Environmental Paper Network
BIOMASS ACTION NETWORK

BURNING UP THE BIOSPHERE

A global threat map of biomass energy development

2024 update

Front cover artwork by Paul Kimbell.

A note on terminology

For the purposes of this report, we define these terms in the following way:

Bioenergy: This term refers to energy generated from burning solid biomass, liquid biofuels and gases.

Biofuels: This term includes the fuel sources; solid biomass and charcoal, liquid biofuels and gases.

Biomass energy: This term refers only to energy produced from burning solid biomass.

Woody biomass: A subset of solid biomass, this term includes wood taken from both forests and plantations, as well as non-forest ecosystems such as savanas. It also includes wood processing by-products.

Forest biomass: A subset of woody biomass, this term refers to wood taken directly from forests.

Energy plant: An industrial facility generating electricity (power), or heat, or heat and power.

Power plant: An industrial facility generating electricity.

A note on units

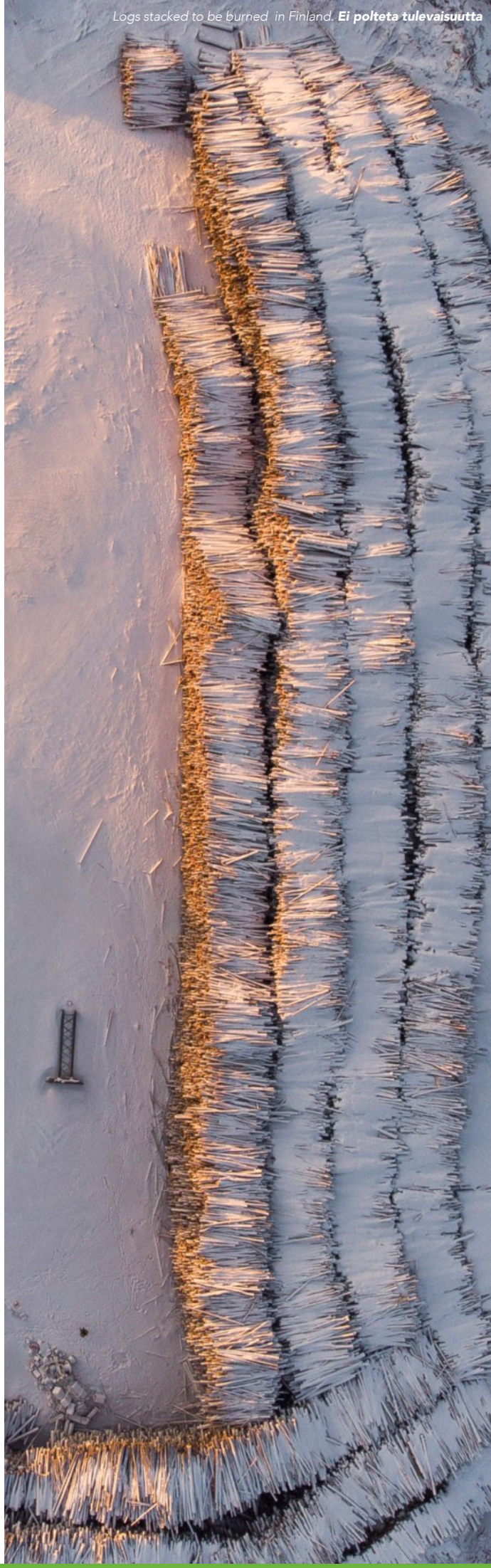
Exajoule (EJ) = a unit of energy equal to 10^{18} joules

Megawatt (MW) = a unit of power equal to 1,000,000 watts

Gigawatt (GW) = a unit of power equal to one billion (10^9) watts

Metric tonne (MT) = a unit of weight equal to 1,000 kilograms

Megatonne (Mt) = a unit of weight equal to 1 million (10^6) tonnes or 1 billion (10^9) kilograms

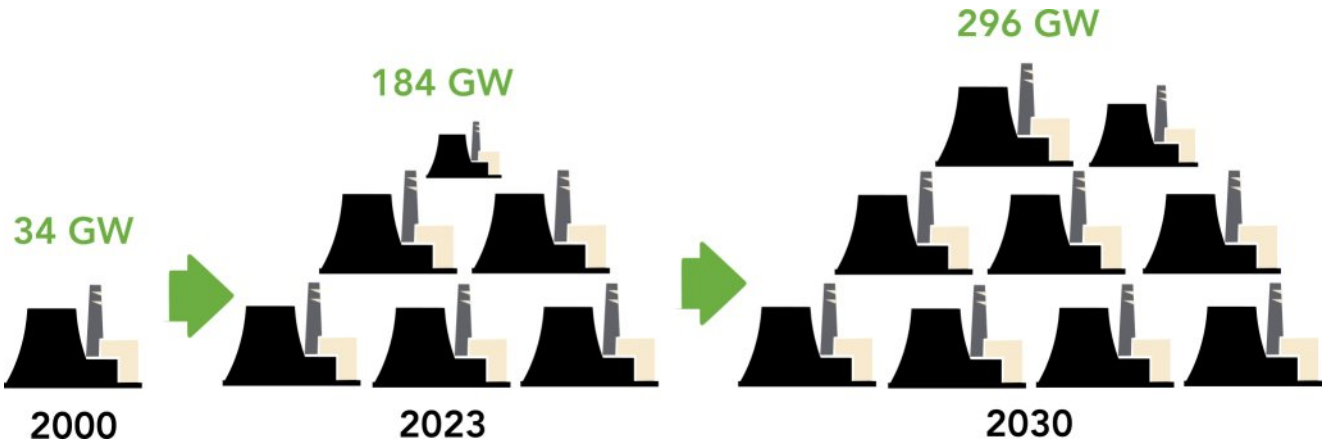


Logs stacked to be burned in Finland. ***Ei polteta tulevaisuutta***

1. The global threat from biomass energy development

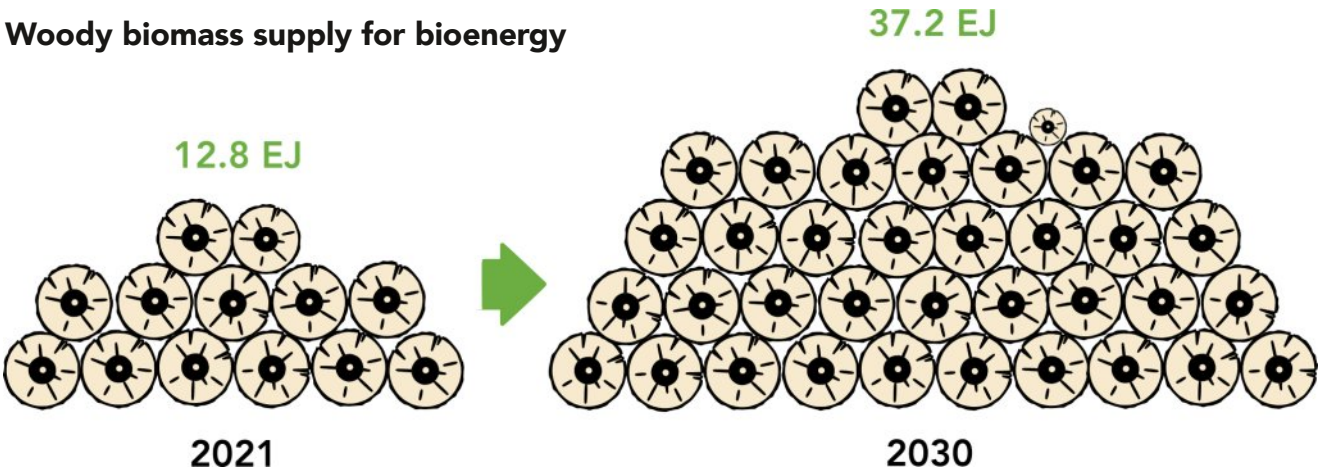
Since 2000, the electricity capacity of bioenergy facilities has increased more than fivefold. The International Energy Agency (IEA) Net Zero Scenario forecasts further growth by 90% by 2030.

Global electricity capacity of bioenergy facilities in IEA Net Zero Scenario

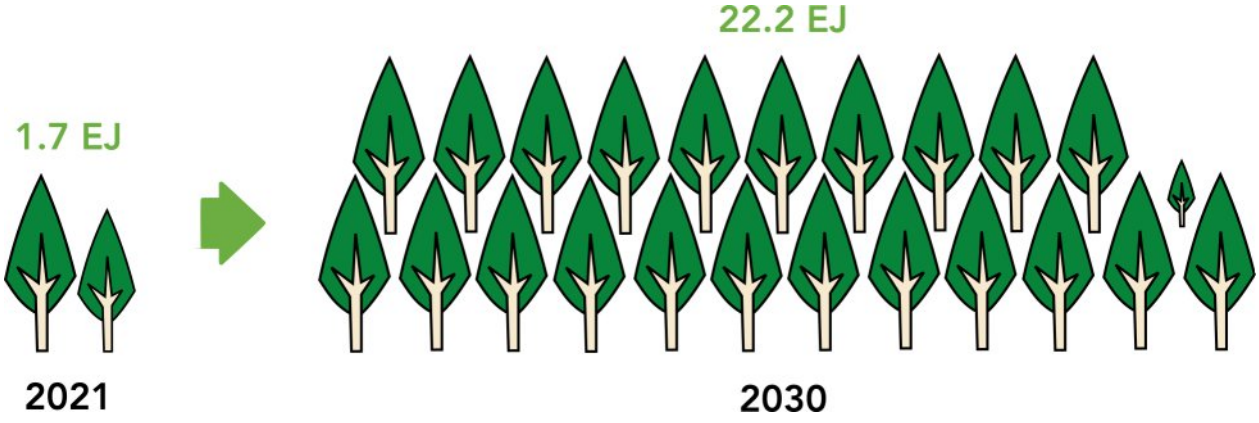


To fuel this growth, the IEA in its Net Zero Scenario provides for tripling the woody biomass supply for bioenergy between 2021 and 2030, including an up to thirteenfold increase in supply of wood from short rotation woody crops.

