solely for heat production. Although most of the woodchip produced for energy generation from primary woody biomass consists of small-diameter trees, the use of sturdy trunk wood has also significantly increased in recent years. According to the principle of cascading use of wood, this should have been used for other purposes or left as living or decaying trees in the forest.

There is much controversy and secrecy in Finland around what wood is being burned for energy. The energy and forest industries claim that they only burn industrial by-products and logging waste, but research by environmental organisations as well as government statistics

Woody biomass consumption in heat and power plants in Finland

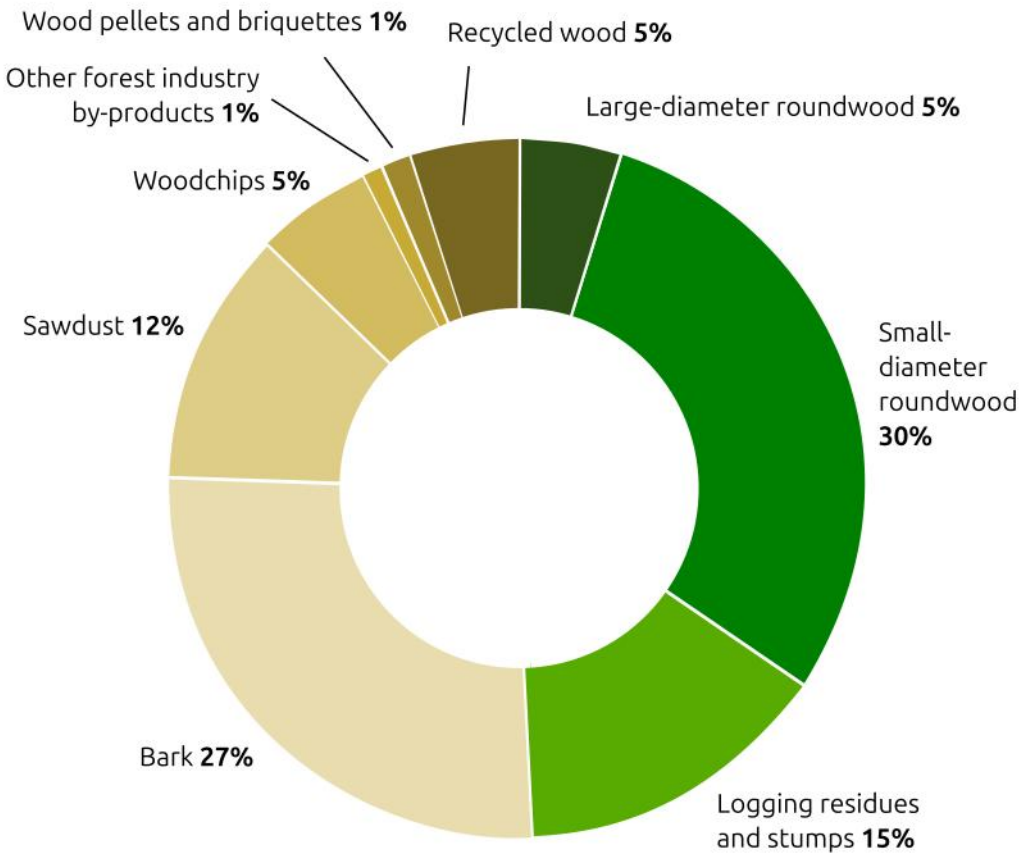


Figure 1: Proportion of different solid/woody biomass fuel types consumed in Finland's heat and power plants in 2023. *Source: Natural Resources Institute Finland*

Changes in woody biomass consumption in heat and power plants in Finland

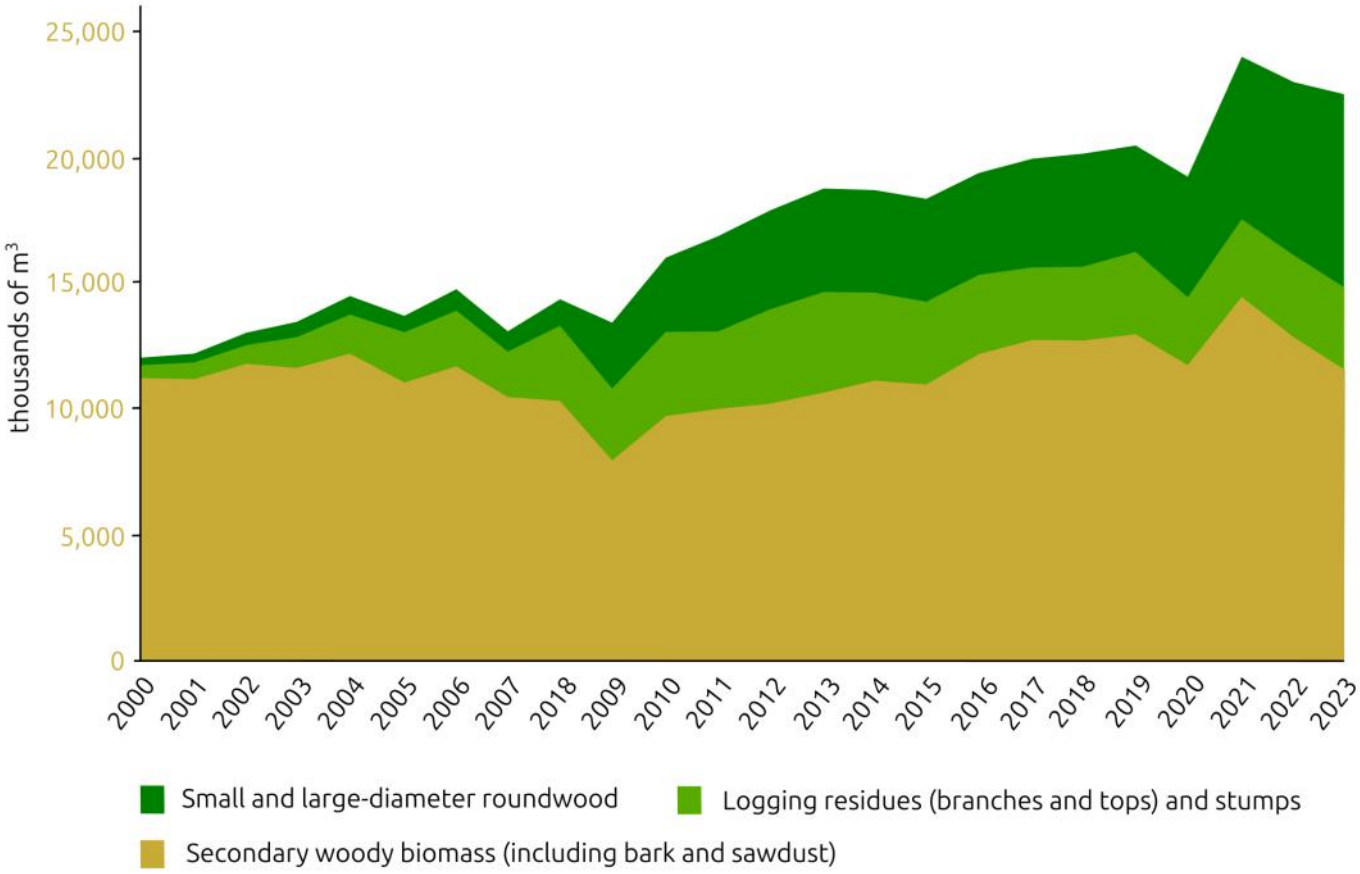


Figure 2: Changes in woody biomass consumption in Finland's energy sector between 2000 and 2023. *Source: Natural Resources Institute Finland*

shows that this is not true. For example, campaigners from the *Ei polteta tulevaisuutta* (Let's not Burn the Future) campaign visited 16 energy wood terminals in 2023 and another 15 in 2024, and found large piles of industrial roundwood waiting to be turned into woodchip and burned.

Even the Forestry Manager of a large pulp and paper company, Stora Enso's Janne Partanen, was quoted in a newspaper saying that at least two million m^3 of pulpwood and even some saw logs are burned for energy every year. Perhaps coincidentally, in 2022 two million m^3 of saw logs, equivalent to around 40,000 truck loads, disappeared from the national statistics. Sawmill operators claimed that pulp mills were to blame, and pulp mill operators pointed the finger at energy companies. Then in January 2024, the Forestry Association of Finland finally acknowledged that two to three million m^3 of pulpwood is also being burned every year for energy. This highlights the fierce competition between forest industries for increasingly scarce raw materials, and Finland's inadequate reporting and monitoring requirements.

Also significant is that the price of energy wood has skyrocketed since the Russian invasion of Ukraine and the ban on wood imports. Before the invasion, 14 TWh of energy was produced with Russian wood imports, mostly in the form of woodchip, accounting for 13% of the total biomass-based energy generation. Forest and energy industries had to source around 10% more wood from Finnish forests to account for the shortfall, particularly woodchip used in CHP plants. In the past, it was less profitable for forest owners to sell their wood for energy production, but currently the price of energy wood is in some areas as high as or even higher than pulpwood. This has caused competition for wood between forest industries and a significant increase in the distance that mills are sourcing wood from. According to the Natural Resources Institute, pulp mills and CHP plants are now *"at least partially drifting into competing for the same tree."*

Finland's major pulp producers and their use of primary woody biomass for energy generation

UPM-Kymmene and Pohjolan Voima

UPM-Kymmene (UPM) has three pulp mills with a total capacity of around 2.4 million tonnes per year, as well as four paper mills, other industrial sites such as sawmills, plywood factories and biorefineries. The three pulp mills produce a large proportion of the energy they consume by burning black liquor in on-site recovery boilers, and they also have CHP plants within the mill complexes that mainly burn woody biomass. Two of UPM's paper mills also have CHP plants that burn woody biomass. Pohjolan Voima, a major energy producer in Finland, is the major shareholder in four of these five CHP plants, and UPM has a 60% shareholding in the company. Pohjolan Voima also operates another CHP plant that burns woody biomass that isn't within a pulp mill complex.

According to UPM's 2023 Annual Report, the company used around 1.65TWh of bark and other woody biomass to generate energy in Finland in 2022, equivalent to around 2.4 million m^3 of biomass.[1] In 2022, Pohjolan Voima's five CHP plants produced 1.2 TWh of electricity and 3.1 TWh of heat, and the company burned over two million tonnes of biomass. Both companies have refused to provide a breakdown of the types of biomass fuels used, so this report estimates primary woody biomass consumption for each CHP plant based on the limited information that is publicly available (see Table 1).

We estimate the total primary woody biomass usage for energy generation associated with UPM mills and shareholdings to be around 0.62 million tonnes. This is equivalent to almost two million m^3 of woodchip, accounting for almost a fifth of all of the primary woody biomass burned for energy generation in Finland each year and more than a quarter of the primary woody biomass burned in CHP plants each year.

UPM's Kaukas pulp mill. *Varpu Sairinen*

Plant name	Pulp mill	Ownership	Capacity (MWe/MWh)	Estimated primary woody biomass consumption (m^3/tonnes)
Kaukaan Voima	Kaukas pulp and paper mill	Pohjolan Voima (54%); Lappeenranta Energy (46%)	125/262	250,000/75,000
Kymin Voima	Kymi pulp and paper mill	Pohjolan Voima (76%); KSS Energia (24%)	76/180	250,000/75,000
Rauman Biovoima	Rauma paper mill	Pohjolan Voima (72%); Rauma Energy (28%)	65/190	225,000/68,000
Alholmens Kraft	Pietarsaari pulp mill	Pohjolan Voima (49.9%); UPM (20.23%); Perhonjoki (29.8%)	265/245	345,000*/150,000
Jämsänkoski CHP	Jämsänkoski paper mill	UPM (100%)	46/324	500,000**/150,000
Porin Prosessi-voima	NA	Pohjolan Voima (100%)	65/212	300,000/100,000
		Total	**642/1413**	**1,870,000/618,000**

Table 1: Biomass power stations associated with UPM-Kymmene and Pohjolan Voima.
* This figure is based on volume of bales rather than woodchip. ** Estimated based on average of other plants.

Kaukaan Voima power plant

The Kaukaan Voima CHP plant is located in UPM's Kaukas pulp and paper mill complex, which produces 700,000 tonnes of pulp a year. The site also includes a sawmill and a biofuel refinery. The power plant started operating at the end of 2009 and is operated by UPM staff. It has an electrical output of 125MW and a thermal output of 262MW. Kaukaan Voima is owned by Pohjolan Voima (54%) and Lappeenrannan Energia (46%), and uses forest industry by-products such as bark and sawdust, primary woody biomass in the form of woodchip and peat as fuel. Wood fuels account for about 80% of the plant's annual fuel needs, of which by-products from the pulp and paper mill account for about 50%. Around 20% of the power plant's feedstock is primary woody biomass, equivalent to 250,000 m^3 or 75,000 tonnes of woodchip a year.[2]

Large-diameter energy wood destined for the Kaukaan Voima power plant. *Ei polteta tulevaisuutta*

Kymin Voima power plant

The Kymin Voima CHP plant is located within UPM's Kymi pulp and paper mill complex, and the pulp mill has an annual capacity of 870,000 tonnes of pulp. The plant started operating in 2002 and is operated by UPM staff. It is owned by Pohjolan Voima (76%) and KSS Energia (24%) and produces process steam for the UPM's Kymi mills and district heating for the municipality of Kouvola, as well as electricity. The thermal output of the power plant is 180MW, and the electrical output is 76MW. More than 90% of the power plant's fuels are wood fuels, including bark and biosludge from UPM's Kymi pulp mill and primary woody biomass. Peat is used as additional fuel to ensure operation in exceptional situations and during peak load, and gas is used as a backup fuel. When the power plant began operations in 2002, UPM-Kymmene's forestry subsidiary was preparing to deliver 150-200 GWh of woodchip from forestry operations annually, equivalent to up to 250,000 m^3 or 75,000 tonnes of woodchip.[3]

Rauman Biovoima power plant

Rauman Biovoima's CHP biomass plant started operating in 2006 and is located in the UPM Rauma paper mill. It produces process steam for UPM's operations (149MW), district heating for Rauman Energia (50MW) and electricity (65MW). Rauman Biovoima is owned by Pohjolan Voima Oy (72%) and Rauman Energia (28%). The main fuels used by the plant are bark, logging residues and recycled wood, which account for 90% of the fuel use. Peat, coal and oil are used as reserve fuels in winter. According to the company, around 600 GWh of energy is generated from burning biomass, of which around 30% is primary woody biomass.[4] This is equivalent to around 225,000 m^3 or 67,500 tonnes.[5]

Energy wood waiting to be chipped. *Ei polteta tulevaisuutta*

Alhomens Kraft power plant

Alholmens Kraft is a biomass plant within the UPM Pietarsaari pulp mill complex, which also has a sawmill and produces 800,000 tonnes of pulp each year. It is owned by Pohjolan Voima (49,9%), UPM (20,23%) and Perhonjoki (29,87%). Given that UPM and Perhonjoki are the joint owners of Pohjolan Voima, the two companies essentially have a 50:50 stake in Alholmens Kraft.

There are two biomass plants on the site, Alholmens Kraft 1 (AK1) and Alholmens Kraft 2 (AK2). AK1 started production in 1991 and has a thermal output of 85MW and an electrical output of 25MW. The plant's fuel is all wood-based, mainly bark, wood waste and sludge. It was sized according to the by-products produced by the adjacent mills. Over the years, the production capacity of the UPM mills increased steadily to the point where there was too much feedstock for AK1 to fully utilise, so planning started for a second power plant.

AK2 started production in 2002 and, at the time, was the largest biomass-burning power plant in the world. It is currently still the largest biomass CHP plant in the world. It produces electricity, steam and heat for UPM's mills, and sells excess electricity to the public grid and heat to the Pietarsaari district heating network. The AK2 plant is unique in that its electrical capacity (240MW) is significantly greater than its heat capacity (160MW).

AK2 is far less efficient than the other plants described in this case study since it needs to dump large amounts of heat to meet its high electrical capacity. Even when the power station is exporting a maximum amount of heat to UPM's mill and the municipal district heating network, at full electrical capacity, a third of the thermal energy contained in the fuel being burned is simply dumped. When AK2 only produces electricity, for example in the summer months when AK1 can handle heat demand alone, the plant runs as a highly-inefficient electricity-only power station, dumping almost 60% of the thermal energy it generates. If the plant had been designed for maximum efficiency, its electrical capacity would be far lower and would only operate when heat demand was highest.[6]

AK2 burns biomass, peat and coal, and the UPM pulp mills are the biggest single provider of wood fuels, mainly bark. Most of the remaining wood-based fuel consists of primary woody biomass, such as logging

Alholmens Kraft power plant, Pietarsaari pulp mill complex. *Jonne Sippola*

UPM logging site in an area of old growth forest. *Greenpeace*

residues from the region's forests. The power plant burns 800 m^3 of fuel per hour at full capacity, and 40-60% of the fuel is biomass-based. About 10-20% of the fuel consumed is peat, and 5-15% is coal, and the plant aims to phase out these fuels and replace them with more biomass.