Woody biomass supply for bioenergy



Short rotation woody crops* supply for bioenergy



* This includes supplying woody biomass from monoculture plantations of fast-growing trees such as eucalyptus, willow and poplar and other woody species such as miscanthus.

2. Key findings and recommendations

Key findings

- **According to the IEA's Net Zero Scenario, a tripling of woody biomass supply for energy is assumed to occur between 2021 and 2030. This will include an incredible and dangerous increase in wood supply from monoculture plantations of up to 13 times current levels to meet the quantities required.**

- UNFCCC biomass carbon accounting rules consider emissions in the energy sector of a biomass-consuming country to be zero, despite there being large emissions at the smokestack. As a result, adoption of this energy source by countries around the world has led to the rapid expansion of power generation in large-scale bioenergy facilities on a global scale. Between 2000 and 2022, the amount of electricity produced from solid biomass increased fivefold.

- This has contributed to a massive increase in the amount of woody biomass burned for energy: A 50% increase in just 11 years between 2010 and 2021 and a 250% increase in global wood pellet production, which reached 47.5 million tonnes in 2022.

- The logging of woody biomass for energy has numerous adverse environmental and social impacts. These include; contributing to the decline of the forest carbon sink in the EU, the deforestation and degradation of valuable forests worldwide (including old-growth and primary forests in North America, Europe and Asia), and human rights violations such as long lasting impacts on human health and the grabbing of Indigenous and local communities' land in the Global South.

- Despite this, countries worldwide continue to support burning woody biomass for energy, and scenarios promoted by key agencies assume further rapid expansion of the industry in the coming years. The International Energy Agency's Net Zero by 2050 Scenario assumes a tripling of woody biomass supply between 2021 and 2030, including a thirteenfold increase in woody biomass supply from short rotation woody crops (SRWC).

- Securing such a large supply of SRWC biomass would necessitate the expansion of monoculture tree plantations, which is already driving deforestation and conversion of Indonesia's rainforests, among others. In Indonesia alone, implementing existing plans for large-scale bioenergy development could result in converting up to 10 million hectares of forest into these "energy" plantations.

- We predict that if current policies to support large-scale bioenergy continue, they will lead to a massive further increase in demand for wood supply, contributing to deforestation and forest degradation, especially in North America and Southeast Asia.

Recommendations

- **The current, flawed biomass carbon accounting rules under UNFCCC and related IPCC reporting methodologies, must be changed.** Emissions from burning woody biomass should be counted in the energy sector and attributed to the consuming country, as is the case for fossil fuels. This will make carbon emissions of both energy sources visible and able to be compared, and help avoid the current practice whereby countries, in order to reduce their reported CO_2 emissions in the energy sector, burn vast amounts of woody biomass, creating an increased demand for wood whilst handing emissions responsibility to the wood producer.

- **Large-scale biomass energy should be excluded from national and international climate targets.** This includes the Global Renewables And Energy Efficiency Pledge and Nationally Determined Contributions. Countries such as the UK, some EU Member States, South Korea, Japan and Indonesia, which already support burning woody biomass for energy on a large scale, should change their approach and move rapidly away to genuinely renewable and low emission energy sources. The resources, especially subsidies, and attention currently devoted to biomass energy development should be redirected to real climate solutions, such as increased energy efficiency, protection and restoration of natural ecosystems, the circular economy, and genuinely low-carbon energy sources, including wind and solar.

- **Co-firing woody biomass with coal should not be considered to be a form of abatement of fossil fuel emissions.** The Glasgow Climate COP made a commitment to "phase down unabated coal power". This undertaking was repeated in the first global stocktake in Dubai.[1] Some countries such as Japan, Indonesia, and EU member states, are expanding the definition of "abatement" to include co-firing other fuels with coal, including woody biomass, in existing coal-fired generators. This interpretation will increase emissions, destroy forests, and damage communities by alienating their land and resources, *while it entrenches the use of coal.* Co-firing woody biomass with coal is not abatement. Biomass energy is unabated power just like coal is.

Wood for use in energy generation, Nidauberg Wald, Switzerland. ***health-and-forest.org***

Contents

3. Introduction

> This report is the second in a series summarising the scale and global extent of a continually growing threat to the world's forests, people and climate, posed by the biomass energy industry. A global network of civil society organisations, the Biomass Action Network of EPN International, has collaborated to map out the threat that this industry poses.

In 2018 our initial report *"Are Forests The New Coal? A Global Threat Map of Biomass Energy Development"* presented the supply and demand dynamics to date and made predictions of the looming threat posed by the growth of large scale energy generation over the decade 2017-2027 supplied by wood pellets, an evolving international commodity. There had been a doubling of biomass energy supply and a quadrupling of pellet production in the decade leading up to 2017, and even more rapid growth forecast for the coming decade – a 270% increase in woody biomass demand.

Ongoing and alarming expansion of the biomass energy industry has necessitated this extensive update, canvassing industry expansion through to 2030. This is occurring in the context of the global climate and biodiversity crises. These existential crises are two sides of the same coin. Climate change is leading to loss of biodiversity, and loss of biodiversity is feeding climate change. The need to protect and restore the natural forests of the world has never been greater. Yet bioenergy has emerged as a false solution working against both climate and biodiversity in the face of the need for positive action.

The acceleration of large scale burning of woody biomass in facilities for energy production, is the focus of our concern. We are not talking about traditional biomass, as used for heating and cooking in many rural areas of the Global South, nor are we focused here on home heating based on community-level wood supply. This is about the establishment and expansion of additional damaging forms of biomass power: stand-alone generating facilities that burn wood chips or pellets to create electricity or combined heat and power (CHP), and conventional (usually coal) power plants converted to burn a mixture of coal and wood fuels (known as co-firing).

Chipping whole beech trunks in Belpberg, Switzerland. health-and-forest.org

Throughout this report we will use the term "woody biomass" to mean wood taken from both forests and plantations, as well as non-forest ecosystems such as savanas and including wood processing by-products.

We have included text on specific issues and regions to illustrate certain aspects and show the global impacts.

We hope this report will be a wake-up call to those **international agencies** promoting expansion of biomass energy; to **governments** that are subsidising coal-to-biomass power plant conversions; will persuade **investors** that financing biomass power is not sustainable; and will persuade **energy analysts, retailers and consumers** to distinguish forest biomass, as a high-carbon 'renewable' energy technology, from lower-emitting technologies like wind and solar.

4. Biomass Industry - past expansion, the present, and outlook for the future

> Since 2000, there has been a massive expansion of the biomass energy sector on a global scale, with a fivefold increase in the amount of electricity and a threefold increase in the amount of heat produced in biomass facilities.

This has contributed to a 50% rise in the amount of woody biomass burned globally, a significant escalation in pressure to increase the amount of wood logged for energy, and associated negative climatic, environmental and social impacts as a result. Net Zero Scenarios promoted by the International Energy Agency (hereinafter IEA) and Renewable Energy Agency (hereinafter IRENA) assume further rapid expansion of the biomass energy industry. In the IEA scenario, the supply of woody biomass for energy is expected to triple between 2021 and 2030. The supply of biomass from short-rotation woody crops is expected to increase thirteenfold. Implementing these scenarios threatens to increase pressure on forests and convert millions of hectares of natural forests, other natural ecosystems, and agricultural land, into monoculture tree plantations.

Renewable energy sources are not only photovoltaic, wind, hydro or geothermal energy, as one might think. On a global scale, most (60%) of energy classified as renewable is generated by burning biofuels, primarily solid biomass (85% of all biofuels[2]). Bioenergy accounts for as much as one-tenth of the World's total primary energy supply.[3]

In this briefing we focus on woody biomass, the main fuel burned in large-scale bioenergy facilities around the world. The last two decades have seen a global surge in bioenergy industry development. Guided by the distorted principles of biomass carbon accounting and misleading claims to carbon neutrality (see sections 6.1 and 7.1), countries worldwide are investing in new biomass energy plants and co-firing biomass with coal to claim a reduction in their reported greenhouse gas emissions from the energy sector.