Only around half of the fuel consumed by AK2 is by-products from UPM's mills, showing that the power station was deliberately oversized to maximise the amount of electricity it could sell to the public grid. The fact that the plant was designed with a much higher electrical than thermal output emphasises this point.

Whilst primary woody biomass accounts for a relatively small fraction of the total fuel use, it will likely keep increasing as the use of coal and peat is phased out. The only publicly available information about the amount and type of primary woody biomass burned at the power station is that it was originally planned to receive around 300,000 bales of forestry residues. This is equivalent to around 345,000 m^3 or 150,000 tonnes of wood.

Jämsänkoski power plant

The Jämsänkoski power plant was originally built by Pohjolan Voima, but is now owned by UPM, and is located within UPM's Jämsänkoski paper mill complex. The plant has both the lowest electrical capacity (46MW) and the highest thermal capacity (324MW) of all of the CHP plants associated with UPM. It produces district heat for the local municipality, process steam for the neighbouring Genencor International enzyme plant and heat and electricity for UPM's mill. Around 80% of the fuel used is biomass-based and includes primary forest biomass, bark and sludge. There is no publicly available information on the quantity of primary woody biomass burned by the plant, but UPM has confirmed that our estimate of around 500,000 m^3 or 150,000 tonnes *"is about in the right scale."*[8]

Porin Prosessivoima power plant

Porin Prosessivoima is a CHP plant within the Venator titnium dioxide factory area in Kaanaa, Pori, and was completed at the end of 2008. It is wholly owned by Pohjolan Voima and produces process heat for industry in the area and district heating to Pori Energia's district heating network. The power plant also generates electricity and has a thermal output of 212MW and an electrical output of 65MW. The plant burns wood-based fuels, peat, waste wood, fossil gas and coal, including around 100,000 tonnes of primary forest biomass per year, equivalent to 300,000m^3 of woodchip.

Metsä Group

Metsä Group is the biggest biomass energy producer of Finland's forest sector companies that produce pulp and paper. Overall, the group produces almost a fifth of Finland's renewable energy, selling excess heat and electricity to district heating systems and the public grid. Metsä Group has four pulp mills, five sawmills, one paper mill, six cardboard mills and four veneer and plywood mills in Finland.

According to information provided by the company, its pulp mills mainly burn black liquor for energy generation in recovery boilers and also operate back-up bark boilers but do not burn primary forest biomass to generate energy. The company does not provide disaggregated data on biomass fuel use, it only reports figures for total wood fuels consumption, the vast majority of which is black liquor. However, primary woody biomass is likely to be used in energy generation at Metsä's other industrial sites that don't produce black liquor, such as sawmills and wood-panel factories. For example, Metsä Wood has eight engineered wood production units in Finland, and 98% of the energy used at them is self-produced from burning biomass. Excess by-products such as sawdust, woodchip and planer shavings are sold to other industries and power stations for energy generation.

According to Metsä Group's 2023 Annual Report, Metsä Forest, the group's forestry subsidiary, delivered 30.4 million m^3 of wood, and its operations procured 29 million m^3. If the difference between these two figures is energy wood, 1.4 million m^3 of primary forest biomass was delivered to the power sector in 2023.[9] Since 89% of the wood Metsä Group uses comes from Finland, it can be assumed that 1.2 million m^3 of the wood it procured in Finland was energy wood, equivalent to around 12% of all primary woody biomass used for energy generation in the country in 2023.

The only information provided on what kind of wood was procured for energy purposes is that *"Purchases of energy wood focused on crown wood,"* and in terms of the company's near-term outlook, *"In energy wood, the demand will focus on crown wood and small trees."* It is also interesting to note that the company reduced its minimum diameter of harvested pulpwood from six to five centimetres in 2023, coinciding with wood deliveries decreasing almost 10% compared to 2022.

A Metsä Group logging site. *Greenpeace*

A Metsä Group energy wood pile. *Varpu Sairinen*

Kemi bioproduct mill. *Elokapina (Extinction Rebellion Finland)*

Given that trees as small as five centimetres in diameter would usually be harvested as a result of forest thinning operations, this highlights how pulp mills are increasingly competing with the energy sector for raw materials. In the past, these trees would have been mainly used for energy generation and not pulp production.

Metsä's Kemi bioproduct (pulp) mill has also attracted controversy and protest. Opened in September 2023, it was the biggest pine-based pulp mill in the world and the largest investment in the history of the Finnish forest industry, partly-financed with a €200 million European Investment Bank (EIB) loan. The new mill requires 7.6 million m^3 of wood per year, which is 2.5 times more than was used by the old mill on the same site. It also produces so much black liquor that it generates 2.5 times the electricity it needs for its own operations, and electricity sales to the public grid are a major economic factor for the mill.

Many scientists and environmental groups warned about the consequences of the Kemi mill's wood demand for the biodiversity of Lapland's forests, where much of the mill's wood is sourced from, and for Finland's overall climate goals. Extinction Rebellion Finland (*Elokapina*) and the Finnish youth group The Finnish Nature Association (*Luontoliitto*) organised several protests during the construction of the mill, and blockaded its entrance the day after it opened.

Blockade of the Kemi bioproduct mill entrance. *Elokapina*

Stora Enso

Stora Enso has one pulp mill, one paper mill, two combined pulp and cardboard mills, two cardboard mills and two packaging mills in Finland. The majority of the company's energy is produced by burning biomass, but the company does not provide information on the types of biomass that are used and has ignored requests for information. However, Stora Enso has been critical of using wood for energy instead of higher-value products. Their former director Annica Bresky said in 2022: *"We are under huge pressure, and it breaks my heart really to see biomass going to energy usage or subsidies going to that region because that breaks all the cascading principles."* It is therefore likely that primary woody biomass is not burned for energy at Stora Enso pulp mills in Finland.

However, the company has a 16% shareholding in Pohjolan Voima, one of Finland's largest users of primary woody biomass for energy, and the company's forestry division is also a major supplier of energy wood to power producers. According to its 2023 Annual Report, 300,000 m^3 of energy wood was harvested from its forestry sites across all the countries it operates in. If this value is extrapolated to third-party forestry lands, the figure rises to 843,000 m^3. It is therefore likely that, in Finland, the company delivered around 312,000 m^3 of primary forest biomass to energy producers in 2023,[10] equivalent to 3% of the total primary woody biomass burned for energy.

Stora Enso also produces wood pellets for the domestic heating market, discussed in more detail in the Sweden case study and, similar to Metsä Group, recently reduced the minimum diameter of its pulpwood to five centimetres in response to increaing competition for wood.

Stora Enso energy wood waiting to be chipped. *Ei polteta tulevaisuutta*

The impacts of biomass-burning in Finland

According to the Finnish Environment Institute, more roundwood is burned in Finland each year than is left standing in privately-owned forests (private forests account for around 60% of the total forest area in Finland) after they are clear-cut in order to maintain a minimal level of diversity.

Although much of the wood may not be fit for use by forest industries, the living and dead trees that are being burned for energy are important for biodiversity. The Finnish Environment Institute found that the volume of dead and decaying wood is reduced by more than two thirds during logging operations, mainly to be used as energy wood, and point out that *"Cutting down old hardwoods and decaying wood, which are essential for endangered and declining forest species, for energy, is a very harmful activity in terms of the diversity of forest ecology."*

Although logging doesn't generally take place specifically for energy generation in Finland, some old growth forests have been logged for energy purposes. This was the case for example in Inari and Salla in Lapland, and in Kuusamo in North Eastern Finland, where pristine old growth forests more than 300 years old were burned for energy.

An assessment of endangered species is carried out every ten years by 180 of Finland's foremost species experts. In the last assessment, the total percentage of endangered species grew from 10.5% in 2010 to 11.9% in 2020, and the number of newly endangered species increased by 420. According to the assessment, one in every nine species in Finland is now endangered, and most of their habitats are dependent on old growth forests. Despite this, only 6% of Finnish forests are protected and disputes over the logging of primary and old growth forests between the forest industry and environmental groups are constant.

Logging also affects community livelihoods and access to non-timber forest products, such as berry and mushroom picking, recreation, tourism and reindeer herding. Especially in Lapland, indigenous Saami reindeer herders and forest owners have come into conflict on many occasions, since logging destroys traditional grazing grounds.

In 2022, research by the Finnish Natural Resource Institute shook the nation by showing that the land-use sector, which includes the forest sector and has been

Logged old growth forests and reindeer grazing grounds in Salla.
Matti Liimatainen/Greenpeace

Wood from the logged old growth forests at Inari waiting to be chipped. *Ei polteta tulevaisuutta*

the foundation of Finnish climate policy, had become a source of emissions for the first time ever as a result of reduced tree growth and excessive logging. The news didn't come as a surprise to the scientific community, but politicians were shocked—how was it possible that the vast Finnish forests were not able to hold the carbon they used to, when industry still claimed that Finnish forests had more wood growing in them than ever before? In January 2025 the Finnish Natural Resources Institute came with even more worrying news; according to the newest greenhouse gas inventory the land-use sector had been an emission source already since 2018 and even the forests had turned from carbon sinks to carbon emitters in 2021.

Journalist Piia Elonen explained how moving away from burning fossil fuels to burning biomass for energy was one of the main reasons for the change. In 2021, burning biomass for energy was responsible for between 42 and 45 million tonnes of CO_2 emissions, which was almost equivalent to the entire country's greenhouse gas inventory for that year, which was 48 million tonnes. Elonen described how *"The emissions caused by burning wood do not show up in the statistics when carbon dioxide rises into the sky, because humans have agreed that at this stage it is emission-free. Instead, emissions are generated when the wood is taken out of the forest."* Therefore, *"they do appear on the other side of greenhouse gas inventories, i.e. in the land use sector… When you move the focus there, the effect is clearly visible. Forest carbon sinks have shrunk year by year. The decrease seems to have started around 2010, i.e. at the same time as Finland's fossil emissions started to be reduced."*

Finland's declining forest carbon sink

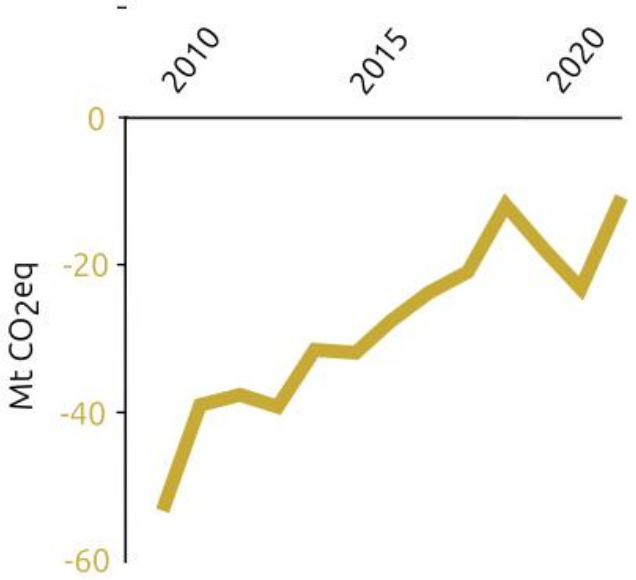


Figure 3: Changes in Finland's forest carbon sink 2009-2021. Sink is expressed in negative values, i.e. the closer the number is to zero, the less CO_2 was fixed by forest ecosystems in that year. *Source: Finland's National Inventory Report of greenhouse gases emissions submitted to the UNFCCC in 2023.*

State-level subsidy and support for burning primary woody biomass

Former Prime Minister Sanna Marin's "Climate Government" led by the Social Democratic Party from 2019-2023 introduced a climate and energy strategy that aimed to almost double the use of primary woody biomass to 16–17 million m³ per year. According to the Finnish Association for Nature Conservation, the constantly rising logging levels and the strong dependency on forest energy were in conflict with the environmental goals of the government programme, the new climate law and international commitments.

Marin's plan to get Finland to carbon neutrality by 2035 relied largely on the land-sector carbon sink, which proved to be a failure when in 2022 it was shown to have become a source of emissions rather than a sink.

Marin's government also continued lobbying the EU to oppose proposals to renew the biomass sustainability criteria in the EU's Renewable Energy Directive, and published a letter demanding that bioenergy should still be regarded as emissions free at the point of combustion.

The Finnish renewable energy subsidy system is based on tax breaks, and the tax exemption for wood-based fuels costs the Finnish state €480 million a year.

CHP plant operators received €106 million in 2022 through the tax break system, a figure due to decline to €56 million in 2024. Limited direct subsidies are also given towards renewable energy generation, and in 2023, €3.5 million was awarded for biomass burning.

The state also supports private landowners to manage their forests via the so-called Metka subsidies (previously known as the Kemera subsidies), most of which is allocated for thinning young forests, where the wood is usually used for energy generation. In 2022, 65% of the total budget (€30 million) was granted for thinning forests, and 47% of that (€14 million) was paid to landowners specifically for extracting energy wood though forest thinning.

Clearcut and burned old growth forest. *Jani Sipilä / Greenpeace*

Conclusions

Primary woody biomass is the fastest growing source of biomass energy in Finland, and now accounts for almost half of all of the woody biomass burned for energy generation each year. The demand for energy wood sourced directly from forestry operations is leading to numerous impacts on biodiversity and the health of forest ecosystems, and excessive logging has also resulted in Finland's land-sector becoming a source of emissions rather than a sink.

Over a quarter of the primary forest biomass burned by CHP plants in Finland can be attributed directly or indirectly to Finland's largest pulp producer, UPM, and this proportion is likely to increase as peat and coal are phased-out as feedstocks for its CHP plants. The CHP plants associated with UPM have been over-sized such that they require more fuel than forest industries can provide in by-products such as bark, and therefore require additional fuel inputs such as primary woody biomass and peat. They have been oversized predominantly to sell heat to municipal district heating networks, and in some cases also to sell electricity to the public grid.

Alholmens Kraft, the largest biomass CHP plant in the world, has been designed to produce large amounts of electricity for export to the public grid, which requires a far greater fuel input than nearby mills can provide in by-products. It is likely to burn more primary woody biomass than any other CHP plant in Finland by weight, and this is likely to grow as the amount of peat and coal burned each year is progressively reduced.

Although two of Finland's big three pulp producers, Metsä Group and Stora Enso, burn large quantities of black liquor to produce energy for their pulp mills, it is unlikely that they also burn primary woody biomass for energy generation at these mills. However, their forestry subsidiaries do procure large quantities of energy wood directly from forestry operations for other users, accounting for some 15% of the primary woody biomass burned in Finland each year.

Put together, pulp-producing companies in Finland procure or burn some 3.4 million m^3 of primary forest biomass for energy generation each year,[11] equivalent to around a third (31%) of the primary woody biomass burned as fuel in heat and power plants in the country, and a fifth of all of the primary woody biomass burned. This contribution is likely to increase in years to come as Finland's energy system continues to move away from burning coal and peat, and due to the lasting impacts of a ban on Russian wood imports.

The continued and growing dependance on burning biomass for energy generation in Finland is hampering efforts towards a truly green and sustainable energy revolution. It is time to face up to what the scientific community and civil society have been warning all along: that there is not enough wood to replace all of the uses of fossil fuels, and that healthy forests are our most valuable tool in fighting climate change and biodiversity loss.

Old aspen trees in an energy wood pile. *Ei polteta tulevaisuutta*

Notes

1. Assuming an average energy density of 0.7 MWh/m^3, given that Finnish softwood bark has a bulk energy density of 0.6 MWh/m^3 and woodchip has a bulk energy density of 0.8 MWh/m^3 (http://www.woodenergy.ie/woodasafuel/listandvaluesofwoodfuelparameters-part1/.)

2. Assuming that one m^3 of woodchip is equivalent to 0.3 tonnes (http://www.woodenergy.ie/woodasafuel/listandvaluesofwoodfuelparameters-part1/)

3. Assuming a bulk energy density of woodchip of 0.8 MWh/m^3.

4. Information provided by email on 20th March 2024.

5. Assuming the energy density of woodchip is 0.8 MWh/m^3, and that one m^3 of woodchip weighs 0.3 tonnes.

6. At maximum overall efficiency AK2's output is 205MWe + (100 + 60)MWt = 365MW. Heat dumped = 550 - 365 = 185 MW. When AK2 runs as electricity-only, the output is 240MWe. Heat dumped is 550 - 240 = 310MW. Source for figures: https://www.modernpowersystems.com/features/featurealholmens-the-world-s-largest-biofuelled-plant-part-1/.

7. The average bale size is three metres long with a diameter of 0.7 m, equivalent to 1.15 m^3, with an average weight of 0.5 tonnes.