Consequently, between 2000 and 2022, on a global scale, the electricity capacity of bioenergy facilities[4] and the amount of electricity generated by burning primary solid biomass increased more than fivefold.[5] The energy generation of heat-only and combined heat and power (CHP) plants almost tripled over the same period.[6] A significant proportion of the fuel used in biomass energy is woody biomass. The expansion of the bioenergy sector has, therefore, contributed to a rapid 50% increase in the amount of wood burned for energy purposes between 2010 and 2021 alone.[i,7] The growing demand for woody

[i] The reported increase relates to the amount of woody biomass in applications other than the traditional use of biomass.

Drax power plant in the UK, the biggest burner of woody biomass in the world. ***Biofuelwatch***

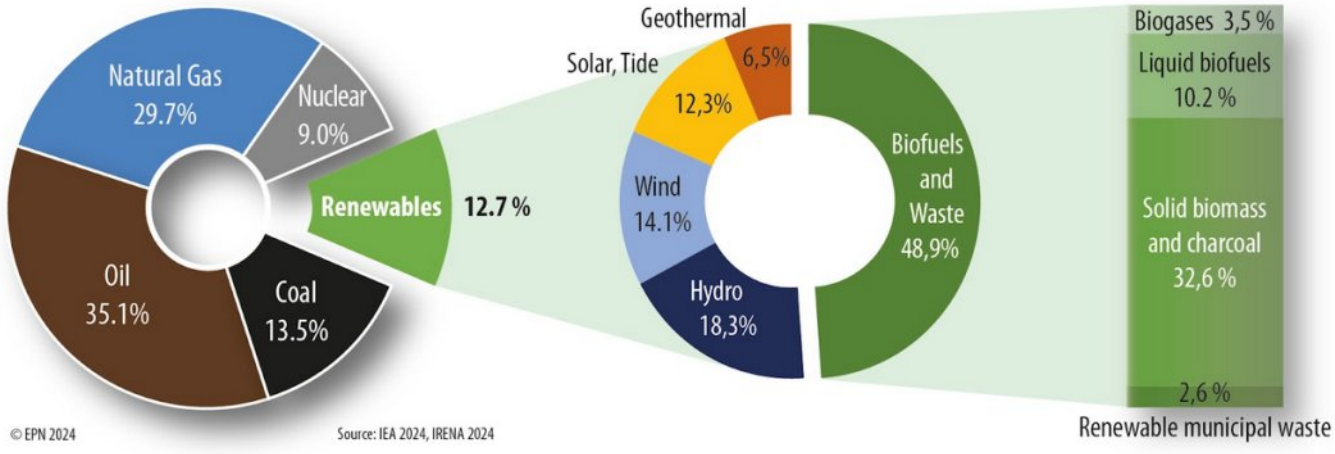


Figure 1: *Total primary energy supply in industrialised (OECD) countries in 2022. Nearly half of all renewable energy is still derived from agricultural crops and forests.*

biomass in the energy sector has several well-described negative environmental and social impacts, including a decrease in the amount of carbon stored by forest ecosystems (see section 7.1), deforestation and degradation of precious forests (see section 7.2), and violations of Indigenous and local communities' rights (see section 7.3).

If the current claim that bioenergy is a sustainable energy source does not change, we can expect it to continue to grow. This is evidenced by scenarios published by, among others, the IEA and IRENA. The IEA Net Zero by 2050 Scenario assumes a 60% growth in the energy supplied from modern solid biomass by 2030 and, in total, more than doubling to reach 73 EJ in 2050.[8] In that scenario, industry and the energy sector account for most of the final energy consumption from modern solid biomass (66 and 80% in 2030 and 2050, respectively).

According to the IEA's scenario, the total supply of woody biomass for bioenergy triples by 2030 (to achieve an increase from 12.8 to 37.2 EJ) to meet the increased demand. Additional woody biomass is expected to come primarily from short-rotation woody crops (including plantations of fast-growing tree species such as eucalyptus, willows and poplars, as well as other woody species, e.g. miscanthus). Supply of this type of woody biomass in this scenario is assumed to grow more than thirteen times (to increase energy production from 1.7 to 22.2 EJ) between 2021 and 2030. Such a huge increase in demand for woody biomass from short-rotation woody crops would in all likelihood result in the expansion of monoculture tree plantations on a global scale, with all the resulting negative environmental and social consequences (see Section 7.2.2). Such an expansion would be in clear contradiction to the recommendations resulting from the joint IPCC and IPBES workshop on biodiversity and climate change, according to which *"Planting bioenergy crops (including trees, perennial grasses or annual crops) in monocultures over a very large share of total land area is detrimental to ecosystems, reduces supply of many other nature's contributions to people and impedes achievement of numerous Sustainable Development Goals."*[9]

Apart from short rotation woody crops, in the IEA scenario, the supply of forest and wood residues increases by a third (to achieve an increase from 8.3 to 11.9 EJ) and biomass from forestry plantings by 11% (from 2.8 to 3.1 EJ).[10] By 2050, woody biomass supply is assumed to increase further, to reach more than 50 EJ, which is over half the total bioenergy supply that year.[11] The 1.5°C Scenario presented by IRENA in its World Transitions Outlook 2024[12] also implies very rapid growth of the biomass energy sector. Biomass consumption for energy purposes more than doubles by 2030 and more than quadruples by 2050. Such rapid and large-scale development of biomass energy threatens to intensify the already existing negative social, environmental and climate impacts, as IRENA acknowledges: *"It will be a major challenge to scale up biomass production to those levels while avoiding adverse environmental or social consequences."*[13]

5. Woody biomass production, consumption and trade

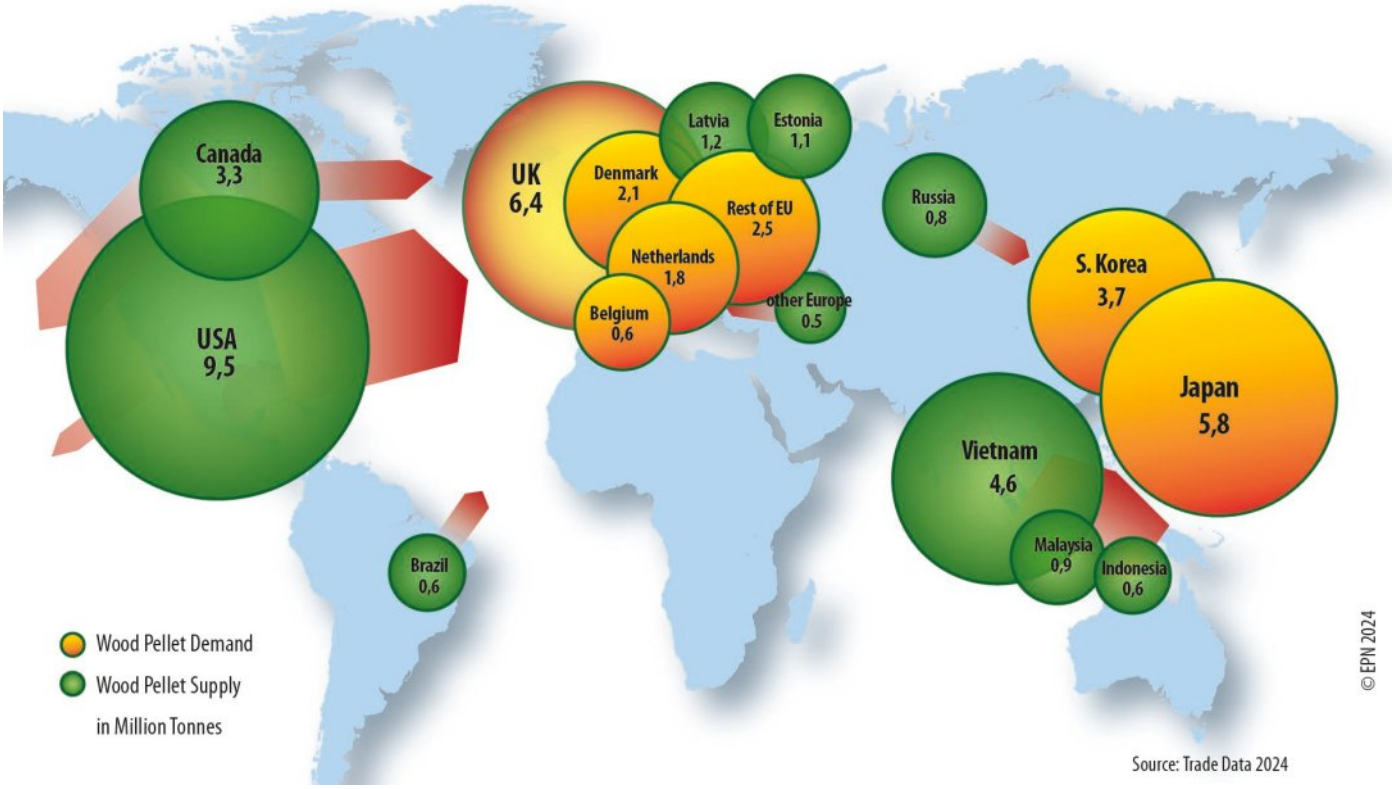
> As a result of the expansion of the biomass energy industry, global production of wood pellets has increased more than 250 % in just ten years to reach 47.5 million tonnes in 2022.

Europe remains the largest consumer of this fuel, where two-thirds of the wood pellets produced globally are consumed. However, the fastest growth in consumption in recent years (between 2017 and 2022) has occurred in South Korea (83% increase) and Japan (sevenfold increase). To meet the biomass industry's demand for woody biomass, European and East Asian countries are importing increasing quantities of wood pellets, primarily from the United States, Canada, and Vietnam, and contributing to the degradation of their natural forests, or their loss through deforestation and the conversion of natural ecosystems into monoculture tree plantations. If the trends observed in recent years continue, we forecast that the growing demand for wood pellets, primarily in East Asia, will lead to a doubling of the wood pellets produced in Canada and Vietnam and an increase in pellet production in the US by half.

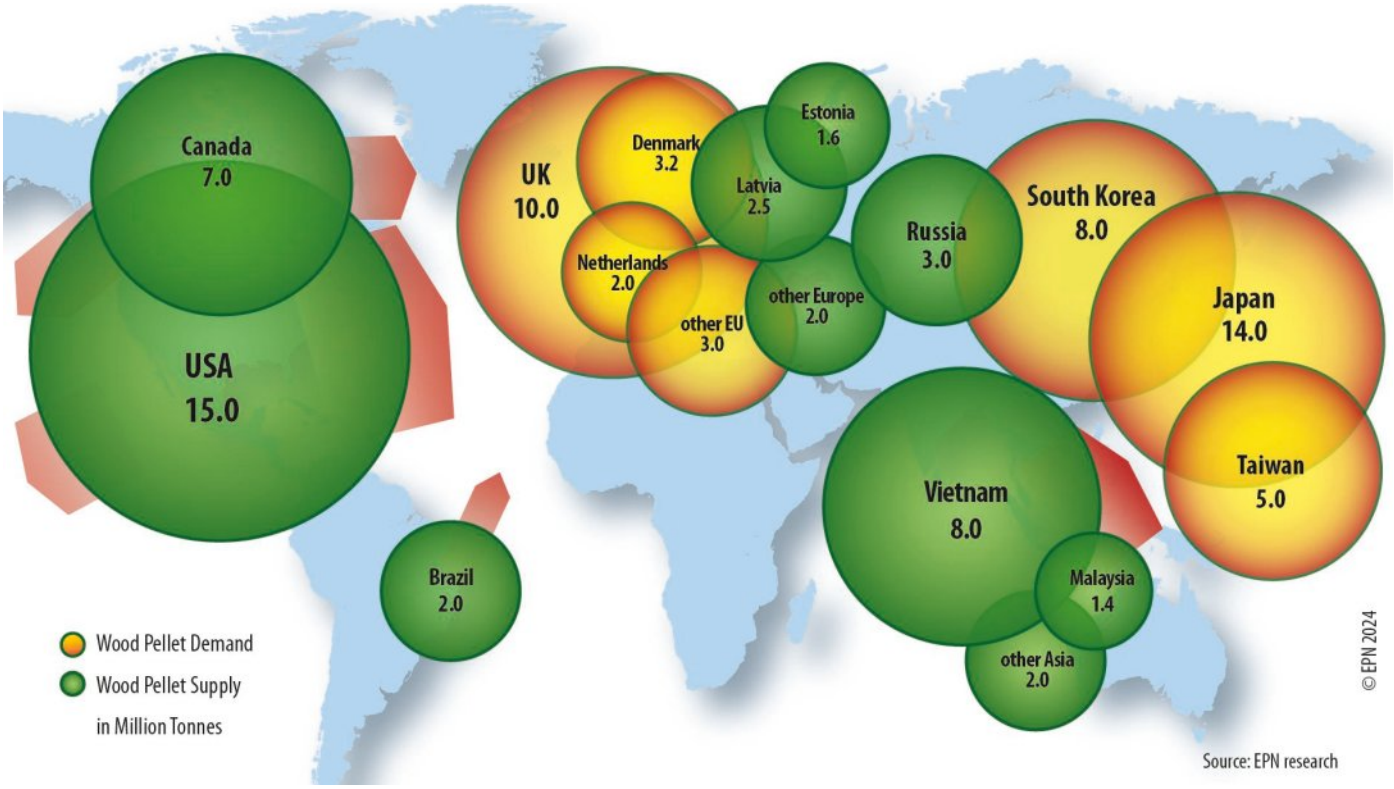
Woody biomass is the most widely used form of solid biomass burned for energy purposes in the world. The main forms of woody biomass used for energy production include fuelwood, charcoal, briquettes, pellets and wood chips. Large-scale energy plants, which are the main focus of this study, burn primarily pellets and wood chips. Here we focus mainly on wood pellets and dedicate much attention to international trade. This is a conscious choice, motivated by the data available and the fact that burning for energy purposes is practically the only use for wood pellets. Large-scale energy plants also use biomass in other forms, such as wood chips. However, wood chips are also used for other purposes, including producing wood pulp and particle boards. As a result, it is difficult to determine the exact proportion of wood chips used for energy purposes, although available data suggests it to be a significant quantity. At the end of this section, we discuss the problem of burning wood chips for energy.

Enviva pellet mill in Ashokie, North Carolina, which manufactures and exports wood pellets. ***Dogwood Alliance***

Import and export of wood pellets in 2023



Import and export of wood pellets in 2030



Figures 2a & 2b: *Import and export of wood pellets reached nearly 23 million tonnes in 2023, an increase of over 60% compared to 2017. By the end of this decade, international trade of wood pellets is expected to double to over 45 million tonnes. The most significant increases are expected in East Asia, while demand in Europe will increase at a lower rate.*[ii]

[ii] The maps show the major imports and exports of wood pellets. This does not include pellets produced and consumed in the same country. 2023 data was based on available trade statistics, whereas 2030 projections are based on information about planned pellet mills and co-firing facilities as well as assumptions about the development of national policies regarding bioenergy, taking into account National Energy and Climate Plans (NECPs).

5.1 Production, consumption and international trade of wood pellets - past and present

> The expansion of the biomass industry is contributing to a rapidly growing demand and, consequently, increasing production of wood pellets on a global scale. Between 2012 and 2022, global production of wood pellets increased more than two and a half times to 47.5 million tonnes. In just five years since the release of EPN's first Biomass Threat Map, pellet production has increased by more than 40%.[14] Rapid demand growth in Europe (excluding Russia and Belarus, but including the UK) and in East Asia, where 85% of all pellets produced worldwide are consumed, accounted for nearly the entire increase in pellet consumption between 2017 and 2022.[15]

East Asia

Remarkably rapid growth in demand during the same period occurred in South Korea (up 83%) and Japan (more than a sevenfold increase). The main reason for this has been the growth of the bioenergy sector. Both countries have been heavily promoting large-scale electricity generation by burning solid biomass in recent years (see section 6.3). In Japan, the generation of electricity from burning this fuel almost doubled between 2017 and 2022,[16] while in Korea, it increased by about two-thirds.[17] As Korea and Japan rely mainly (90%) on imports to meet their demand for wood pellets, the greater demand has been met primarily by increasing imports (70% for Korea and 99% for Japan).

The largest supplier to both East Asian countries is Vietnam, which ships most of the wood pellets produced in its territory to them.[18] Demand in Korea and Japan has resulted in an unprecedented increase in pellet production. It has increased more than ninety-fold in just one-decade,[19] reaching more than 4.6 million tonnes in 2022 and contributing to deforestation and degradation of valuable tropical forests.[20] In addition to Vietnam, Japan imports a significant amount of pellets from the United States and Canada, contributing to the degradation of forests, including the old-growth forests of North America.

An activist in Gorontalo, Indonesia, stands in the street to protest against the export of woody biomass, taken from fragile Indonesian forests, to fuel power plants in Japan and Korea. ***Trend Asia***

Vietnam - a major supplier of wood pellets

Vietnam has emerged as a major wood pellet supplier globally. 95% of its product goes to South Korea and Japan, the two major consuming locations in East Asia. The dynamics for exporting to these two markets are different.

Commencing in 2010 – 2015, the wood pellet export industry has expanded rapidly, becoming one of the most important components of Vietnam's wood processing and export sector. Exports grew by 28 times, from 175,000 tons in 2013 up to nearly 4.9 million tons in 2022.[21] Exports are still expanding. There is strong competition between wood chip exports and wood pellets in Vietnam's central region.

Input materials for wood pellet production vary by region, as does the quality of pellets. Between 400-500 enterprises manufacture pellets, whilst around 100 are directly involved in exporting. One of the biggest challenges for Vietnam in exporting pellets is the unsustainability of raw materials, including their quantity, standards, and quality, according to industry analyst Forest Trends.

The Biomass Action Network holds serious concerns over the conversion of natural forests to plantations occurring as the industry expands, and the use of mixed waste from imported wood for furniture manufacture whose legality cannot be verified.

The certified product goes to Japan, which has standards interpreted to require traceability and some level of sustainability. A scandal around certification fraud and suspension of An Viet Phat by FSC in 2021 has had negative impacts on the whole wood pellet sector in Vietnam and also brought negative reputational impacts in Japan. Non-certified wood goes to South Korea, which has lower standards for pellet quality and no sustainability criteria.