8. Information received via email on 8th September 2024. Scale refers specifically to woodchip with a moisture content of 40-60%.

9. This assumption has been made based on the fact that other companies cite energy wood figures in their annual reports. Metsä Group did not reply to email correspondence on this issue.

10. Stora Enso harvested *"10.5 million m^3 (forest cubic metres)"* from owned and leased forests in 2023, and delivered 10.2 million m^3 to its mills. 0.3 million m^3 (3%) was therefore energy wood. Total deliveries to all mills were 28.1 million m^3, excluding energy wood. If energy wood is harvested at the same proportion, then all energy wood is equivalent to 843,000 m^3. Finland represents 37% of total wood use, equivalent to 312,000 m^3 of energy wood.

11. Assuming that Metsä Group and Stora Enso don't supply CHP plants associated with UPM with energy wood.

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Piling on the pressure

The impacts of the pulp and paper industry's domination of the biomass electricity market in Portugal

GreenVolt's Figueira da Foz II dedicated biomass power station at the CELBI pulp mill.

biofuelwatch
AAA acréscimo
Quercus
iris associação nacional de ambiente
Environmental Paper Network

Summary

Portugal's pulp and paper sector is making record profits despite the current intersecting global crises. Its heavy investments in biomass electricity are a contributing factor, and it now produces ***almost 80% of the electricity generated from burning biomass in Portugal*** *through its combined heat and power (CHP) and electricity-only power stations, and* ***operates over half of the dedicated biomass electricity capacity****.*

Underlying the sector's focus on biomass electricity are generous renewable energy subsidies. This incentive for burning woody biomass has encouraged the pulp and paper sector to **decouple biomass burning from relying on by-products** of the pulping process as a feedstock. **Less than half of the woody biomass burned by the sector comes from bark and other industrial by-products**, with the majority being sourced directly from forestry operations.

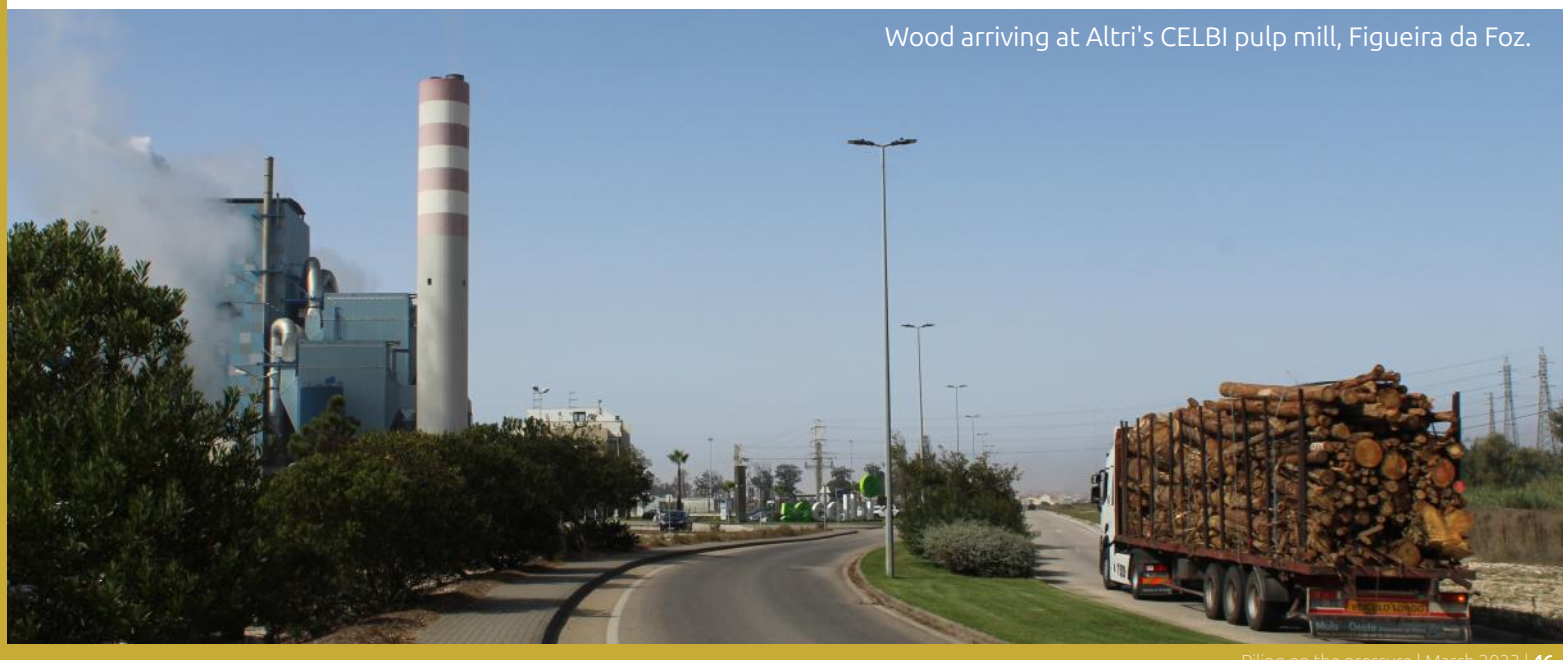
The two most significant recent developments are **Altri/GreenVolt's 34.5MW electricity-only biomass power station in Figueira da Foz**, and **The Navigator Company's neighbouring biomass boiler that replaced a fossil gas combined heat and power (CHP) plant**. Both are dependent on large volumes of woody biomass directly from forestry operations, and have been financed as "green" developments.

In total, six electricity-only biomass power stations and five CHP plants associated with the pulp and paper industry **burn around 2.9 million tonnes of woody biomass each year, more than any other sector**. Over half of this comes directly from forestry operations. Pulp and paper companies claim that only forestry residues and industrial by-products are burned in their power stations, but **far more woody biomass is burned by the biomass energy and wood pellet industries each year than could be available as genuine residues**, as defined in Portuguese legislation.

The pulp sector claims that burning woody biomass helps it to meet its climate targets and reduce the risk of wildfires. However, biomass electricity often results in **greater emissions than fossil fuel equivalents**, and in recent years **the scale of wildfires has only increased, particularly in forestry areas, as biomass electricity capacity has grown**. On top of this, the over-extraction of woody biomass from forestry areas is harming soil health and adding to pressure for the expansion of harmful eucalyptus plantations.

Three key areas of action that must be taken are:

- The introduction of an immediate moratorium on new biomass electricity capacity, and ending its eligibility for renewable energy subsidies;
- A cap on woody biomass consumption at pulp mills so that only secondary biomass (i.e. pulp mill and other wood processing by-products) are used as feedstock for energy generation;
- For subsidies for biomass electricity generation to be redirected towards genuinely renewable energy generation, energy efficiency and fire risk reduction techniques that incentivise the conservation and regeneration of native forests.



Wood arriving at Altri's CELBI pulp mill, Figueira da Foz.

Introduction

Pulp and paper is big business in Portugal and despite the ongoing economic, political and public health crises in recent years, the sector has seen unprecedented profits. Portugal's biggest pulp and paper producer, The Navigator Company, saw profits of almost €400 million in 2022, up almost 130% on the previous year. The second largest producer, Altri, saw profits up almost 300% in 2021, with this upward trend continuing in 2022.

Biomass electricity is increasingly contributing to the profitability of these companies as they diversify into other areas of the bioeconomy and take advantage of strong policy support for burning biomass. Between them, Portugal's pulp and paper sector account for almost 80% of the biomass electricity generated in Portugal each year.[1] Dominating the sector is Altri, which operates three pulp mills and, together with its subsidiary GreenVolt, produces around 40% of the biomass electricity generated.[2] Sales of electricity from biomass burning earned GreenVolt €130 million in 2021, and it is estimated that Altri earned around €100 million.[3] The Navigator Company also operates three pulp mills and produces over a third of the electricity generated from biomass in Portugal, which earned it €135 million in sales in 2021. A seventh pulp mill is operated by DS Smith and produces an estimated 4% of the biomass electricity generated each year. Portugal's pulp and paper companies have benefited significantly from unprecedented increases in wholesale electricity prices, due primarily to Russia's invasion of Ukraine, to the extent that the value of The Navigator Company's electricity sales doubled in 2022 compared to 2021.

Glossary

Biomass electricity: Electricity generated through the combustion of biomass, including woody biomass and black liquor.

Dedicated/electricity-only biomass power station: A power station that burns biomass and generates electricity, put where the heat produced is not utilised for another purpose.

Combined heat and power (CHP) power station: A power station that produces electricity and utilises the heat generated for an industrial process, or for heating and cooling supplied to a district heat network or individual customers.

Woody biomass: Solid plant-based material with a high lignin content, such as woodchip, roundwood, bark or sawdust. Black liquor is not included in this definition.

Primary woody biomass: Any plant-based biomass that is sourced directly from forests and tree plantations. Also called "forest wood". Forestry or logging residues are included in this definition.

Secondary woody biomass: By-products and residues of wood processing industries such as pulp mills as sawmills.

Residual biomass: Plant-based material that is leftover from or a by-product of forestry or agricultural operations. This includes residual logging/forestry residues, black liquor and bark.

Residual woody/forest biomass: Under Portuguese legislation this is defined as *"the biodegradable fraction of products and waste resulting from the installation, management and harvesting of forestry operations (stumps, roots, leaves, branches and tops), woody material resulting from phytosanitary operations and measures to defend the forest against fires, and control areas with invasive species…"*

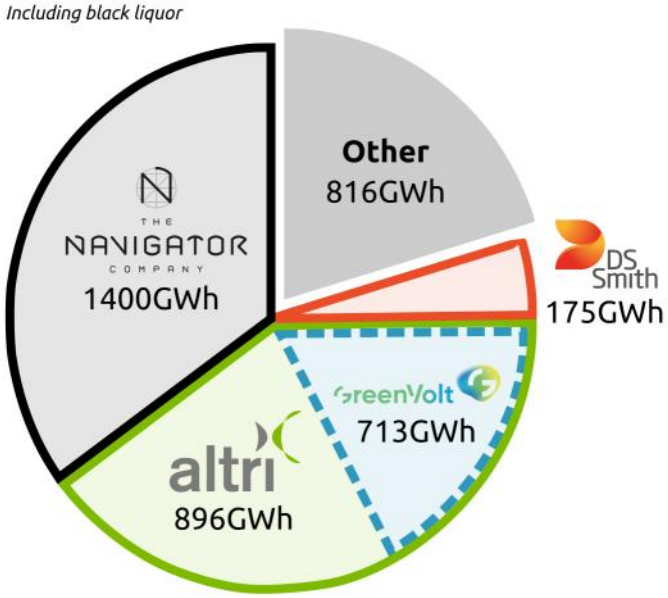
Industrial by-products: Processing residues that result from industrial processes. In pulp mills these are predominantly black liquor and tree bark.

Black liquor: An aqueous solution of lignin residues and other material that is extracted during the pulping process, when pulpwood is converted to paper pulp. It is usually burned in a recovery boiler to produce steam and electricity for pulp mill operations.

Pulp mills have traditionally generated heat and electricity for their own needs by burning black liquor and bark in combined heat and power (CHP) plants, two of the main by-products of the pulping process.

Biomass electricity generation by company in 2021 in Portugal

Including black liquor

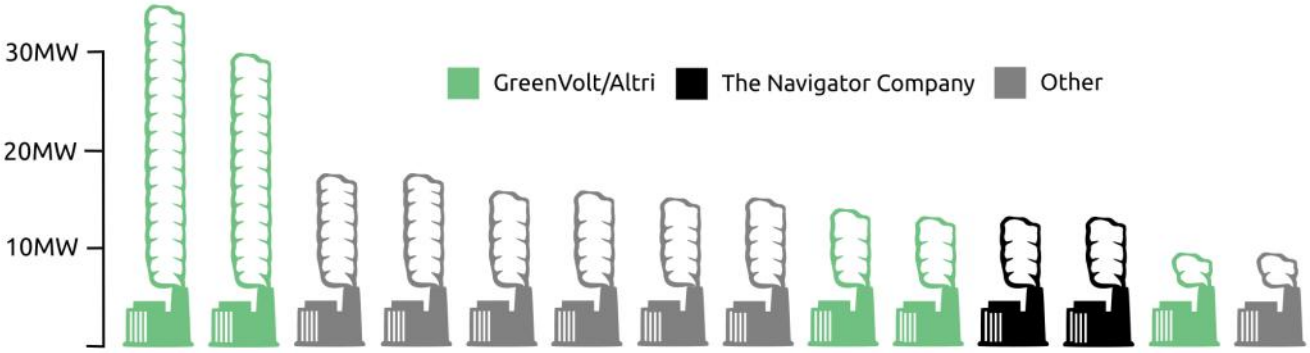


However, in order to take advantage of policy support and public subsidies for biomass electricity, highly inefficient electricity-only biomass boilers have been constructed inside pulp mill complexes. They require additional woody biomass to be brought in directly from forestry operations, and only export electricity to the public grid. The pulp and paper sector now controls over half of the installed capacity of electricity-only biomass power stations in Portugal.

Two new CHP plants that are fuelled exclusively with woody biomass have also been built recently (by The Navigator Company at its Figueira da Foz mill and Altri at its CAIMA mill) to replace fossil gas capacity. They also require significantly more biomass than the by-products produced by their respective pulp mills. The new plants allow the sector to claim significant emissions reductions, and in one case also sell electricity to the public grid at subsidised rates.

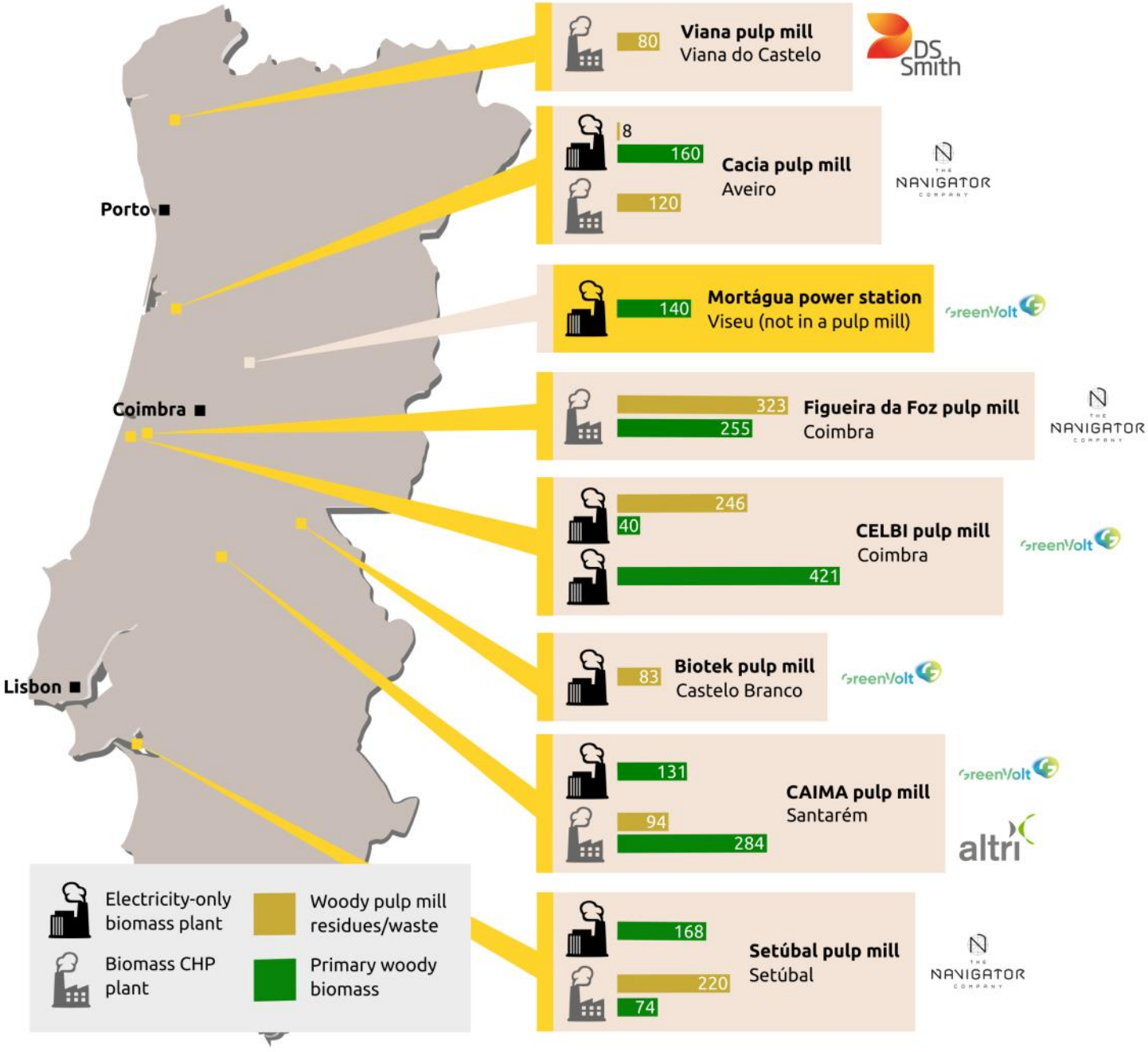
The justification for burning biomass at pulp mills centres around reducing emissions to meet climate targets and reducing the risk of wildfires.