Vietnam has a lot of potential to expand wood pellet exports to Japan as that country expands its biomass burning, with strong competitive advantages in terms of transportation distance, price and quality compared to other pellet producing countries.

Uncertainty in the South Korean market from Vietnam has arisen because of imports of Russian pellets, which are no longer accepted in Europe and are now being sold to Korea instead, as that country has no sanctions. High instability, especially in terms of prices, might be improved in the next few years but the general market trend is predicted to be flat as Korea also puts greater reliance on domestic sources.

Internally, domestic use of wood pellets in Vietnam's light and heavy industry is at low levels but is developing as a so-called climate measure. A few biomass power plants are being introduced.

Deforestation in northern Vietnam. ***Alliance of Bioversity International/Flickr***

Europe

Despite a minor percentage increase (30% between 2017 and 2022) in consumption compared to East Asia, Europe remains the undisputed leader in burning wood pellets for biomass energy. In 2022, consumption of this fuel in the EU Member States and UK reached 30.4 million tonnes, equivalent to 64% of global production in that year. The country consuming by far the most significant volume of wood pellets for biomass energy in Europe (7.8 million tonnes in 2022) remains the UK, importing more than 95% of its fuel from overseas, primarily the United States. A massive increase in consumption (more than tenfold) occurred in the Netherlands, which burned around 2.6 million tonnes of wood pellets in 2022, mainly from the United States.

Southern Carpathians, Romania. ***xulescu_g/Flickr***

CASE STUDY

Expansion of the wood pellet industry in the Balkans

The countries of eastern Europe and on the Balkan Peninsula are home to some of the most pristine forests left on the European continent. Relatively untouched valleys harbour a vast diversity of wildlife, with wild rivers cutting through intact forested catchments that have thus far survived the ferocious logging for commodity wood products that has sadly become the norm in almost all the rest of Europe. Yet, things are changing quickly and not for the better. The more inaccessible and remote forests of eastern Europe and the Balkan Peninsula are now under threat in the name of renewable energy. With non-EU European countries seeking closer ties to the union, treaties such as the Energy Community Treaty have transformed energy policies and trajectories in these countries.

A few years ago, there were a tiny handful of EN-Plus certified pellet manufacturing mills on the Balkan Peninsula. Today there are nearly 100 Active EN-Plus certified pellet manufacturers between Slovenia and Greece with another twenty facilities in Romania and Bulgaria.[22] EN-Plus is one of the leading "certifiers" of pellets, however certification is about the quality of the product you are burning and has nothing to do with sourcing or forest management. In Romania, pellets that make their way onto the market in western European countries are sourced from old-growth forests in remote valleys in the Carpathian mountains.[22]

Pellets produced with wood sourced in different places are mixed and certification labels do not allow the consumers to learn where the product they are buying comes from. Consequently, traders can sell pellets sourced from precious forests as green, renewable, eco-friendly products. Many of the forests where pellets are sourced are supposedly protected Natura 2000 sites, but there is very little enforcement of European environmental legislation in Romania. Coupled with biomass energy facilities now being financed with money from EU companies and governments, the last intact forests of eastern Europe and the Balkan Peninsula are facing this never before experienced, commodity threat. One that will have lasting damaging consequences for forest ecosystems, economies, and the communities that depend on healthy forests and real renewable energy sources to thrive.

5.2 Production and international trade of wood pellets - predicting future trends

> We anticipate further growth in wood pellet production and international trade, if current trends remain unchanged. Europe and East Asia will remain the primary consumers of wood pellets imported primarily from Canada, the US, and Vietnam. Demand for wood pellets in Europe will remain at similar levels, with a possible increase in demand in the UK.

The main driver of production growth will be the rapidly growing demand in East Asian countries. This is likely to include Japan, where a feed-in tariff for 7.6 GW capacity of biomass power plants was approved until 2022, of which only 3 GW came online. Uptake continues slowly but steadily and all of the approved capacity may not be online by the end of the decade. The commissioning of the approved, installed capacity could result in a more than doubling of wood pellet imports, from 5.8 million tonnes (Mt) in 2023 to as much as 14 Mt in 2030. In South Korea (which imported 3.7 Mt of wood pellets in 2023), five biomass power plants are currently in the pipeline, and the existing fleet is set to increase by more than half by 2026. This could result in wood pellet imports more than doubling to as much as 8 Mt in 2030. Taiwan may become a new player in the market. Currently, pellet imports are insignificant, but this is expected to change in the coming years. The country aims to increase its share of renewable energy to 20% of its total power capacity by 2025, relying significantly on biomass.[24] Should Taiwan follow the path laid out by Korea and Japan and convert a significant number of its 55 coal-fired units to biomass, its imports of industrial pellets could rise to 5 Mt in 2030.

The increase in demand in East Asia will likely be met by importing more pellets from proven destinations - Vietnam, the US, and Canada. Currently, in the US, wood pellet mills with a total capacity of approximately 5 Mt are under construction or proposed.[25] If even some of these are realised by 2030, the country's wood pellet exports could increase by half to 15 Mt. The demand in East Asian countries could lead to the doubling of exports of wood pellets in Canada and Vietnam, which may export 7 Mt and 8 Mt respectively in 2030.

Drax Smithers pellet mill in BC, Canada. ***Bulkley Valley Stewardship Coalition/Flickr***

World pellet map and tradeflows 2022 (in Mt)

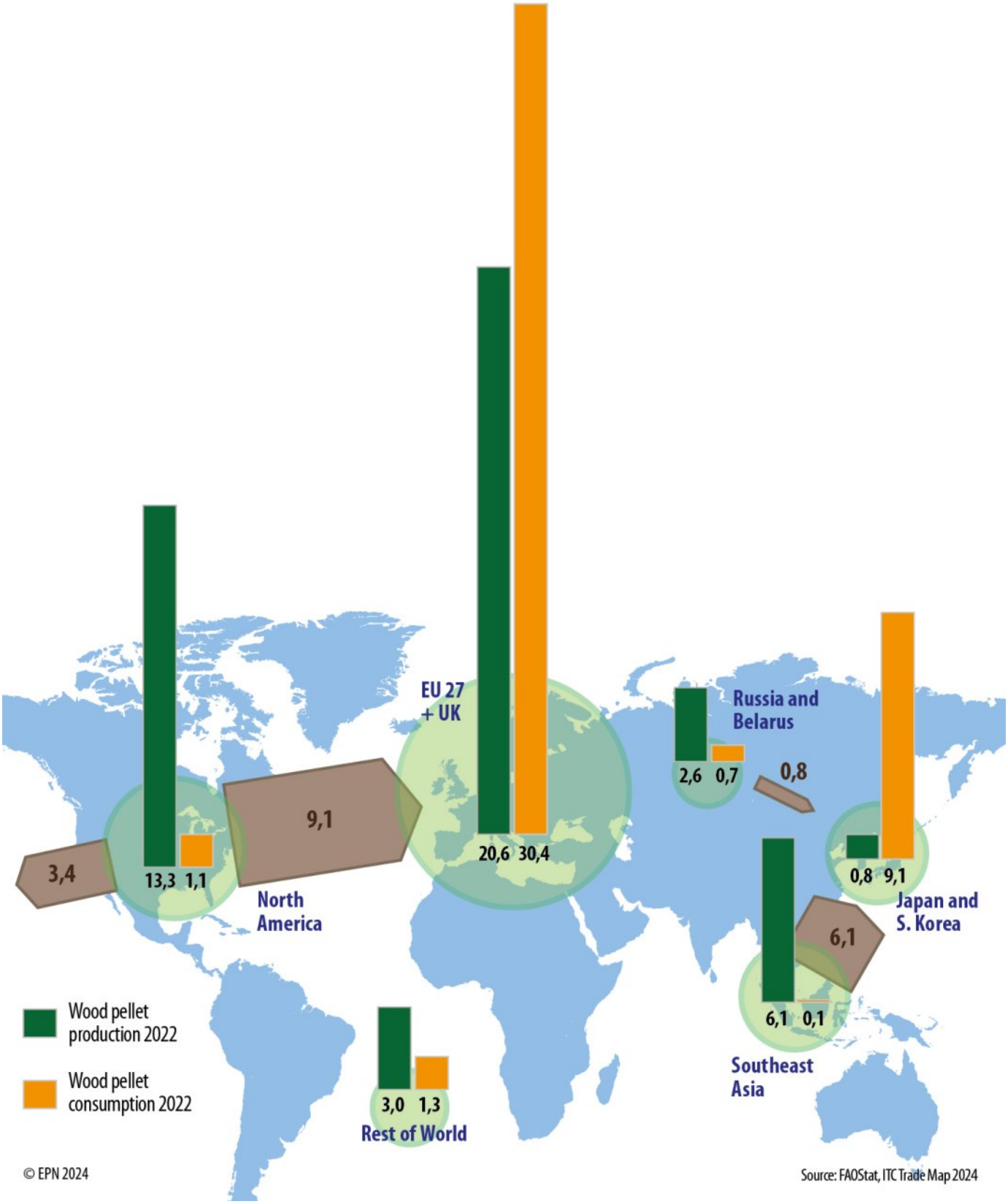


Figure 3: *Production and consumption of wood pellets is highest in Europe, with large quantities imported from North America. Since the second decade of the 21st century, Japan and South Korea have also become major importers of wood pellets, leading to a rapid proliferation of production facilities in Southeast Asia, mainly in Vietnam.*

Chipping whole oak trunks in a Natura2000 site, Switzerland. ***health-and-forest.org***

5.3 Use of wood chips for energy generation - in large volumes

> **Wood pellets are not the only type of woody biomass burned in large-scale energy plants. Another fuel commonly used worldwide in this type of facility is wood chips. Like wood pellets, wood chips are produced mostly from woody biomass derived from forests. These can include the by-products of the wood processing industry, but a significant proportion of the wood chips used for energy purposes are produced by chipping roundwood.**

In 2022, approximately 269 million m^3 of wood chips were produced worldwide, 15.5 % more than in 2000. However, based on the available data, it is difficult to determine what proportion of the wood chips are used for energy production, as apart from energy use, they have other applications, primarily production of wood pulp and wood particle boards. Nevertheless, in most countries with developed bioenergy sectors, large amounts of wood chips are burned for energy purposes.

As with wood pellets, Europe and East Asia are among the regions where the most wood chips are burned for energy purposes. Already in 2013, in the European Union Member States, there were more than 3,000 energy plants with an installed capacity of more than 1 MW using around 51 million tons of wood chips for energy purposes[26] (see case study on Finland below). In Japan, the support given to biomass energy mentioned previously, has contributed to a rapid increase in the amount of wood chips burned in biomass power plants there. In just six years, between 2015 and 2021, the amount of wood chips burned increased by 55% reaching more than 10.7 million tonnes. More than half of the wood chips burned that year came directly from Japan's forests.[27] There has also been a rapid increase in demand for wood chips in the energy sector in South Korea in recent years. Between 2014 and 2022, the amount of wood chips burned in power plants increased more than fivefold to 338,000 tonnes.[28]

Burning wood chips to produce energy: How the biomass industry destroyed the forest carbon sink in Finland

Finland, one of the most bioenergy-dependent countries in the world, is an excellent example of how burning large amounts of domestically sourced wood chips can destroy a country's forest carbon sink . Nearly a third of total energy and more than two-thirds of the renewable energy consumed in this country comes from burning wood fuels. At the same time, of the approximately 30 million m^3 of woody biomass burned annually, only about 1.5% is in the form of wood pellets and briquettes. Most solid wood fuels consumed are domestically sourced timber, logging residues, and by-products of the wood industry burned as wood chips (see Figure 4).

Finland perfectly illustrates how the expansion of large-scale bioenergy contributes to lowering the amount of CO_2 sequestered by forest ecosystems. Energy production in this country is based mainly on wood burning. The last two decades have seen a rapid expansion of the bioenergy sector there. Since 2000, the amount of electricity from primary solid biomass has increased by a quarter, and the amount of heat has risen by almost two and a half times. This has significantly increased the demand for woody biomass at Finnish combined heat and power (CHP) plants. In 2023, they burned 10.5 million m^3 more wood fuels than in 2000 - an 87% increase. Most of this increase has been met by increased consumption of primary woody biomass logged directly from Finnish forests. Burning of small trees and large-size wood increased by 7.4 million m^3 during this period and logging residues and stumps by 2.8 million m^3, which together accounted for 97% of the total additional woody biomass burnt in 2023 in Finnish heat and power plants compared to 2000 (see Figure 5).

The increase in wood consumption in the energy sector was one of the main drivers of the intensification of wood harvesting in the analysed period. Increased wood removals in turn, were a significant factor in reducing the amount of CO_2 absorbed by Finland's forests. Overall, timber harvesting increased in Finland between 2000 and 2023 by 13.3 million m^3. Increased wood combustion in heat and power plants accounts for more than half of this increase. Meanwhile, between 2000 and 2021, the CO_2 uptake in Finland's forests decreased by two-thirds. According to the Finnish Natural Resources Institute, one of the main reasons for this decrease was increased timber harvesting.

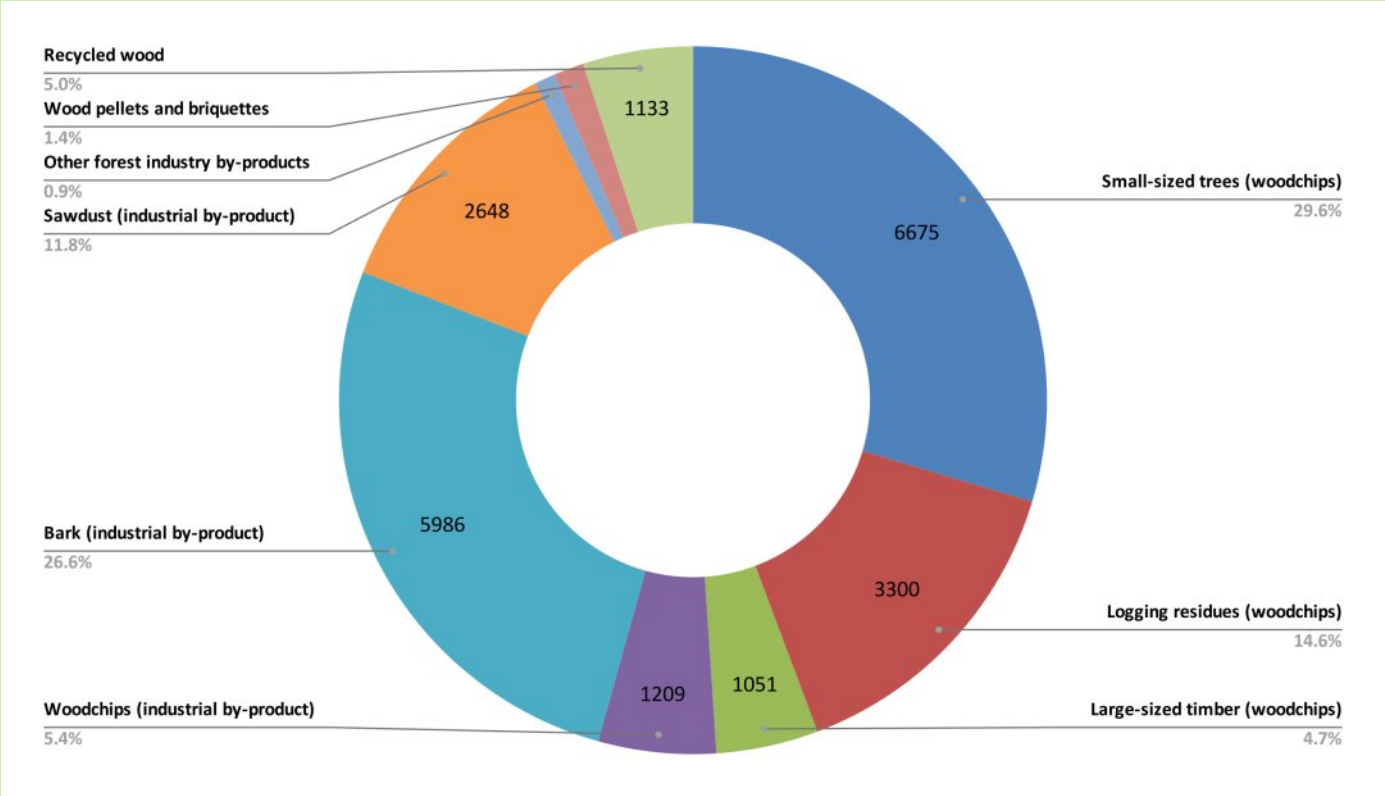


Figure 4: *Woody biomass consumption in Finnish heat and power plants in 2023. Values are expressed in thousands of cubic metres.*[29]