Electricity-only biomass power stations 10MW$_e$ or larger in Portugal



Wood arriving at The Navigator Company's Figueira da Foz mill.

Biomass power plants associated with the pulp and paper industry and their estimated annual woody biomass consumption *(thousands of tonnes)*



The Navigator Company is by far Portugal's biggest corporate emitter of carbon from fossil fuels, with its three pulp mills falling within the top 11 biggest point sources of carbon emissions in the country.[4] The Navigator Company has committed to reaching "carbon neutrality" by 2035, which includes reducing direct CO_2 emissions in its industrial facilities by 86% by 2035 (relative to 2018) and achieving 80% renewable energy consumption by 2030. The remaining emissions are due to be offset through plantation forestry projects. Biomass is a central pillar of its decarbonisation strategy because it is treated as "carbon neutral". Its new biomass plant at the Figueira da Foz pulp mill is a flagship project that it claims has reduced the company's overall emissions by 30%.

Altri has similar emissions reductions targets, aiming for 60% reductions in process emissions by 2030, and 30% in fossil fuel emissions relating to its supply chain by 2030. It also aims to increase the amount of renewable electricity it injects into the public grid by 60% by 2030, as well as for 100% of the primary energy it consumes in its industrial units to be renewable in origin by 2030.

A eucalyptus logging site near Figueira da Foz.

How much biomass is burned, and where does it come from?

Pulp and paper companies use on-site CHP boilers to produce heat and electricity for their own industrial processes in the pulp mills, and the excess electricity generated is sold to the public grid at subsidised rates. They also often have dedicated biomass power stations that only produce electricity, which is also injected into the public grid, usually at a higher subsidy level. As well as burning pulp mill by-products (mainly bark and black liquor) and primary woody biomass, some pulp mills in Portugal also still have fossil gas CHP plants that are operational or used as backup.

Within Portugal's pulp mill complexes there are currently six electricity-only biomass power stations and five CHP plants that burn woody biomass, plus one other electricity-only power station (highlighted in yellow in the diagram on page 5) that isn't associated with a pulp mill but is owned and operated by the sector. Although energy generated by burning black liquor is considered to be energy from biomass in Portugal and across the EU, for the purposes of this report only the impacts of woody biomass will be considered.

In total, around 2.9 million tonnes of woody biomass were burned in power plants associated with Portugal's pulp industry in 2021, of which around 57% was sourced directly from forestry operations (see table on page 17). The smaller share was made up of pulp mill by-products such as bark. Over one million tonnes of primary woody biomass (i.e. wood taken directly from forests or tree plantations) were burned by Altri and GreenVolt and the remaining 660,000 tonnes were burned by The Navigator Company.[6]

Of the 12 power stations described above that burn woody biomass, it is likely that only three exclusively burn by-products of the pulping process. On top of this, only two of Portugal's seven pulp mills (DS Smith's Viana mill and Altri's Biotek mill) are not thought to currently burn primary woody biomass for energy generation.

None of the companies mentioned in this report make biomass sourcing information publicly available, and all refused to supply information such as the quantity and type of biomass they burn. In addition, neither Portugal's Directorate General for Energy and Geology (DGEG) or Institute for Nature Conservation and Forests (ICNF) agreed to provide power station-specific sourcing information, although DGEG did provide total biomass consumption figures for electricity generation.

The industry states repeatedly that only residual biomass[7] is used in their power plants. GreenVolt claims to have *"an absolutely unshakable principle: we only use residual biomass to produce electricity... This waste is given value, at the same time as encouraging forest clearing, thus contributing to mitigating the risk of fires."* In theory, only electricity produced through burning forestry residues (as defined in Portuguese legislation) and industrial by-products is eligible for Portugal's subsidy scheme. However, sourcing claims are impossible to verify given that monitoring and reporting requirements are minimal, self-assessed and not independently verified, and have also not been made publicly available (this is discussed in more detail on page 10). In addition, the primary woody biomass that is burned enters through the same access as wood used for pulp production in all except one of the power stations discussed. Wood often arrives already chipped, making it impossible to ascertain what is being used.

Portugal's pulp and paper sector primarily uses eucalyptus to produce pulp and manages around a quarter of the extensive eucalyptus plantations that are concentrated in central and northern regions of the country. In addition, over 70% of all biomass burned for electricity generation in Portugal in 2021 was classed as eucalyptus residues,[8] it can be assumed that the vast majority of the primary woody biomass sourced by the pulp industry comes directly from eucalyptus plantations.

The fire risk reduction myth

Wildfires are one of Portugal's biggest environmental, social and political problems, particularly in northern and central regions where they are most frequent. The biggest fires on record occurred in 2017 when over half a million hectares burned and more than 100 people lost their lives.

Fire risk reduction is one of two main justifications put forward both for burning woody biomass and for producing wood pellets (large amounts of which go to power stations in other European countries). The argument used by industry is that reducing fuel load through removing forestry residues in high-risk areas will help to reduce the spread and intensity of fires. If this were true, then fire severity should decrease as more woody biomass is burned in power stations or turned into wood pellets.

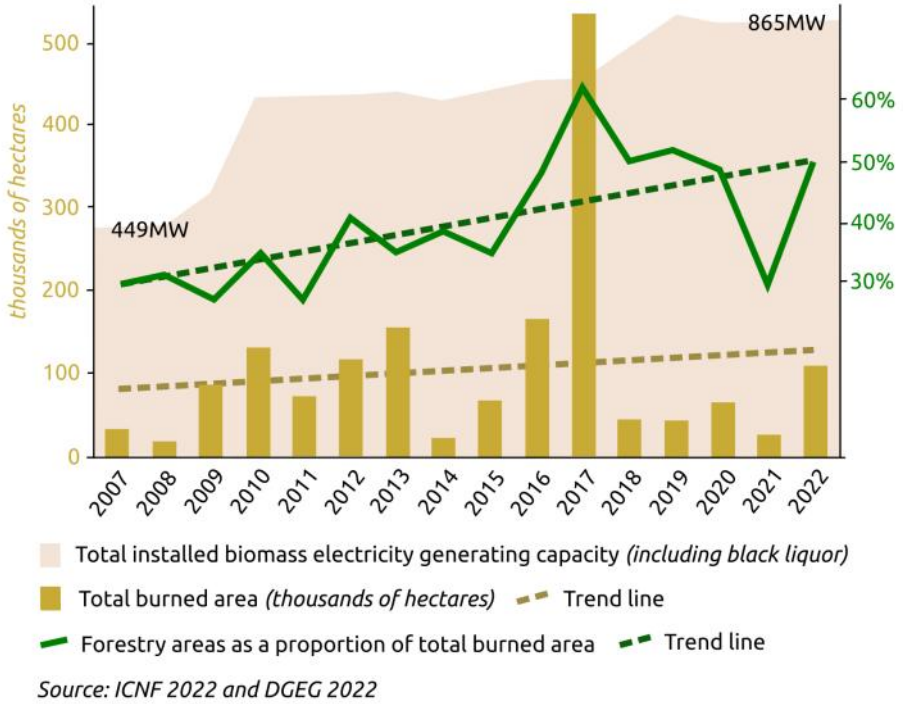
However, there is very little evidence that this strategy is working and, in fact, a report prepared for the Portuguese parliament in 2013 found that *"the idea that the construction of biomass plants throughout the country would decisively reduce the risk of fire...does not fully correspond to reality."* The total installed biomass electricity capacity has almost doubled in Portugal since 2007. This is partly the result of a public tender for a series of new electricity-only biomass power stations (see graph), which came in response to large-scale fires in previous years. Wood pellet production also increased significantly during this time. However, in the same time period, forestry areas (which include plantations) have overtaken other land uses (such as unmanaged forests and scrubland) as having the highest amount of burned area, and in general the amount of land burned each year is still increasing.

Rather than reducing the environmental damage caused by fires, the demand for woody biomass for energy generation in Portugal is putting more pressure on and over-exploiting forest resources. A significant part of Portugal's land mass is characterised by poor quality soils that have low organic content, and the over-extraction of logging residues only exacerbates this and increases the risks of soil degradation and desertification.[9]

There are many alternatives to managing fuel load in rural and forestry areas that can contribute to reducing fire risk, such as: using logging residues as fertiliser by chipping them and spreading the woodchip over soils; the appropriate use of controlled fire; and silvo-pastoralism, which can also bring economic benefits to rural populations. Any subsidy support redirected from biomass electricity generation towards these alternatives would support the livelihoods of small-scale farmers and rural landowners, whereas subsidies given to biomass power station operators end up in the hands of large companies and urban elites.[10]

It is also worth noting that the biomass electricity and wood pellet industries are likely to be the principal beneficiaries of wildfires, as the tree trunks that are left behind are a large source of relatively cheap and dry feedstock. Further still, the biomass that is suddenly made available following large fires gives the false impression that there is an abundance of woody biomass, when in fact it is becoming increasingly scarce, especially in the case of native pine forests.

Changes in Portugal in total installed biomass electricity capacity, total area burned in forest fires and forestry areas as a proportion of burned areas, 2007-2022

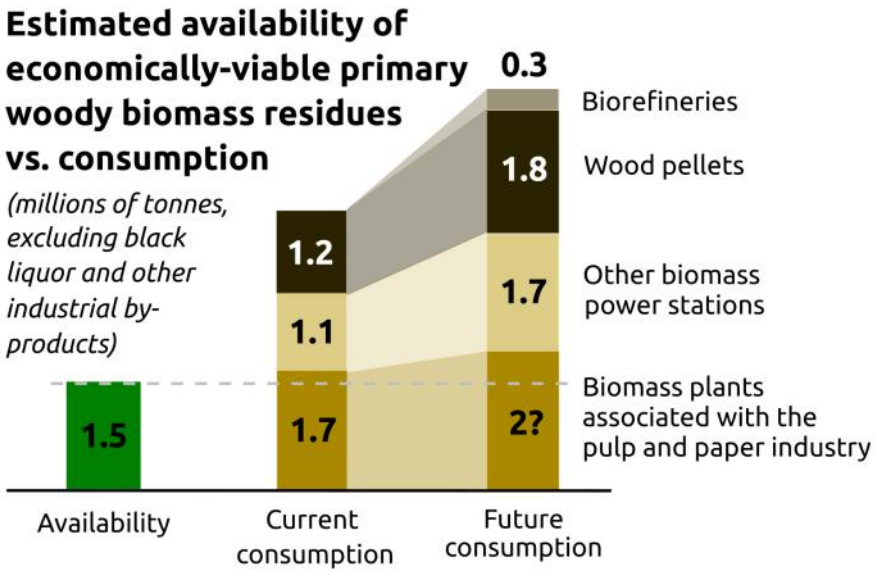


Source: ICNF 2022 and DGEG 2022

How much residual woody biomass is there in Portugal?

The availability of residual woody biomass as defined in Portuguese legislation (referred to as "residual forest biomass" in Portugal) is a controversial topic due to the scale of industry demand and competition for raw materials between the bioenergy and wood pellet industries in particular.

Also, definitions of what constitutes residual biomass are often so vague and monitoring systems so ineffective that in practice any type of wood can be classed as a residue. Throughout EU member states, terms like "forestry residues" and "low-value wood" are being widely used to include roundwood, i.e. wood from whole trees. Furthermore, regardless of definitions, burning any kind of wood has climate and ecosystem impacts.



In the absence of accurate reporting and verification, the claim that only residues are used to produce biomass electricity in Portugal can be assessed by comparing estimates of availability and demand. According to a report submitted to Portugal's parliament by a group of parliamentarians convened by the Agriculture and Sea Commission in 2013, the annual availability of residual biomass was around two million tonnes, of which half was in the form of branches and tops from forestry operations. The report also stated that demand for residual biomass for energy generation and pellet production was already thought to exceed three million tonnes.

In 2017, as part of the National Plan for the Promotion of Biorefineries prepared by the National Laboratory of Energy and Geology (LNEG), the total availability of residual woody biomass for energy was determined as 2.8 million tonnes per year, of which about half corresponded to forestry operations[11] and would therefore be an economically viable feedstock. Another study on using forest bioenergy to reduce fire risk prepared for the Portuguese Parliament in 2021 indicates that there are potentially 2 million tonnes of residual woody biomass per year. The most recent available figures are from the *Bioeconomia 2030* report, prepared by the Office of Planning, Policies and General Administration *(Gabinete de Planeamento, Políticas e Administração Geral)* of the Portuguese government. It quotes an annual residual woody biomass availability of three million tonnes, of which a third is from unmanaged forest and scrub areas, which are unlikely to be economically-viable, and only 440,000 tonnes are available from eucalyptus plantations nation-wide.

There is also a large discrepancy between the potential and the effective availability of residues from forestry operations. Given the steep terrain and poor road networks typical of much of Portugal's tree-covered areas, the costs of extraction and transport of forest residues are high. In many cases it is only economically viable to harvest a small fraction of residues for energy production. According to research by The University of Trás-os-Montes and Alto Douro (UTAD), the effective availability of biomass is 43-65% of the total potential.

Given the above, it is reasonable to assume that the annual availability of economically-viable residual woody biomass from forestry operations in Portugal is around 1.5 million tonnes in total, and residues from eucalyptus plantations less than half a million tonnes, which is considerably less than what is being burned by the pulp and paper sector each year. In addition, the pulp and paper sector isn't the only consumer of

A eucalyptus plantation near Figueira da Foz.

Eucalyptus plantation logging residues at a biomass power station in Central Portugal.

Eucalyptus and pine roundwood at a biomass power station in Central Portugal.

primary woody biomass for energy generation. Other biomass power stations consume around 1.1 million tonnes per year at full capacity, which is expected to rise given current policy support for new power stations[12] and wood pellet production is estimated to have consumed around 1.2 million tonnes in 2021, which is also expected to rise considerably.[13] Further still, Portugal's National Plan for the Promotion of Biorefineries *(Plano Nacional de Promoção das Biorrefinarias)* calls for the creation of three new biorefineries with a total woody biomass demand of over 300,000 tonnes.

Government statistics provided by the Directorate-General for Energy and Geology (DGEG) back these figures up, with the total consumption of residual woody biomass for electricity production (not including wood pellets) reported to be over 2.14 million tonnes in 2021. Further still, 1.35 million tonnes of this was eucalyptus, which is more than three times the estimated availability of eucalyptus residues published in the government's *Bioeconomia 2030* report in 2021. There must therefore be large amounts of roundwood from whole trees being burned in power stations each year, which wouldn't be classed as residual biomass under current legislation in Portugal.

Subsidy support for burning biomass

Portugal's recent legislation governing subsidies for new biomass power stations[14] mandates that they must be located near to critical fire risk areas and/or areas with a high concentration of forestry land, and that specific types of biomass must be used in order for the electricity generated to be eligible for support. These are agricultural residues, residual woody biomass or fast-growing tree plantations planted specifically for energy generation.[15]

Agricultural residues are generally not an economically-viable option for energy generation except for industries that create the residues themselves, and tree plantations specifically for energy generation are not yet thought to have been planted on a large scale. The focus of biomass sourcing for energy generation is therefore on primary forestry residues,[16] defined in Portugal (see glossary) as leftovers and waste from forestry operations, such as stumps, roots, leaves, branches and tree tops. In theory, roundwood or sections of tree trunk are excluded (except in the case of phytosanitary operations).

Monitoring of biomass feedstocks is carried out by the Institute for Nature Conservation and Forests (ICNF) and in order for electricity from biomass plants to be subsidised, operators must meet three main requirements:

- A 10-year action plan detailing the long-term sustainability of biomass supply must be approved and written into the contract signed between power station operators and public utilities;
- Operators must submit an annual report to ICNF describing and identifying the quantity, type and origin of the biomass consumed at the plant in the previous year; and,
- Operators must allow inspections of the plant, as well as undefined auditing and monitoring of biomass consumption by the ICNF, the Directorate-General for Energy and Geology (DGEG), or by an accredited entity hired by the producer, at their request.

Portuguese NGO ZERO recently revealed that of the 13 biomass power stations that were receiving subsidies for electricity generation[17] at the time that their request for information was made, ICNF had only evaluated the 10-year plans of six plants. Just four had been approved, while one was approved conditionally and another was rejected. Whether or not all of the plants continue to receive subsidies was not confirmed and, according to ICNF, any legal non-compliance with legislation is the responsibility of the DGEG. The content of the plans was also not made publicly available. This has led ZERO to fear that there is *"a complete lack of control over the operation of biomass plants"* and that *"access to subsidies for biomass energy production does not comply with the legal framework"*.