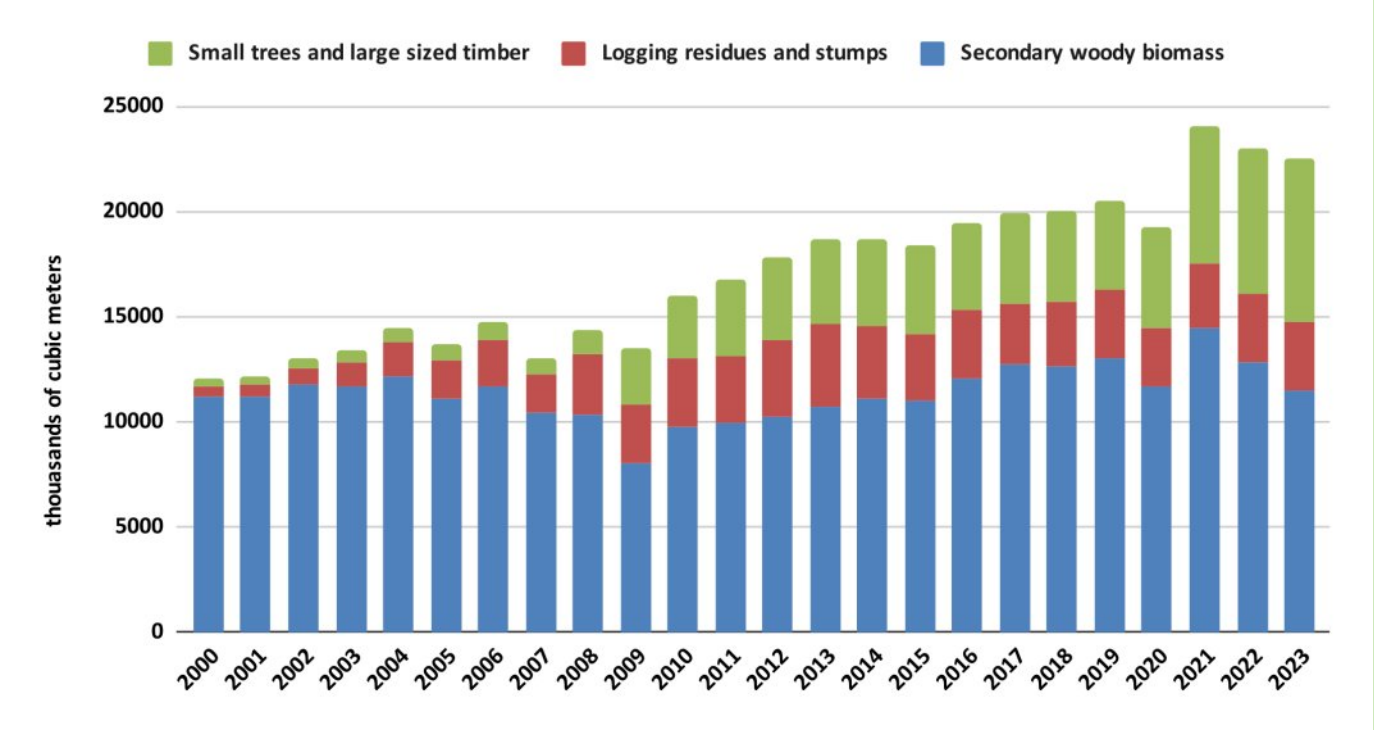


Figure 5: *Wood fuel consumption in Finnish heat and power plants 2000 - 2023.*[30]

Logs stacked to be burned in a bioenergy plant in Finland. ***Ei polteta tulevaisuutta***

Bioenergy plant Egger Holzwerkstoffe Brilon GmbH & Co. in Germany. ***Bomenstichting Achterhoek***

How Germany is burning its forests for energy

Due to generous subsidies, Germany is among the countries which burns the most wood in Europe.[32] More than half of all trees that are cut down are burned for energy.[33] Logging rates have been rising significantly since 2016 (by 20%).[34] By far the most wood is burned in domestic pellet stoves, however, medium-size biomass plants have been proliferating, and several large new plants and coal-to-biomass conversions are proposed.[35] Furthermore, wood burning for district heating is expected to increase, since local authorities are seeing it as an easy option in "heat transition strategies", which every local authority has to develop. So far, wood imports have been negligible, although the German Environment Agency warns that this could change drastically without a change in policy direction.[36]

The impacts of intensive logging on Germany's forests are dramatic. Unsustainable logging and forestry policies are dramatically worsening the impacts of extreme weather events, such as three recent consecutive drought years. Since 2017, Germany's forests have been a net source of CO_2 emissions.[37] 600,000 hectares of conifer monocultures have died off and more forest is seriously damaged. Preventing further forest loss, including die-back from drought and beetles, requires a shift towards close-to-nature forestry, allowing forests to regenerate naturally, and protecting more forest from logging. The growing demand for biomass and thus wood overall, stands in the way of such a change and therefore of the long-term preservation of forests.

6. Drivers of the expansion of biomass burning

> The root cause of the biomass industry's expansion is the UNFCCC's flawed emissions accounting rules, which consider the large emissions from biomass burning in the energy sector to be zero.

They were the basis for the introduction of policies promoting biomass energy in the UK, EU member states, South Korea, Japan and Indonesia, among others. The lavish subsidies available for burning woody biomass in these countries, has led to an increase in the intensity and profitability of logging and a huge increase in demand for wood. We are now facing the threat of a proliferation of policies promoting biomass energy on a global scale through the Global Renewables and Energy Efficiency Pledge. In itself, increasing the share of renewables in energy production is desirable, but if it is based on support for biomass energy it will lead to an exacerbation of the already existing negative impacts caused by this industry.

UNFCCC COP15 in Paris. ***UNFCCC/Flickr***

UNFCCC COP15 in Paris. ***UNFCCC/Flickr***

6.1 Carbon accounting - flaws and loopholes

> Burning woody biomass for energy releases greenhouse gases (GHG) into the atmosphere, including at least as much CO_2 as burning coal per unit of energy produced, and usually more.[38] Yet many countries treat biomass energy as zero carbon or carbon neutral and therefore give it financial and regulatory support as a 'renewable' energy.

Why biomass carbon accounting rules are flawed[39]

The carbon emissions released when biomass is burned to produce energy are not reported nor accounted for in the energy sector accounts of the country where the biomass is consumed.[40] This is in stark contrast to how emissions are recorded for all fossil fuels, which are accounted for in the energy sector of the country where they are consumed. Treating biomass differently creates a false impression of zero emissions from biomass energy, in comparison to emissions from burning fossil fuels.

Instead of counting biomass emissions at the smokestack, the GHG emissions from biomass energy are supposedly accounted for in the Land Use, Land Use Change and Forestry sector (LULUCF) where the biomass is logged.[41] However, in the land sector, the emissions sources are never broken down to show emissions resulting from biomass burning for energy, instead they show only the overall change in forest carbon stocks from all causes. If a country imports biomass for energy production then information about, and accountability for, the change in carbon stocks is meant to be found in the LULUCF sector accounts of another country.

There are many cases where biomass emissions are not counted at all. Emissions impacts in the land sector are themselves often grossly understated. Also when raw wood is processed into pellets, the associated emissions usually aren't assigned to biomass. When the woody biomass is imported from a country that does not account for land sector emissions under the Paris Agreement, this also creates an accounting loophole.

Smokestack emissions from burning biomass in the EU

The European Union submits aggregate reports, which take into account the emissions of all its member states and in them, it provides information on emissions from biomass combustion. These emissions have tripled since 1990, reaching nearly 600 Mt CO_2 in 2021 (see figure 6). As a comparison, in the same year, emissions from EU transportation amounted to 782 Mt CO_2.

Large emissions from biomass energy in Europe were revealed, after a refinement of IPCC reporting methodologies recommended that countries submitting National Inventory Reports of GHG emissions to the UNFCCC Secretariat, should include smokestack emissions from burning biomass in their energy sector as memo points. This means that they are not counted in the overall emissions balance, i.e. they do not increase the energy sector emissions of the reporting country. Nevertheless, these data are a valuable source of information on the actual climate impact of a country's biomass energy industry.

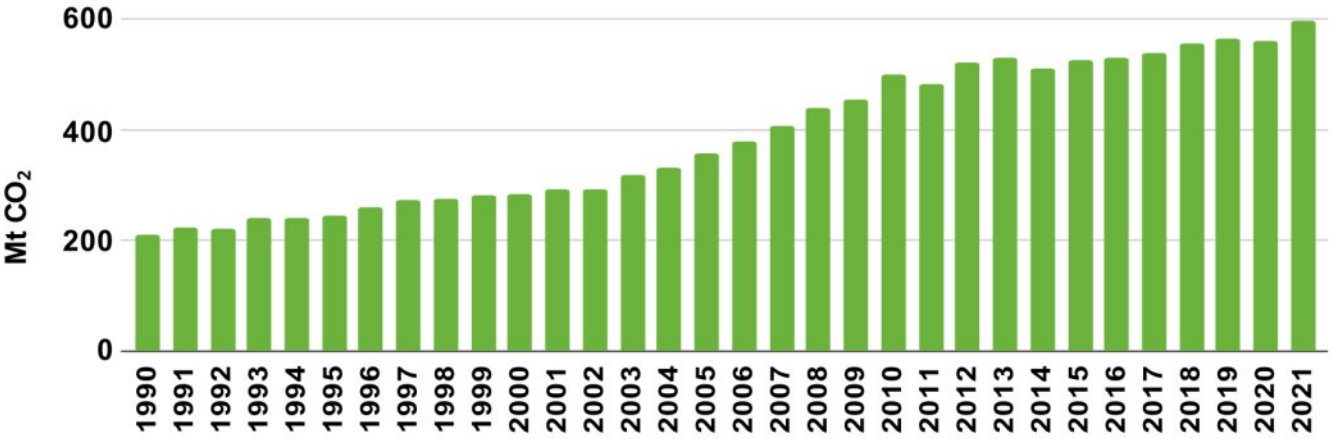


Figure 6: *CO_2 emissions from burning biomass in EU Member States between 1990 - 2021 according to EU's National Inventory Report 2023.*[42]

6.2 Policies encourage biomass energy

Countries worldwide have invested in new biomass energy facilities aiming to reduce their GHG emissions. The direction was set by the European Union as early as 2001, with the first directive promoting the development of renewable energy sources, which defined biomass as such a source.[43]

The policy of promoting biomass as a renewable energy source, which continued over the next two decades, led to the expansion of the bioenergy sector and a doubling of the amount of wood burned in the EU Member States.[44] Other countries have followed the Union's example. The Renewable Energy Portfolio Standard introduced in South Korea in 2012 has led to a 9-fold growth of biomass power generation, and the use of imported and domestically sourced wood pellets increasing in 10 years by factors of 28 and 15, respectively.[45] Feed-in tariffs introduced in Japan that year resulted in a tripling of the electricity generated from biomass burning and contributed to a spike in the amount of pellets imported into the country.