In addition, annual reporting requirements are fulfilled through self-assessment, and it is unclear if any level of independent verification or inspection is carried out by ICNF. ZERO states *"that there is no monitoring system in place that allows for the accurate and credible identification of the type of biomass being used for energy nationwide. Theoretically this is done through harvesting reports that are filled in and accompany the transport of forest biomass that arrives at a given industrial site... However, ICNF refers to this as a guideline and does not enforce it as a requirement, meaning that it is of little value. On top of this, the fact that significant amounts of biomass used in power stations and pellet mills arrives as woodchip makes it practically impossible to trace its origin."*

The problems surrounding biomass electricity generation in Portugal are increasingly being recognised, even by industry. For example, the 2020 Portuguese Renewable Energy Forum concluded that *"it does not make sense to promote dedicated biomass electricity, because these power stations will never reach the minimum greenhouse reduction values required in a sector that urgently needs to decarbonise… power plants dedicated to burning forest biomass should consequently be disincentivised."* Although new legislation has recently been introduced to oblige new biomass power stations to utilise the heat generated as well as generating electricity, the overall impacts of biomass sourcing will remain the same.

Case studies

GreenVolt and the Figueira da Foz II electricity-only power station

GreenVolt, which is 59% owned by Altri, operates and wholly-owns all four of the dedicated biomass electricity power stations at Altri's pulp mills, plus a dedicated biomass power station that isn't attached to a pulp mill. Its total biomass electricity generating capacity in Portugal is 100MW, which it plans to expand by constructing at least one new power station. Greenvolt also owns a 51% stake in Tilbury Green Power, a 41MW biomass power station that burns waste wood in the UK. GreenVolt's power stations in Portugal burned around 1.1 million tonnes of woody biomass in 2021, 65% of which came directly from forestry operations and the remaining 35% from pulp mill by-products, predominantly bark.

Through their wholly-owned subsidiary *Sociedade Bioelétrica do Mondego, S.A.*, GreenVolt operates Portugal's newest and largest dedicated biomass electricity power station, within Altri's CELBI pulp mill complex in Figueira da Foz. Figueira da Foz II has a 34.5MW_e capacity and operates at an alarmingly low efficiency of just 22%.[18] This means that only around a fifth of the energy contained in the biomass is converted into electricity, with the other four fifths being lost to the atmosphere as heat. This is in part due to the fact that although GreenVolt claim that the power station is new, the biomass boiler was actually built decades ago. Altri decommissioned an old 310MW_t[19] recovery boiler that previously burned black liquor, and it was then retrofitted to burn solid biomass.

At full capacity the power station is designed to burn 460,000 tonnes of biomass per year, which is sourced entirely from outside of the pulp mill, meaning that no pulp mill residues such as bark or sawdust are burned in the power station. In 2021 the power station burned over 420,000 tonnes of biomass, requiring 1.44 tonnes of biomass per MWh of electricity generated. GreenVolt earned around €34 million in electricity sales through the operation of the plant and received an average tariff of €116/MWh through Portugal's renewable energy subsidy scheme.

GreenVolt operates another electricity-only biomass power station at CELBI, Figueira da Foz I, which has the capacity to inject 30MW of electricity into the public grid. In 2021 it burned over 350,000 tonnes of biomass and earned the company another €27 million in electricity sales. Figueira da Foz I mainly burns pulp mill wastes such as bark, although it also requires significant amounts of primary woody biomass sourced directly from forestry operations.

Figueira da Foz II was financed through the issue of a Green Bond, whereby GreenVolt were able to raise €50 million of the €83 million total cost through almost 5,000 separate lenders. The success of the bond issue led the company to issue a second, eventually rising to €150 million, to refinance the acquisition of Tillbury Green Energy in the UK and expand its solar and wind portfolio.

Altri's CELBI pulp mill complex, Figueira da Foz.

Altri's new biomass boiler at the CAIMA pulp mill

A new CHP biomass boiler at Altri's CAIMA pulp mill was approved by the Portuguese Environment Agency in January 2022 and is currently under construction. The 76MW$_t$ boiler will produce heat and electricity for the pulp mill and inject 5.3MW of electricity to the public grid. It replaces the existing but much smaller (24MW$_t$) biomass boiler, as well as an existing gas boiler, which will be used as a back-up. The biomass boiler will require 378,000 tonnes of woody biomass each year, three quarters of which will be brought in directly from forestry operations.

The new boiler will run alongside a recovery boiler that mostly burns black liquor, as well as GreenVolt's 12.8MW$_e$ dedicated biomass power station, which operates at around 28% efficiency and requires 130,000 tonnes of woody biomass from forestry operations per year. In total, CAIMA's annual woody biomass requirement for energy generation will reach half a million tonnes, around 80% of which will be sourced from outside the pulp mill. Altri claims that the new boiler will mean that the CAIMA pulp mill runs entirely on "renewable energy".

The Navigator Company's Figueira da Foz mill.

The Navigator Company and its new biomass capacity

The Navigator Company's flagship decarbonisation project is a new biomass boiler at its Figueira da Foz pulp mill, which began operating at the end of 2020. It claims that it has reduced the mill's emissions by 57%, and the company's overall emissions by 30% across its three pulp mills and other industrial sites. The 131MW$_t$ boiler provides heat and electricity to the pulp mill and replaced a smaller biomass boiler and a 67MW$_t$ fossil gas boiler. The European Investment Bank provided half of the total cost of the new boiler, with a €27,5 million loan, one of a number of loans that the bank has provided to the company in recent years.

Although the new boiler doesn't export electricity to the public grid, it is still reliant on primary woody biomass that is sourced directly from forestry operations, which accounts for almost half of its annual biomass demand of around 580,000 tonnes. The company notes in its 2021 annual report that the supply of biomass to the plant increased substantially during the first full year of the boilers operation.

The Navigator Company's original Environmental Impact Assessment quoted a residual woody biomass availability in the local area of 193,000 tonnes in a "maximum use scenario", which is considerably lower than the 255,000 tonnes required by the boiler each year. When questioned about this by the Portuguese Environment Agency, the company claimed that biomass can be sourced from much further away, up to 120 km from the pulp mill by road, making available an additional 139,000 tonnes. It is generally accepted, however, that residual biomass is only economically-viable as a feedstock up to 75 km away from where it is being burned due to the cost of transportation. This either means that subsidy levels are so generous that

they allow sourcing from much further away, or that higher quality wood is being used (or both).

The Navigator Company is also in the process of converting its lime kilns to be fueled by biomass instead of fossil gas. Lime is used in the pulping process and most mills operate their own lime kilns. The first such conversion took place at its Setúbal mill in 2021, and was partly financed through a €4.5 million grant from the EU's Innovation Fund. The company claims that this conversion is a first in Portugal, and will reduce the kiln's direct greenhouse gas emissions by 76%. The company plans to convert a second kiln in Setúbal and the kilns at its pulp mill in Cacia, Aveiro.

According to the company, the kiln will burn *"100% hardwood residues (eucalyptus sawdust and pellets)"*, which will be sourced from pulp mill by-products.

There is no publicly available information on the biomass consumption of the converted lime kiln, but it is estimated to be around 20,000 tonnes per year.[20] Converting all of the lime kilns at the Setúbal and Aveiro mills would require around 60,000 tonnes of additional biomass per year.[21] It is likely that this would displace by-products currently being burned at the biomass CHP and electricity-only plants at the two pulp mills, meaning that they would need to source more woody biomass from forestry operations.

Industry plans for increased biomass burning and potential new developments

Portugal's pulp and paper sector is already heavily invested in and dependent on biomass heat and electricity, and it is unlikely that new electricity-only developments on the scale of Figueira da Foz II for example would be given consent in future, given the current legislative framework. In addition, all but two of the remaining fossil gas CHP plants have already been replaced with biomass. However, there are a number of planned expansions and possible new developments. These include:

A new biomass CHP plant at the Cacia mill in Aveiro: The Navigator Company is planning to install a new biomass CHP boiler at its Cacia mill, which will be slightly larger than and presumably replace the existing one (79MW_t). There is very little publicly available information about it and an application has not yet been made to the Portuguese Environment Agency.

Converting lime kilns at The Navigator Company's pulp mills: As already discussed, further conversions of lime kilns to be fueled by biomass are planned at the Setúbal and Cacia pulp mills, requiring an estimated total of 60,000 tonnes of biomass per year.

Another biomass power station in Mortágua: GreenVolt is currently waiting for a production licence to be granted by DGEG for a new 10MW_e biomass power station in Mortágua, after it entered into an agreement with the municipality. The new plant will be developed under the framework established by Decree-Law no. 64/2017,[22] which legislates for an additional 60MW_e of biomass capacity in Portugal, with a maximum of 10MW_e per development. Whilst originally planned as an electricity-only power station, changes to legislation now oblige operators to utilise the heat generated as well, although it is unclear who the power station's heat customer would be. The plant is likely to require around 140,000 tonnes of woody biomass per year, however, information about this development is extremely limited, given that Environmental Impact Assessments are only required for power stations above 50MW in Portugal.

Replacement of remaining fossil gas CHP plants: There are two remaining fossil gas CHP plants at pulp mills in Portugal, one at The Navigator Company's Setúbal mill and the other at DS Smith's Viana mill. There are currently no publicly announced plans to replace either with biomass. However, in order for The Navigator Company to achieve its emissions reductions targets, it is likely that within the next six to 12 years it will need to replace fossil gas with biomass at the Setúbal mill. The new biomass CHP plant would need to be on a similar scale to the one recently constructed at its Figueira da Foz mill, and require similar quantities of woody biomass.

The impacts of eucalyptus plantations and the threat of their expansion

Given the pulp and paper sector's dependence on eucalyptus and the scarcity of forestry residues in general, their increased use of woody biomass for energy generation will lead to both increased imports of eucalyptus wood, and increased pressure for the expansion of plantations in Portugal, particularly plantations dedicated to energy generation.

In 2021 Portugal imported 1.6 million tonnes of eucalyptus woodchip and roundwood, mainly from Spain (950,000 tonnes), Brazil (650,000 tonnes), and most recently Mozambique (45,000 tonnes), altogether an increase of 23% on the year before. The impacts of eucalyptus plantations in Brazil are well documented, and include impacts on traditional and *quilombola* communities such as landgrabbing and loss of food sovereignty and water resources, as well as significant biodiversity impacts where eucalyptus monocultures are replacing diverse ecosystems such as the Cerrado. Imports from Mozambique come from highly-controversial plantations operated by Portucel Moçambique, a wholly-owned subsidiary of The Navigator Company. Numerous rights violations have been extensively documented in the provinces that the company operates in, including landgrabbing, and the harassment and intimidation of peasant farming communities.

A eucalyptus plantation in Central Portugal.

While the social impacts of eucalyptus are less pronounced in Portugal and Spain than in Brazil and Mozambique, NGOs such as Quercus have been campaigning against the impacts of extensive plantations across the Iberian Peninsula for many years. Portugal already has proportionally more eucalyptus plantations than any country in the world, and their continued expansion would compound the many significant impacts that they are responsible for. Eucalyptus plantations are fire-prone and allow fires to spread quickly and with a high intensity across large areas, and, being an exotic and invasive species, they also reduce biodiversity considerably. They place significant strain on water resources, exacerbating the severe drought conditions that are being experienced more frequently due to climate change. Their planting often involves using heavy machinery to plough on-contour, which removes existing vegetation and causes significant soil erosion and loss of soil fertility.

Despite the introduction of a law banning the establishment of new eucalyptus plantations in Portugal, the pulp and paper and forestry industries have continued to lobby strongly for an increase in plantation areas. The President of Portugal's National Association of Forestry, Agricultural and Environmental Companies *(Associação Nacional de Empresas Florestais, Agrícolas e do Ambiente/ANEFA)* called for new tree plantations to be established in order to fulfil demand for biomass for energy generation, and in recognition of the fact that there is insufficient residual biomass to satisfy demand.

In January 2022 Quercus and other Portuguese NGOs criticised the Portuguese government for *"giving in to pressure from the pulp and paper industry"* through its plans to increase the limits set for eucalyptus plantations across the country, effectively giving the green light to nearly 40,000 additional hectares. Then in August 2022 NGOs denounced calls by Portugal's pulp and paper industry association, CELPA, for the establishment of new eucalyptus plantations in unmanaged forest and scrub areas as a fire reduction strategy, and called for the overall area of plantations to be significantly reduced instead. The United Nations Special Rapporteur on human rights and the environment agrees with this position, having said in September 2022: *"I saw extensive monocultures of Eucalyptus trees during my visit [to Portugal] and recommend taking steps to reduce the area of land covered by this species. Experts recommend substituting native species that are more fire resistant, such as oak, cork and chestnut trees, and creating more diverse landscape mosaics."*

The corporate capture of forestry policy-making in Portugal

The extensive lobbying power of Portugal's pulp and paper industry continues to exert a strong influence over forestry-related decision-making. Decades of privileged access to successive Portuguese governments has resulted in the dismantling of forestry regulation, the unimpeded spread of highly impactful eucalyptus plantations and vast public subsidies and support mechanisms directed towards the sector.

The authors of *Portugal em Chamas* (Portugal in Flames), published in 2018 describe how: *"In the last decades, the influence of the pulp and paper industry over political decisions relating to forestry has grown to the extent that it has become totally dominant, traversing the sphere of influence in the corridors of power, making public ultimatums to governments and arriving at direct governance… The revolving door between the public and private sectors in forestry is another dramatic example of these conflicts of interest, with high costs to the country and enormous benefits to the companies."*

The most recent example of this revolving door is the fact that Francisco Gomes da Silva, a former Secretary of State for Forests and Rural Development, is now the director-general of the pulp and paper sector's industry association CELPA. He has recently claimed that eucalyptus trees sequester more than double the amount of carbon than any other species in Portugal, and that new plantations should be supported with climate finance as *"the fastest way to remove carbon from the atmosphere"*. However, published scientific research points to the fact that natural forests are 40 times better at sequestering carbon than plantations, and that *"plantations hold little more carbon, on average, than the land cleared to plant them."*

The climate impacts of burning wood for energy

The emissions associated with burning biomass for energy are usually ignored by industry, leading to claims that generating energy from biomass is carbon neutral and renewable. This is due to the fact that, under UNFCCC accounting rules, the CO_2 emitted through biomass combustion and the life-cycle greenhouse gas emissions associated with it do not have to be accounted for. In theory, these emissions are accounted for in the land use sector when carbon is lost from forests and other ecosystems, although this is often does not happen consistently and accurately.

However, much scientific study on the overall climate impacts of biomass burning suggests that rather than being carbon neutral, it is actually increasing levels of CO_2 in the atmosphere for substantial periods of time. The immediate carbon emissions associated with burning woody biomass are similar to and often even higher than burning coal (per unit of energy). This large initial increase in carbon emissions creates a "carbon debt" which increases over time as more and more biomass is burned. The carbon debt is highest when roundwood is burned. Regrowing trees and displacement of fossil fuels may eventually pay off this carbon debt, but regrowth takes time that we do not have when it comes to tackling climate change.

Even if the primary woody biomass burned by the pulp and paper sector were to be entirely logging residues and no roundwood whatsoever, this would still result in significant greenhouse gas emissions and cannot be considered carbon neutral. A recent study looking at biomass power stations that burn forestry residues in the US concluded that after 10 years the net emissions impact (NEI) ranges from 41%–95%. This means that if the wood had been allowed to decompose naturally rather than burned, after 10 years there would be up to 95% less carbon in the atmosphere, due to the fact that decomposition releases carbon much more slowly than combustion and leaves carbon behind in the soil as organic matter.

Another recent study in the US showed that burning wood pellets made primarily from pine plantation thinnings, considered a forestry residue, results in a negative impact on the climate for more than 40 years. Whilst the impact timescale might be less for plantation species with a shorter rotation such as eucalyptus, these timescales are still hugely significant given the urgency of the climate crisis and the need for emissions to be reduced immediately.

It is also important to note that, despite a shift towards digitalisation in recent decades, the consumption of paper products has steadily increased. This is due to the growing production of single use products such as packaging, whereby paperboard and cardboard now account for two thirds of global paper production. This has dramatically shortened the life of paper products, given that packaging is usually discarded on the same day that it reaches its final consumer. The carbon contained in short-lived paper products is returned to the atmosphere almost immediately, meaning that paper products are storing less and less carbon over increasingly short timescales.

GreenVolt's dedicated biomass power station (right) and Altri's recovery boiler (left) at the Biotek pulp mill, Vila Velha de Ródão.

Conclusions and demands

The pulp and paper sector is now the largest consumer of woody biomass for energy generation in Portugal, and the biomass power stations associated with the industry burn some 1.7 million tonnes of primary woody biomass directly from forestry operations, in addition to 1.2 million tonnes of pulp mill waste each year. In order to profit from lucrative renewable energy subsidies for biomass electricity, and to meet climate targets, in recent years the sector has focused on building electricity-only power stations inside pulp mills and replacing fossil gas CHP boilers for woody biomass.

The sector's drive towards energy from woody biomass is decoupling power generation from pulp mill by-product streams, whereby more than two thirds of the woody biomass burned is now sourced directly from forestry operations. Operators are taking advantage of existing grid connection points and infrastructure, as well as established biomass supplies, to build highly inefficient and polluting power stations alongside already highly harmful pulp mills.

Rather than this being an example of a circular economy, or closed-loop system, it is resulting in more and more woody biomass being extracted and burned, which increases carbon emissions and impoverishes soils further. Such high demand for biomass in general is also driving increased imports of wood from places where community rights are being trampled on, and creating more political pressure for the expansion of eucalyptus plantations in Portugal.

In order to remedy the situation, the Portuguese government must urgently:

- Introduce a moratorium on new large-scale biomass energy generation capacity, and end its eligibility for renewable energy subsidies;
- Restrict biomass use at pulp mills such that only secondary and waste biomass can be used as feedstock for energy generation, not primary woody biomass;
- Overhaul monitoring, reporting and verification procedures so that accurate, independently verified and publicly available assessments of what feestock is being used and its origin can be made at each power station or CHP plant;
- Ensure that no new eucalyptus plantations are licenced, and commit to an immediate and significant reduction in plantation areas;
- Redirect subsidies for biomass electricity towards genuinely low-carbon renewables, energy conservation and fire risk reduction techniques that incentivise the conservation and regeneration of native forests, and ensure that the benefits of financial support stay with small-scale land-owners in rural areas.

Biomass power stations associated with the pulp and paper sector in Portugal

Power station	Pulp mill and location	Operator	Type	Electrical grid injection capacity (MW)	Total thermal capacity (MW)	Estimated total woody biomass consumption in 2021 (thousand tonnes)	Estimated total primary woody biomass consumption (thousands of tonnes)
Termoelétrica de Constância		Greenvolt	Electricity only	12,8 MW	39MW	131	131
Central a biomassa CAIMA	CAIMA, Constância	Altri	CHP	5,3MW	76MW	378	284
Figueira da Foz I		Greenvolt	Electricity only	30 MW	95MW	353	40
Figueira da Foz II (SBM)	CELBI, Figueira da Foz	Greenvolt	Electricity only	34,5 MW	135 MW	421	421
Ródão Power	Biotek, Vila Velha de Ródão	Greenvolt	Electricity only	13 MW	40 MW**	83	0
Termoelétrica de Setúbal		Navigator	Electricity only	12,5 MW	40 MW**	168	168
Cogeração de Setúbal	Setúbal	Navigator	CHP	54MW*	150 MW**	294	74
Caldeira a Biomassa	Figueira da Foz	Navigator	CHP	-	131 MW	578	255
Termoelétrica de Cacia		Navigator	Electricity only	12,5 MW	49,75MW	168	160
Cogeração de Cacia	Cacia, Aveiro	Navigator	CHP	35,1 MW*	72 MW*	120	0
Caldeira de biomassa	Viana do Castelo	DS Smith (formerly Europac)	CHP	5 MW	35MW	80	0
Central Termoelétrica de Mortágua	N.A., Viseu	Greenvolt	Electricity only	10 MW		141	141
					Total	**2915**	**1674**

* Total capacity for plant, which has a black liquor recovery boiler and woody biomass boiler
** Estimated

Notes

1. This includes dedicated biomass power stations and CHP plants that burn woody biomass and/or black liquor. The Navigator Company produced around 1400GWh of electric energy from biomass (black liquor and woody biomass) in 2021, Altri produced 896GWh (black liquor and woody biomass), Greenvolt produced 713GWh (woody biomass only), DS Smith produced an estimated 175GWh (black liquor and woody biomass), and the total biomass electricity generation in Portugal in 2021 was 4000GWh.

2. GreenVolt operates all of the electricity-only biomass power stations at Altri's pulp mills, whereas Altri operates the pulp mill CHP plants, which usually export excess electricity to the public grid.

3. This figure is an estimate as Altri has not published equivalent figures.

4. https://glasgowagreement.net/inventories/PT/Inventario_PT_Acordo_Glasgow_Relatorio.pdf. It should be noted however that this emissions inventory considers biomass as zero emissions, and therefore accepts bioenergy-related emissions reductions. Consequently, Portugal's largest pulp mill, CELBI operated by Altri, does not feature in the inventory.

5. Throughout the report the amounts of biomass referred to are green tonnes, or biomass with 50% humidity, rather than dry tonnes. These figures do not include black liquor as a feedstock.

6. See page 17 for a break-down of consumption at each pulp mill and power station.

7. In Portugal residual biomass is defined as the leftovers from agricultural and forestry operations, such as bark, branches and tree tops, and industrial waste and by-products, such as black liquor, bark and sawdust. See Text Box on "Subsidy support for burning biomass" for more information.

8. According to DGEG (2023), of the 2.14 million tonnes of biomass burned for electricity generation in Portugal in 2021, 1.53 million tonnes was eucalyptus residues. .

9. João Camargo and Paulo Pimenta de Castro, 2018. Portugal em Chamas - Como Resgatar as Florestas. https://www.bertrandeditora.pt/produtos/ficha/portugal-em-chamas-como-resgatar-as-florestas/21475947.

10. *Ibid*.

11. Gírio, F. Plano Nacional para a Promoção das Biorrefinarias – Horizonte 2030. LNEG. 2017.

12. This figure is an estimate based on 113MWe capacity operating 350 days per year and consuming 1.5 tonnes of biomass per MWh, and an estimated 20% of biomass from industrial by-product streams. Additional capacity of 60MW in the future is expected to require around 600,000 tonnes of biomass.

13. https://zero.ong/wp-content/uploads/2022/06/barometro-2022-pt-.pdf. Total consumption 1.5 million tonnes, minus an estimated 20% of biomass from industrial waste streams.

14. *Decreto-Lei n.º 64/2017, de 12 de junho*, amended by *Decreto-Lei n.º 120/2019, de 22 de agosto* and *Decreto-Lei n.º 73/2022, de 24 de outubro*.

15. Biomass from land clearance as part of fire protection measures and from operations to control invasive species and remove diseased trees are also included in this definition, although these tend not to be economically-viable due to transportation costs and the presence of contaminants such as soil.

16. According to DGEG (2023), 87% of the biomass burned to generate electricity in 2021 was eucalyptus and maritime pine, Portugal's two main forestry species.

17. Under *Decreto-Lei n.º 5/2011*, which is earlier legislation but still includes the obligation of a 10-year plan.

18. 34.5MWe/135MWt)*85% boiler efficiency=22%

19. MWt = Total thermal capacity

20. Converting one kiln will avoid 185,000 tonnes of CO_2e over 10 years. The IPCC emissions factor for fossil gas is 56 tonnes of CO_2 per Tj, therefore 3,304 Tj of energy would have been produced by fossil gas. If eucalyptus wood produces around 19,000 Kj/kg (https://cfnielsen.com/wp-content/uploads/2021/02/Calorific-value-biomass.pdf), then 1.7 million tonnes are required over 10 years, or 17,000 tonnes per year. In addition, this study (https://bioresources.cnr.ncsu.edu/resources/green-pulp-mill-renewable-alternatives-to-fossil-fuels-in-lime-kiln-operations/) quotes a biomass demand of 382 tonnes of biomass per day for a 1,500,000 tonne pulp mill. Comparing this to Setúbal would equate to a biomass demand of 49,000 tonnes per year, or 24,500 tonnes per kiln.

21. If the Aveiro mill produces 320,000 tonnes of pulp per year compared to 550,000 at Setubal, the Aveiro mill will require around 58% as much biomass as Setubal in its lime kilns ((20,000 x 2)x1.58=63,000).

22. Subsequently amended by *Decreto-Lei n.º 120/2019, de 22 de agosto* and *Decreto-Lei n.º 73/2022, de 24 de outubro*.

March 2025

Pulp mills and biomass plants in Germany

Germany has five pulp mills, as well as a large number of paper mills, with the latter using waste paper for around 60% of its production. They also use pulp from eucalyptus plantations in Brazil and Uruguay, as well as pulp from virgin wood from Germany and elsewhere in Europe.

According to the German Environment Agency (*Umweltbundesamt*), the pulp and paper industry is amongst the country's five most energy intensive sectors. In 2022, it was responsible for almost 13 million tonnes of CO_2 emissions from fossil fuel burning.

2023 industry figures showed that fossil fuels (mostly coal) generated 23 TWh of primary energy used in German pulp and paper mills, while 12 TWh came from biomass (excluding 0.29 TWh from biogas and 3.3 TWh from Refuse Derived Fuel, i.e. mixed waste that includes plastic). The remainder (5.3 TWh of heat and 7.9 TWh of electricity) is purchased externally and will therefore also include fossil fuels and some biomass energy.

According to the same industry report, biomass burned by the industry in 2023 consisted of 4.4 million tonnes of 'waste liquor', i.e. pulp mill sludges, 415,334tonnes of bark, 698,482 tonnes of pulp mill fibre residues (i.e. rejects from pulp production), and 287,6000 tonnes of other residues. In addition, 333,966 of other, unspecified, biomass were purchased and burned, which could include roundwood.

Germany is gradually phasing out its coal burning, with many coal plants due to shut down by 2030 and the last ones by 2038. There is a high chance that operators will simply switch from burning coal and other fossil fuels to burning wood, with no benefit to the climate at all. Essity has already announced such a plan in Mannheim and, in December 2024, Koehler Group completed a coal-to-biomass conversion at its paper mill in Oberkirch. The example of Hürth described below is indicative of what the implications of this will be for forests.

Furthermore, at least two pulp and paper companies are expanding into wider biomass energy markets, beyond supplying process energy and selling some additional electricity to the grid. These are Mercer International, which has built a 150,000 tonne capacity wood pellet plant, and Koehler Group, which operates five biomass cogeneration plants that don't supply the company's paper mills. Koehler Group has also recently acquired two wood and biomass logistics and trading companies, one in Germany, the other in France.

E.on's new biomass plant at UPM paper mill in Hürth

The amount of primary woody biomass burned to provide energy for paper production increased significantly in January 2024, after E.on commissioned a biomass cogeneration plant on the outskirts of Cologne to provide heat and power for an adjacent UPM paper mill in Hürth and to export electricity to the grid.

The plant is designed to burn 45 tonnes of wood an hour all year round, equivalent to 360,000 tonnes of wood a year.[1] This new biomass plant represents a 107% increase in the total amount of wood other than pulp mill residues burned to supply energy for the entire pulp and paper industry in Germany. Even more alarming, roundwood accounts for the majority of the biomass burned in Hürth, according to information disclosed by the operators to the government's registry of power plants. Ironically, UPM's paper mill in Hürth fully relies on recycled paper and the company prides itself on its efficiency. Yet, in order to turn recycled paper into paper for printing newspapers, UPM relies on hundreds of thousands of tonnes of wood being burned, most of it from whole trees.

[1] If the plant operates for 8,000 hours a year, which is generally assumed to be the maximum number of hours for heat and power plants, allowing for routine maintenance.

Overview of biomass use by pulp mill operators in Germany

Essity

Essity is a multinational company with its headquarters in Sweden, which produces health and hygiene products, from paper tissues and sanitary pads to wound care materials. It was founded as a spin-off from SCA, a Swedish company that features extensively in the chapter about Sweden in this report.

Essity operates an integrated pulp and paper mill in Mannheim, a city in Baden-Württemberg, using mostly wood but also some wheat straw. The plant has a biomass boiler with a net electrical capacity of 28.45 MW. Pulp mill residues provide two-thirds of the energy, with the remaining third consisting of forest wood from the region. In 2022, Essity announced plans for a new biomass cogeneration plant to replace fossil gas boilers. They stated that this would burn wood purchased mostly from the region.

UPM Hürth pulp mill. *Ocrho/Wikimedia Commons*

Mercer International's Stendal pulp mill. *Felix König/Wikimedia Commons*

Mercer International

Mercer International is an international pulp and paper and wood products company with its headquarters in Canada.

In Germany, Mercer operates two pulp mills, one in Arneburg in Saxony-Anhalt, the other in Rosenthal am Rennsteig in Thuringia. In 2021, the environmental NGO ROBINWOOD staged a protest outside the pulp mill in Arneburg, protesting against wasteful use of whole trees for pulp and paper production as well as wasteful energy use. However, as far as bioenergy use is concerned, the company has advised NGOs and the media that they only use pulp mill residues, and there is no evidence to the contrary, even though the recovery boilers in Arneburg have a combined net electric capacity of 140 MW and export some of that electricity to the grid.

However, as well as operating the two pulp mills, Mercer International acquired a large sawmill, wood processing plant and pellet mill in Torgau, Saxony, from a German company in 2022. The pellet mill produces up to 150,000 tonnes of wood pellets a year. The site includes biomass boilers with a combined net capacity of 11 MW electricity and 55 MW heat, with part of the electricity exported to the grid. It burns bark as well as woodchip.

Finally, the company operates a large sawmill in Saalburg-Ebersdorf, with an adjacent 13 MW electricity and 50 MW heat capacity biomass boiler which burns sawmill residues as well as arboricultural residues, a term which includes trees cut down for road building or other developments.

According to information published in an industry magazine, Mercer also burns woodchip from forest wood in its biomass boilers (excluding those linked to its pulp mills).

Sappi's Alfeld pulp mill. *Katanga/Wikimedia Commons*

Sappi

Sappi is a multinational pulp and paper company with its headquarters in South Africa. It operates two integrated pulp and paper mills in Germany: one in Alfeld, Lower Saxony, the other in Ehingen (Donau) in Baden-Württemberg. A third mill, in Stockstadt am Main in Bavaria, is currently being decommissioned and is therefore not included in this report.

Sappi's Alfeld mill burns mostly black liquor in its biomass boiler and generates additional energy from burning fossil gas.

In the Ehingen mill, 77% of the fuel burned is biomass, including black liquor, bark and wood residues from the pulp mill, as well as some biogas. There is no evidence of Sappi using forest wood or sawmill residues for energy generation in Germany.

Koehler Group diversifies into burning wood for energy generation

Koehler Group is a German company founded in 1807 to produce paper. In 2012, the company founded Koehler Renewable Energy as a fully-owned subsidiary. It invests in biomass cogeneration plants, onshore wind, solar PV and hydro power.

Koehler Group operates biomass plants at two of its paper mills: one in Kehl, the other in Oberkirch, both in Baden-Württemberg. Furthermore, Koehler Renewable Energy operates five stand-alone biomass cogeneration plants. Four of them are not associated with paper production, and one supplies energy to a paper mill operated by a different company.

As well as burning wood for energy, Koehler Group acquired the majority of shares in the wood and biomass logistics and trading company Zollikofer Group in 2021. In August 2024, Zollikofer Group then bought up a similar French company, SAS REKO Energie Bois (REKO).

With regards to the waste wood burning in Oberkirch and possibly Wiesmoor, the following information is important: In Germany, 83% of all waste wood is burned for energy, whereas in Italy, 82% of waste wood is recycled, mostly to make panelboard. The overcapacity of waste-wood burning energy plants has caused panelboard producers to rely far more heavily on using whole trees from the forest instead of waste wood. Waste wood burning thus contributes to the over-exploitation of forests in Germany.

Location	Net electrical capacity (MW)	Thermal capacity (MW)	Biomass burned	Other information
Brunsbüttel, Schleswig-Holstein	4.9	31.7	100,000 t woodchip, including from arboricultural residues	
Dollbergen, Lower Saxony	8.62	38	120,000 t woodchips from forest wood and arboricultural residues	Heat sold to Avista Oil (lubricants from waste fossil fuel oil)
Elsfleth, Lower Saxony	5.48	26	90,000 t virgin wood	Heat and electricity sold to Omni Park paper mill
Goch, North-Rhine Westphalia	8.5	28	90,000 t virgin wood	Heat sold to food processing company
Greiz, Thuringia	1.7	16.7	20,000 t wood dust from forestry industry residues	Steam and electricity for paper mill. Lignite plant converted to wood 2023.
Kehl	11.6	61.7	150,000 t waste wood grades 1-4	Heat and power for paper mill, some power exported to grid
Oberkirch[2]	12.9	44	Woodchips, 'green waste', mill residues[3]	Heat and power for paper mill, some power to be exported to grid
Wiesmoor, Lower Saxony	2.4	13.4	50,000 t woodchips, likely waste wood	Heat sold for greenhouses

Table 1: Biomass power stations burning woody biomass associated with Koehler Group.

[2] Note that this boiler will start burning biomass during 2024. It is currently being converted from coal to biomass.
[3] Unlike pulp mills, paper mills do not produce significant quantities of residues.

With regards to the waste wood burning in Oberkirch and possibly Wiesmoor, the following information is important: In Germany, 83% of all waste wood is burned for energy, whereas in Italy, 82% of waste wood is recycled, mostly to make panelboard. The overcapacity of waste-wood burning energy plants has caused panelboard producers to rely far more heavily on using whole trees from the forest instead of waste wood. Waste wood burning thus contributes to the over-exploitation of forests in Germany.

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Biomass energy and pulp production in Spain

ENCE's electricity-only biomass power station in Huelva.
Wikieditorarigurosa/Wikimedia Commons

Spain is Europe's 5th largest wood pulp producer. In 2022 it produced 1.5 million tonnes of pulp, equivalent to 4.4% of European production. It has an installed biomass electricity capacity of 615MW and produces some 7.3 million dry tonnes of woody biomass each year to generate energy, which includes primary woody biomass and industrial by-products such as bark, as well as wood used for domestic heating and wood pellets. A government study published in 2010 concluded that Spain has a potential annual residual forest biomass availability of around 6.6 million tonnes, of which 4.5 million tonnes would come from forestry operations.

ENCE and Magnon Renewable Energy: Spain's largest pulp and biomass electricity producers

ENCE Energía & Celulosa is Spain's largest producer of both pulp and biomass electricity. The company operates two pulp mills in Galicia and Asturias with a combined capacity of over one million tonnes of pulp, and both mills have biomass CHP plants that burn woody biomass alongside recovery boilers that burn black liquor.

ENCE's subsidiary, Magnon Renewable Energy, operates another eight electricity-only biomass power stations in various parts of the country that aren't associated with pulp mills, with a combined electricity capacity of 266MW. Put together, ENCE's combined biomass electricity capacity is 378MW, equivalent to over 60% of Spain's total installed biomass electricity capacity.

ENCE's two biomass CHP plants burn both bark produced as a by-product of pulp production and primary woody biomass sourced directly from forestry operations, that take place mainly in industrial eucalyptus plantations. According to Magnon, two of the electricity-only power stations it operates burn residues from olive oil production processes, and the others burn a mixture of biomass from forestry operations and agricultural residues. Put together, ENCE's biomass plants consumed almost 2.2 million tonnes of woody biomass in 2022, equivalent to almost a third of all woody biomass-based fuels used in Spain each year.

ENCE only discloses total biomass use at each of its power plants, and has refused to provide a breakdown of biomass types and their origins. However, it is estimated (see table below) that up to 1.8 million tonnes of biomass burned by the company could have come directly from forestry operations. If this figure is compared to the estimated annual availability of residual primary biomass from forestry operations for energy use, it is equivalent to 40% of the nation-wide figure.

The ENCE and Magnon biomass plants are certified through the SURE certification scheme, which companies sign up to voluntarily and relies on self-reporting. It was implemented to ensure compliance with the EU's REDII legislation and to certify the sustainability of power station feedstocks. However, it does not require companies to make sourcing information available to the public. On top of this, ENCE's Sustainability Manager is a member of the SURE Technical Committee (another pulp company, Stora Enso, is also represented on the committee), and the Spanish Biomass Association, the biomass industry's trade representative, is the SURE national partner for Spain. These conflicts of interest clearly undermine the credibility of the scheme.

ENCE's Pontevedra pulp mill and biomass plant. *Estevoaei/Wikimedia Commons*

Altri, Greenalia and Greenfibre: A new pulp mill and biomass plant in Galicia

Portuguese pulp and paper giant Altri announced in 2022 its intention to build "the most sustainable cellulosic based fiber plant in the world," *a 200,000 tonne capacity* "sustainable fibre biofactory" *geared towards the production of lyocell, from which textile fibres can be produced, in Palas de Rei, in central Galicia. The project is being developed by Greenfibre, a Spanish company created by Altri, and in which Altri has a 75% stake. The other 25% stake is held by Greenalia, a Spanish company with a 50MW electricity-only biomass plant in Galicia and plans to construct two more of a similar size in Galicia and Asturias. .*

The project, referred to as Projecto GAMA, was recently granted "Strategic Industrial Project" status by the governing Galícian Xunta, which released a public consultation in early March 2024. The consultation describes the project in more detail, and highlights the fact that the mill will be significantly more geared towards producing pulp for paper products than for use in the textile industry. In its first phase of operation, the mill will produce 250,000 tonnes of pulp each year and 60,000 tonnes of lyocell, which would require 1.2 million cubic metres of eucalyptus wood. When fully operational, the mill will produce up to 400,000 tonnes of pulp and 200,000 tonnes of lyocell annually, making it the largest pulp mill in Spain.

Energy generation will be a key part of the project, and Altri intends to *"Sell excess green energy to the grid."* The only publicly available information about the mill's energy generation infrastructure is that it will have a 500MWt recovery boiler (powered by black liquor) and a 250MW_t biomass boiler (powered by woody biomass), as well as a 45MWt lime furnace (powered by gas). It is unclear whether the biomass boiler will be an electricity-only or CHP plant, but it is likely to be the former, given that Altri operates four electricity-only biomass plants at its three pulp mills in Portugal (see Portugal case study), and that Greenalia already operates a large electricity-only biomass power plant in Galicia and has plans to construct two more in Spain. When running at full capacity, the biomass boiler could require up to 820,000 tonnes of biomass [1]and the mill is likely to produce around 120,000 tonnes of bark.[2] This means that up to 700,000 tonnes of primary woody biomass sourced directly from forestry operations could be required each year.

Local resident groups such as the Plataforma Ulloa Viva and NGOs such as Greenpeace have strongly opposed the plans. Chief amongst the criticism is the fact that the mill will use up to 45 million litres of water a day in a

[1] Assuming that the energy density of woodchip is 0.8 MWh/m^3, and that one m^3 of woodchip weighs 0.3 tonnes. 250 MW_t = 2,190,000 MWh per year, equivalent to 2,737,500 m^3 of woodchip or 821,250 tonnes.
[2] Assuming that each tonne of pulp produces 0.2 tonnes of bark. 600,000 tonnes of pulp is therefore equivalent to 120,000 tonnes of bark.

Harvesting eucalyptus in Galicia.
Salva la Selva

Protest against Greenfibre pulp mill in Galicia. *Brais Lorenzo*

region that suffers regular water shortages in the summer months, equivalent to the daily consumption of over 300,000 people. 30 million litres of water per day will also be discharged back into the Ulla river. Galicia's largest trade union has questioned the "dubious legality" of the Xunta's planned award of a water extraction licence to Greenfibre, and points out that the mill will consume as much water as the whole of the Lugo municipality, were the mill will be situated, each day.

Another significant concern is the impact that the mill would have on eucalyptus plantation expansion. Greenpeace Spain describes how, at full capacity, the mill would require 2.4 million tonnes of wood yearly from eucalyptus plantations, equivalent to almost 40% of what was harvested in Galicia in 2022. The mill would compete for wood with Ence's two pulp mills in the region (Pontevedra in Galicia and Navia in neighbouring Asturias), and with Altri's Portuguese rival, The Navigator Company, which also sources wood from eucalyptus plantations in Galicia and Asturias. The Galician Society of Natural History also highlights the fact that *"ENCE's pulp mills in Pontevedra and Navia are directly responsible for the fact that 28% of Galicia's forest land is covered by eucalyptus (409,000 ha)"* and that the new mill would increase pulp production by 33% and result in the expansion of eucalyptus plantations in the Galician mountains, with enormous impacts on terrestrial and aquatic ecosystems as well as increased fire risks.

In terms of finance, the first phase of the project will require an investment of 900 million Euros, and Altri is hoping that some 250 million Euros of this will be financed through state funding, following the Spanish Government's agreement to support Galician industry with more than 2.1 billion Euros from EU funds and state budgets. In particular, finance is likely to arrive via the NextGenerationEU fund, which was designed to help in the post-pandemic recovery. Greenpeace Spain also points out the fact that Greenalia's new Corporate Affairs & Sustainability Director, Beatriz Mato, was a Minister in the Galician Xunta for almost 10 years, and questions whether this revolving door between government office and the pulp mill developers is designed to facilitate Altri's access to public finance.

The Plataforma Ulloa Viva appealed for public responses to the consultation process in April 2024, and in May 2024 organised a protest that drew 20,000 people to Palas de Rei to show the strength of local feeling against the plans for the new pulp mill. Public protest against the new mill is clearly having an effect, given that Greenfibre suspended its public consultation events, following a raucous reception from local residents.

Greenalia's electricity-only biomass plant

As well as having a 25% stake in Altri's new pulp mill in Galicia, Greenalia also operates the 50 MW Curtis-Teixeiro electricity-only biomass plant in Galicia, which began operating in 2020 with the help of a 50 million Euro EIB loan. Although not directly related to pulp production, the power station mostly burns baled tree branches and tops that are left behind following eucalyptus logging operations carried out for pulp production and has 30 balers working at logging sites throughout Galicia. According to the company, the plant was supplied with 450,000 tonnes of forest biomass in 2022, which was sourced within an average radius of 73 km from the plant. Greenalia also has two more 50MW electricity-only biomass power stations in the early stages of development, in Villalba, Galicia, and the port of Gijón, Asturias.

Other pulp and paper mills that burn primary woody biomass

Smurfit Kappa operates two integrated pulp and paper mills in the Basque Country in northern Spain, in Nervión and Sangüesa, which between them consume more than a million cubic metres of pine each year. The Nervión mill invested 25 million Euros into a new biomass CHP plant in 2009, which allows it to burn over 100,000 tonnes of primary woody biomass each year. The DH Smith Dueñas mill in Palencia also operates a small 15 MW_t biomass boiler that requires up to 40,000 tonnes of biomass to be brought in from outside of the plant's operations.

Conclusions

The pulp and paper industry is clearly the major player in the biomass electricity sector in Spain and is responsible for a great deal of the primary woody biomass that is burned in the country each year.

Put together, Spain's pulp industry and power stations associated indirectly with the pulp industry account for around 428 MW of electrical capacity, equivalent to more than two-thirds of Spain's overall biomass electricity generating capacity. These plants require in the region of 2.8 million tonnes of biomass each year, of which up to 2.4 million tonnes could come from primary sources and logging operations in industrial tree plantations in particular. This is equivalent to over a third of all of the woody biomass used for energy generation each year in Spain, and over half of the estimated annual availability of primary residual biomass throughout the whole country.

If Altri's pulp mill and biomass plant are constructed, and if Greenalia's two new biomass plants are developed, this would create an additional overall demand of around 1.7 million tonnes of woody biomass, which would represent a 70% increase on existing demand from biomass power stations linked directly or indirectly to the pulp industry. This highlights the importance of opposing these new developments.

Bailing eucalyptus logging residues in Galicia, which were burned in the Greenalia biomass power station. *Salva la Selva*

Plant name (location)	Operator	Capacity (MWe)	Woody biomass consumption in 2022 (kt)	Estimated primary woody biomass consumption (kt)
Pontevedra pulp mill (Galicia)	Ence Energia y Celulosa SA	50	200	150*
Navia pulp mill (Asturias)	Ence Energia y Celulosa SA	62	360	240
Huelva power stations (x3) (Andalucía)	Magnon Green Energy/Ence Energia y Celulosa SA	137	885	885
Lucena power station (Andalucía)	Magnon Green Energy/Ence Energia y Celulosa SA, Grupo Santamaría	27,1	123	0
La Loma power station (Andalucía)	Magnon Green Energy/Ence Energia y Celulosa SA	16	84	84
Enemansa power station (Castilla-La Mancha)	Magnon Green Energy/ENCE Energía & Celulosa	16	71	0
Biollano power station (Castilla-La Mancha)	Magnon Green Energy/ENCE Energía & Celulosa	50	285	285
Merida power station (Extremadura)	Magnon Green Energy/Ence Energia y Celulosa SA	20	186	186
Nervión pulp mill (País Vasco)	Smurfit Kappa	22,4	>100	100
Curtis-Teixeiro (Galicia)	Greenalia	50	450	450
Dueñas paper mill (Palencia)	DS Smith	15(MWt)	46	39
		450,5	**2790**	**2419**

Table 1: Biomass power stations burning woody biomass associated with the pulp industry.
* Assuming 200 kg of bark are produced per Adt of pulp (range is 100-300 kg).

Plant name (location)	Operator	Capacity	Estimated primary woody biomass consumption (kt)
Gijón, power station (Asturias)	Greenalia	50 MWe	518,000
Villalba power station (Galicia)	Greenalia	50 MWe	500,000
Projecto GAMA (Galicia)	Greenfibre (Altri/Greenalia)	250 MWt	700,000
		450,5	**1,718,000**

Table 2: Planned biomass power plants that will burn woody biomass associated with the pulp industry in Spain.

Mondi SCP pulp mill in Ružomberok, Solvakia. *Mineralysk/Wikimedia Commons*

Other examples of burning biomass at pulp mills in the EU: Mondi SCP in Slovakia

Mondi SCP is an integrated pulp and paper mill in the town of Ružomberok in northern Slovakia, near the border with Poland and the Czech Republic. Mondi SCP has a production capacity of around 550,000 tonnes of pulp[1] and 926,000 tonnes of paper and containerboard. Mondi Group (one of the top ten pulp and paper produing companies in the world) is the mill's majority owner, and describes it as one of the company's largest mills in the world, as well as being the largest in the country.

49% of shares are owned by Eco-Invest, which belongs to the Slovak and Czech oligarch Milan Fiľo. The pulp mill was last expanded three years ago, yet the company has already announced plans for further expansion and has reportedly applied to the government for up to €40 million investment aid.

For many years, concerns have been raised about close links between Mondi SCP's senior management and the Smer-SD party, which has been in government for all but five years since 2006. Prime Minister Fico (Smer-SD) granted the joint venture generous tax incentives in 2012 and again in 2016, the latter to help finance the recent pulp mill expansion. Questions have been raised in the media as to whether generous and repeat support for Mondi SCP may be linked to family connections, i.e. the fact that Prime Minister Fico and the head of the board of directors at Mondi SCP (Miloslav Čurillová) are one another's in-laws.

Locally, there have been persistent concerns about air pollution and odour from the pulp mill complex. A Citizens' Initiative for a Healthy Ružomberok was set up in 2001 and continues to campaign for clean air. According to a spokesperson for the initiative, there have been *"constantly recurring nuisances affecting Ružomberok's population: stench, noise and dust caused by repeated malfunctions or accidents from operations."* The group campaigned recently against Mondi SCP's permitting application to install a bigger biomass boiler which would be allowed to co-incinerate mixed waste.

Mondi SCP operates three biomass-fired recovery boilers, which generate 94% of the pulpmill's energy, as well as providing the main source of district heating in the town.

One boiler (RB1) has been in operation since 1981. It has a thermal input of 98.8 MW and, at full capacity,

[1] This estimate is based on the fact that around 700,000 tonnes of pulp are produced in Slovakia each year and Slovakia's only other pulp producer produces 150,000 tonnes per year.

burns 340,000 tonnes of woody biomass, 30,000 tonnes of pulp and paper sludge and 28,500 tonnes of sewage sludge a year. Woody biomass includes pulp mill by-products such as bark and sawdust, which is estimated to be around 110,000 tonnes a year,[2] implying that 230,000 tonnes (770,000 m^3)[2] are "chipped forest residues." This can refer to anything from brash to whole logs, and is supplied by Slovakia's largest wood and biomass trading company Slovwood, which also has its headquarters in Ružomberok.

The second recovery boiler (RB2) was installed in 2005, and the third (RB3) was commissioned in 2014. Those two boilers appear to be burning black liquor only.[4]

In 2023, Mondi SCP obtained a permit to replace its existing RB1 biomass boiler with a new, larger one, although the company has not yet announced whether it will definitely go ahead with those plans. The permit allows for co-incineration of up to 40% mixed waste with biomass. Unless mixed waste is also burned, the new boiler will require up to 456,000 tonnes of woody biomass plus pulp and paper sludge, as well as up to 113,501 tonnes of sewage sludge per year.

The new biomass boiler will burn up to 288,000 tonnes of biomass (including pulp and paper sludge) plus waste, or up to 456,000 tonnes biomass without waste coincineration, as well as up to 113,501 tonnes of waste water sludge a year. It was approved against significant local opposition, including a petition signed by more than 1,000 residents, concerned about the potential for even more pollution.

In addition to sourcing wood from Slovakia, Mondi SCP also purchases wood from the Czech Republic. In May and June 2023 Greenpeace put GPS trackers into logs cut down in highly biodiverse and old growth forests, and they tracked logs from unauthorised logging in old growth Ždánice Forest in the Western Carpathians to Mondi SCP's pulp mill. Even after the European Commission threatened Czechia with financial penalties for failing to adequately protect Ždánice Forest, the Czech government only put a very small fraction under protection.

Subsequently, Greenpeace also tracked a large, very old oak tree from the Dambořický les Natura 2000 site, i.e. an area meant to enjoy the highest level of protection under the EU Habitats Directive, to the Mondi mill in Ružomberok.

[2] Assuming that one tonne of pulp results in 200 kg of bark.
[3] Assuming that one m3 of woodchip weighs 300 kg.
[4] This assumption is based on the fact the EIA for a new RB1 boiler presents biomass consumption figures for the existing RB1 boiler that are identical to the figures dating from 2010.

Placing a GPS tracker in a tree in Hodonín, Czechia. *Greenpeace*

The climate impacts of burning primary woody biomass for energy

The emissions associated with burning biomass for energy are usually ignored by industry, leading to claims that generating energy from biomass is carbon neutral and renewable.

This is because, under current UNFCCC carbon accounting rules, the CO_2 emitted through biomass combustion and the life-cycle greenhouse gas emissions associated with it do not have to be accounted for in the sectors where they occur. In theory, these emissions are accounted for in the land use sector when carbon is lost from forests and other ecosystems, although this does not happen consistently and accurately.

In fact, there is an increasingly clear link between biomass harvesting and land sector carbon sink losses across the entire EU. In some member states in particular, such as Finland, where government statistics on wood used for energy specifically identified roundwood burning as one of the drivers of the loss. The EU as a whole lost about a quarter of its annual land sector carbon sink between 2002 and 2020. In seven EU member states, including Germany, the land sector has become a net source of CO_2 emissions, and in a further 11 member states, including Finland and Sweden, the land carbon sinks are now smaller than they were in 1990, when the Kyoto Protocol was signed.

Much scientific study on the overall climate impacts of biomass burning suggests that rather than being carbon neutral, it is increasing levels of CO_2 in the atmosphere for substantial periods of time. The immediate carbon emissions associated with burning woody biomass are similar and often even higher than burning coal (per unit of energy). This large initial increase in carbon emissions creates a "carbon debt" which increases over time as more and more biomass is burned. This carbon debt is highest when roundwood is burned. Regrowing trees and displacement of fossil fuels may eventually pay off this carbon debt, but regrowth takes time that we do not have when it comes to tackling climate change.

Even if the primary woody biomass burned by the pulp and paper sector were to be entirely genuine logging residues and no roundwood whatsoever, this would still result in significant greenhouse gas emissions and cannot be considered carbon neutral. A recent study looking at biomass power stations that burn forestry residues in the US concluded that after 10 years, the net emissions impact (NEI) ranges from 41%–95%. This means that if the wood had been allowed to decompose naturally rather than burned, after 10 years, there would be up to 95% less carbon in the atmosphere because decomposition releases carbon much more slowly than combustion and leaves carbon behind in the soil as organic matter. It is important to note that in this context, within the EU, the term "residues" is so meaningless that it can in fact include any kind of roundwood.

Another recent study in the US showed that burning wood pellets made primarily from pine plantation thinnings, (considered a forestry residue), results in a negative impact on the climate for more than 40 years. Whilst the impact timescale might be less for plantation species with a shorter rotation, such as eucalyptus grown in Southern Europe, these timescales are still hugely significant given the urgency of the climate crisis and the need to reduce emissions immediately. On top of this, the timescales will be even more significant for slower-growing forest and plantation types in northern Europe.

It is also important to note that, despite a shift towards digitalisation in recent decades, the consumption of paper products has steadily increased. This is due to the growing production of single-use products like packaging, such that paperboard and cardboard now account for two-thirds of global paper production. This has dramatically shortened the life of paper products, given that packaging is usually discarded on the same day it reaches its final consumer. The carbon contained in short-lived paper products is returned to the atmosphere almost immediately, meaning that paper products are storing less and less carbon over increasingly shorter timescales.

The Impacts of the high demand for wood on the EU's forest carbon sink will mean that climate targets are missed

There is general agreement that, in the short and medium term, increased wood harvesting leads to a reduction in the forest carbon sink. Consequently, over-harvesting is one of the main reasons why the amount of CO_2 being sequestered by Europe's forests is too low to meet fast-approaching climate targets. Meanwhile, two-thirds of the woody biomass consumed in the EU is used for energy generation (48%) and the production of wood pulp (18%). Between 2009 and 2021, the EU's forest carbon sink decreased almost every year and was reduced by more than a third (37%) in total (see Figure 1).[2] As forests are the main component of the EU's overall land-based carbon sink,[3] this has also significantly decreased in recent years. In 2021, the EU's land-based carbon sink sequestered 253 Mt CO_2eq, far from the EU 2030 binding target of 310 Mt CO_2eq and further still from the 2040 and 2050 targets (380 and 450 Mt CO_2eq, respectively).

One of the main reasons for the decline of the EU's forest carbon sink is the increase in timber harvesting rates in European forests due to growing demand for woody biomass. According to the European Commission's Joint Research Centre (JRC) Wood Resources Balances statistics, demand for wood in the EU increased by 172.5 million m^3 annually between 2009 and 2017 (the latest year for which the JRC published data). Seventy per cent of this increase in demand can be attributed to the increasing consumption of wood for energy generation (99.8 million m^3) and wood pulp (21 million m^3). The increased demand for wood between 2009 and 2017 was met primarily by increased harvesting in EU Member States' forests (50%) and additional supply from unknown sources (25%), which is to a great extent likely to to include unreported harvesting. Since 2017, wood extraction in the EU has continued, increasing by around 8.6% or 45.6 million m^3 by 2021 (Figure 1).

Most of this increase can be attributed to the use of wood for energy, which increased by approximately 43.1 million m^3 over the same time period. In contrast, EU wood pulp production remained consistent during this period, although the pulp and paper industry remains an important driver of the high demand for wood in the EU. According to the European Scientific Advisory Board on Climate Change: *"The available data therefore shows a correlation between increased demand for woody biomass – primarily for energy purposes – and an increase in harvesting, which in its turn has contributed to the reduction of the forest carbon sink."*

In light of the above, it is evident that the high and increasing demand for short-lived wood products (biomass for energy and pulp) is an important driver of the decreasing EU forest carbon sink.

[2] Own calculation based on EU's greenhouse gases inventory submitted to the UNFCCC.
[3] In the EU, the land-based carbon sink falls within the LULUCF (land use, land use change and forestry) sector and under its corresponding legislation.

Changes in the European Union's forest carbon sink and roundwood harvest (2009-2021)

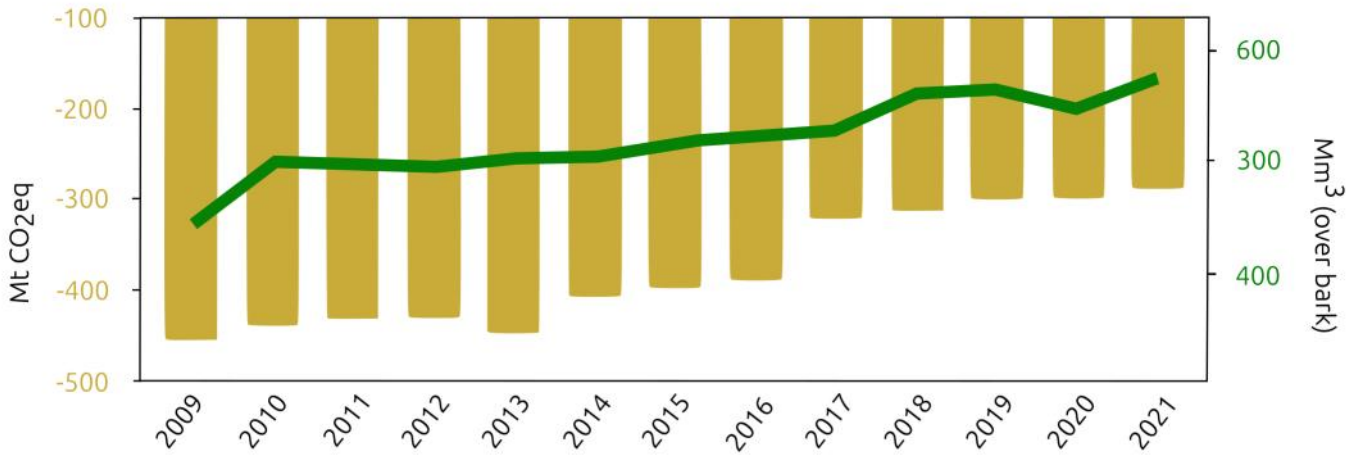

Figure 1: Changes in the EU's forest carbon sink (Mt CO_2eq) and annual roundwood harvest (Mm^3 over bark) between 2009 and 2021. Sink is expressed in negative values, i.e. the closer the number is to zero, the less CO_2 was fixed by forest ecosystems in that year. Forest carbon sink data is derived from the European Environmental Agency's 2023 Annual European Union greenhouse gas inventory 1990–2021 and 2023 inventory report submission to the UNFCCC Secretariat. Roundwood harvest data sourced from the FAO. FAO roundwood data is expressed in m^3 under bark. A standard conversion factor recommended by FAO and UNECE (1.12) was used to convert under bark to over bark harvest figures.

The biodiversity impacts of burning wood for energy

According to the European Environment Agency, forestry is the main activity exerting pressure on valuable forest habitats protected under the Habitats Directive. Given that more than half of the EU wood harvest is currently used for energy, biomass-burning will be a significant—if not the most significant—factor in terms of the impacts of forestry industries on forest habitats.

Both biomass energy and pulp production rely heavily on so-called pulpwood or low-grade wood, much of it composed of trees harvested before they are large enough to be used for high-quality sawmill products. Both bioenergy and pulp and paper production thus favour industrial tree plantations and drive their expansion. Such plantations, often intensively grown using agro-chemicals and heavy machinery during planting and logging, provide little or no habitat to wildlife. Furthermore, they deplete and degrade freshwater and soils. Industrial tree plantations are being expanded at the expense of diverse forest ecosystems, including in Finland and Sweden. In Spain and Portugal, eucalyptus plantations are not only bereft of biodiversity but are a major cause of wildfires which spread far beyond the plantations themselves, harming wildlife and people.

At the same time, a significant amount of wood for pulp and paper and biomass energy burned in that sector comes from clearcutting of biodiverse forest ecosystems. While the biodiversity impacts of clearcutting forest ecosystems are obvious, removing logging residues after or during forestry operations can also have high biodiversity impacts, particularly if coarse woody material is being removed. Even in the case of finer materials such as branches and leaves, the biodiversity impacts can be high, especially if significant proportions of residues are being removed from logging sites and little is left behind. This is due to a number of factors, including the fact that removing residues removes nutrients and decreases soil organic carbon, which can lead to long-term loss of productivity in forest areas and significant impacts on forest ecosystems. It also affects a huge range of saproxylic insects and other arthropods, including beetles, moths, bees and spiders, which depend on dead or dying wood. These are a highly threatened species group in the EU, mainly due to the shift towards intensive commercial forestry. At the same time, the logging

Metsä Group logging site in Finland. *Greenpeace*

Finance for new biomass developments

In recent years, several EU development funds have been used to finance biomass energy developments at pulp mills. For example, in Portugal, the EU Recovery and Resilience Fund recently provided €44.4 million in finance for a new biomass power plant at Altri's CAIMA mill, and the EU's Innovation Fund was also used to replace gas with biomass at The Navigator Company's lime kilns at its Setúbal mill.

Altri also hopes to access millions in finance for its new pulp mills and biomass power plant in Spain via the NextGenerationEU fund, designed to support economic recovery from the impacts of pandemic lockdowns in disadvantaged areas. The EIB has also been central to many biomass energy developments associated with pulp-producing companies, particularly in Portugal.

operations required to collect and remove residual biomass may lead to the extraction of, or damage to, highly ecologically valuable dead wood and create ecological traps when piles of residues are left in forests and then removed and burned.

Whilst forestry certification schemes such as PEFC explicitly recommend that standing and fallen dead wood should be left in quantities and distribution necessary to safeguard biological diversity, a number of studies[4] have found that the translation of this principle into practical guidelines was insufficient compared to what would be needed to maintain healthy ecosystems. Another study found that removal rates of harvest residues in Finland and Sweden were, on average, 76%, which is considerably higher than the levels assumed to have negligible impacts on biodiversity. Given the costs and logistics involved in removing relatively low-value logging residues, there is a clear economic incentive for logging companies to remove as much as possible from logging sites, especially when monitoring of forestry practices by state authorities is often inadequate.

The case studies in this report also make the case that the biodiversity impacts of logging for pulp production cannot be separated from the specific impacts of harvesting biomass for energy generation. Pulp companies are often vertically-integrated, meaning that the same companies carry out forestry operations for pulpwood and biomass energy at the same time, and the lack of transparency in supply chains makes it impossible to distinguish what wood is being used for what end.

Furthermore, the subsidies associated with and profits generated from biomass burning are an increasingly important economic incentive for pulp companies as they diversify their income streams away from a reliance on paper-based products. Whether it's the destruction of old-growth forests on Indigenous lands in Sweden or the impacts of extensive monoculture eucalyptus plantations in Portugal, biomass energy generation is an intrinsic part of the picture, and the impacts of the various aspects of pulp industry operations should not be compartmentalised or seen as distinct from each other.

[4] Johansson *et al.* (2013), Jonsson et al. (2016) and Kuuluvainen *et al.* (2019) from JRC report.

Nordic Paper pulp mill in Sweden. *Marina Ilaria*

Overall conclusions and recommendations

The five country-wide case studies documented in this report show a strong link between the pulp industry and the scale of primary woody biomass burning for energy. In all but the case of Germany, it can comfortably be stated that pulp-producing companies are the dominant force in biomass electricity generation.

The pulp producers in the five countries assessed burn around 25 million m^3 of primary woody biomass annually,[5] equivalent to around one million m^3 per million tonnes of pulp produced. If this is extrapolated to the rest of Europe's pulp production, the figure could be ca. 45 million m^3 of wood. This is equivalent to 16% of all of the primary woody biomass burned for energy in the EU in 2021.

The companies described in this report claim that this is a sustainable, low-carbon way of producing energy that efficiently utilises an otherwise wasted resource. However, increasing biomass energy capacity at pulp mills throughout the EU to satisfy greater production outputs and the desire to sell electricity and heat to external customers, is resulting in more and more wood being extracted from forests and plantations. This only increases carbon emissions and impacts soil health and other aspects of forest ecosystems that, for instance, require dead and decaying wood to maintain biodiversity. The increasing use of primary woody biomass and woody by-products that could have alternative industrial uses to energy generation increases pressure for further logging, as the overall demand for wood is higher.

Another important trend that is increasing overall demand for wood for energy generation is the fact that pulp companies are diversifying into other areas of the bioeconomy (hence the term "bioproduct mill" being used in place of a pulp mill, especially for new developments), and producing fuels from refined woody biomass. This is most pronounced in Sweden, where pulp-producing companies are responsible for around 50% of the country's wood pellet production, and significant investments are being made into producing transport biofuels.

Country	Pulp production in 2022 (millions of tonnes)	Estimated annual direct and indirect consumption of primary woody biomass for energy generation associated with pulp industry (million m^3)	Estimated proportion of country's total primary woody biomass burned for energy by pulp industry
Sweden	11.8	5.5	20%
Finland	9.2	3.4	18%
Portugal	2.8	5.7	63%
Germany	2.2	2.5	8%
Spain	1.5	8.0	28%
Total	**27.5**	**25.1**	

[5] This figure refers to cubic metres of woodchip.

Recommendations for policy-makers

End subsidies, tax exemptions and public finance for biomass energy and perverse incentives for logging: State subsidies and support mechanisms are the driving force behind new biomass energy developments associated with pulp mills or pulp-producers, particularly for electricity generation. There are also a number of subsidies in place that incentivise wood being extracted from forests and plantations for energy generation. The exemption of biomass energy from CO2 pricing and taxation constitutes another subsidy.

Increase transparency and information disclosure to the public about supply chains and biomass feedstocks: Accurate and up-to-date information on the type and origin of biomass feedstocks should be made publicly available for all energy generation infrastructure in EU countries, along with details of monitoring and verification action taken by public bodies such as forestry authorities. This could be partly achieved by effective transposition of the revised Renewable Energy Directive (III) rules.

Reduce the demand for energy from the pulp and paper industry by reducing the production of short-lived products that quickly end up as waste: Ultimately, the main use of biomass energy generation associated with pulp mills is to satisfy the huge electricity and heat demands of pulp and paper production. The most efficient way of reducing this energy demand is to drastically reduce production levels, particularly of short-lived products such as disposable packaging.

A Finnish forest. *Risto Sauso/Greenpeace*