Having set its targets, the European Union aims to lead the world in achieving the Global Renewable Energy Target. At COP 28 in Dubai, at the initiative of the President of the European Commission, a Global Renewables and Energy Efficiency Pledge was launched. 118 countries which supported the pledge, committed *"to work together to triple the world's installed renewable energy generation capacity to at least 11,000 GW by 2030."*[46] In itself, setting such a target is desirable. Still, every effort should be made to ensure its fulfilment is not accomplished by drastically increasing energy production from woody biomass. Meanwhile, scenarios for reaching net zero in 2050, outlined recently by the IEA and FAO, assume a tripling of electricity and heat production from solid biomass in modern bioenergy facilities over the next three decades[47] (see section 4).

Abatement and the problem with biomass co-firing in Indonesia

Biomass co-firing is the practice of burning coal and biomass together to produce electricity. This concept has been gaining popularity among policymakers, as it is seen as a way to reduce carbon emissions (due to a carbon accounting loophole - see section 6.1) and help the world transition away from fossil fuels.[48] This is appealing to coal-dependent countries trying to meet their promised carbon emission reduction targets. However, while it may look good on paper, this policy of coal *abatement* serves simply to act like a lifeline for coal, ensuring its continued use and extending the life of dirty coal-fired power plants for years to come. In fact, a potential step forward in doing away with coal-fired energy completely was stopped in its tracks in 2021 at COP26, when a commitment was made only to *"phase down unabated coal power."* Something which was repeated in the first global stocktake in Dubai in 2023. This has, in effect, further incentivised co-firing with biomass, as the concept of abatement has been opportunistically hijacked to include it.

An example of this can be found in Indonesia, where the government now plans to implement co-firing at the sites of 52 coal plants (comprising 107 generators) across the country by 2025, in order to meet its Nationally Determined Contributions in the Paris Agreement.[49] It is estimated that doing this will require a supply of around 10 million tonnes of wood pellets a year, which is equivalent to an area the size of 3.27 million football fields.[50] This demand for biomass could drive deforestation rates as high as 2.1 million hectares a year, with potential for total loss of up to 10 million hectares of forest, and bring Indonesia's forests to an "irreversible point" by 2040.[51] Emissions from deforestation of up to 108.2 Mt CO_2 are estimated.[52]

An area of forest logged for biomass in Gorontalo, Indonesia. ***Forest Watch Indonesia***

6.3 Subsidies accelerate uptake and associated harm

> As governments subsidise renewable energy to accelerate its uptake and a transition away from fossil fuels, the flawed fix of industrial scale biomass energy has benefited because it is identified as renewable, despite its demonstrated negative consequences for the climate and biodiversity. Developed countries in particular heavily incentivise the use of biomass, sometimes on greater levels than genuine renewables such as wind and solar.

Policy incentives for biomass are estimated to be 15 billion EUR in the EU27, 1 billion GBP in the UK, and 400 million USD equivalent in South Korea every year.[53] The proposed bioenergy with carbon capture and storage (BECCS) project in the UK is seeking even greater, 1.7 billion GBP/year, subsidies.[54] The boom in building biomass power plants in Japan has been primarily driven by the feed-in tariff, which at its peak in the period 2016-2019, was the highest incentive for wood biomass in the world, at ¥24 (roughly US$0.20) per kilowatt-hour.

The Global Biodiversity Framework adopted by the Convention on Biological Development and progress with the Paris Agreement call for enhanced coherence to reach climate and biodiversity targets. An important aspect is the imperative to phase out harmful subsidies. Support for biomass is a textbook case of subsidies harmful to biodiversity, justified only by abusing the carbon accounting loophole, and should be subject to a substantial phase-out starting 2025 per GBF Target 18. The Paris Agreement also contains a provision (2.1(c)) for making finance flows consistent with a pathway towards low greenhouse gas emissions, so subsidies for biomass energy should also be eliminated on this basis.

Demonstration against UK government subsidies for biomass energy. ***Biofuelwatch***

South Korea's outsized support for biomass power[55]

The expansion of biomass power in South Korea is mainly driven by the Renewable Portfolio Standard (RPS). Under this scheme, indirect subsidies, known as the Renewable Energy Certificate (REC) weightings (i.e., multipliers), support the adoption of renewable energy sources, including biomass. Electricity producers can trade these certificates in the market, at the prices determined by the supply and demand dynamics. However, REC revenues can vary significantly as the weightings are contingent on the energy source and the type of facility. This variability makes REC weightings the most direct and critical means through which the government manages the profitability of renewable energy.

The baseline renewable on which REC weightings are centred is mid-scale solar photovoltaic, which is given a standard weighting of 1.0. Weightings are multipliers, so a higher rating designates a greater subsidy. Currently, woody biomass receives weightings up to 2.0. In particular, the highest are given to burning 'forest residues' in biomass-only power plants (2.0) and co-firing with coal in coal power plants (1.5). Regular (roundwood) biomass can also receive a weighting of up to 1.5 when burnt in biomass-only plants, and up to that of 1.0 when co-fired with coal. All these subsidies are on par with or higher than solar (0.5–1.6) and wind (1.2–2.5) (Fig. 4).[56]

A CHP plant in South Korea. Wikimedia Commons

Such high weightings were made possible ironically because woody biomass stands as one of the most expensive sources of electricity, and RECs are designed to compensate for the high costs. While the global average generation cost for solar has plummeted to 11% of what it was a decade ago, the cost for biomass remained at 75%.[57] The Korea Energy Economic Institute's analyses for previous REC weighting revisions, show that biomass is indeed more costly than solar and onshore wind in the Korean context as well.[58] This high cost is primarily due to the cost of wood for fuel, a valuable and limited resource whose price is only expected to rise.

At the same time, the South Korean authorities determined the weightings based on a blind assumption that burning biomass generates zero emissions, effectively nullifying the environmental impact section of the decision criteria, which already received only 11% of the overall consideration. Leaning into the industry's claim that logging for biomass is part of 'sustainable forest management', the government also overlooked the fact that 83% of wood pellets are sourced from around the world, including the natural and biodiverse forests of Southeast Asia and Canada. In particular, imports of internationally sanctioned Russian wood pellets have surged by eight-fold since the invasion of Ukraine. Even 'forest residues' produced in South Korea are harvested through clear-cutting 87% of the time, and industrial grade roundwood takes up 46% of all domestic forest biomass.[59]

Nonetheless, the high REC weightings for biomass have resulted in a 42-fold increase of biomass energy since the introduction of the RPS in 2012. This makes biomass the second-largest renewable electricity source in South Korea, surpassing wind by three times. It is estimated that since 2015, the country's biomass power has received 3.7 billion USD worth of RECs. In other words, burning a tonne of wood received 79 USD in subsidies, and emitting a tonne of CO_2 was subsidised with 59 USD. This paradox resulted in burning 50 million tonnes of wood and the cumulative emissions of over 70 $MtCO_2$.[60]

This decision-making in South Korea reaffirms the elephant in the room, that it is imperative for the IPCC and UNFCCC to close the accounting loophole and address how the carbon payback period falls outside the timeline of the Paris Agreement's 1.5°C temperature goal. In the meantime, the government subsidies for biomass continue to enable the climate, biodiversity, and humanitarian crises.

Logs arriving at an Enviva pellet mill, southeastern USA. ***Dogwood Alliance***

Enviva's bankruptcy - questions over viability of the industry

Despite the fact that the biomass industry is heavily subsidised, the economic viability of biomass energy has proven itself to be unpredictable, as evidenced by the case of Enviva, the world's largest producer of wood pellets. In 2023, it missed deadlines for delivery of wood pellets to Europe and Japan, cancelled dividends to shareholders, and suffered a sharp stock-price decline. In March 2024 it sought the protection of US bankruptcy courts and began restructuring.[61]

While the business press focused on a couple of bad bets on price movements for raw materials and finished pellets, there are a range of structural weaknesses emerging in both the pellet production and biomass energy sectors that contributed to Enviva's sudden, precipitous demise.

Firstly, a decreasing ability to compete with wind and solar and a failure to innovate. The unit cost of wind power has declined steadily for over a decade, whilst the declining cost of solar power is even more dramatic. Biomass has no such downward trend and, further, it shows no innovation potential in basic production processes. Attempts to pursue pyrolysis, 'black pellets' and 'bio-coal' have been in vain. Additionally, biomass' baseload power advantage is eroding as storage gets cheaper. The trend toward lower-cost storage is likely to further accelerate in this decade.

Then there are the feedstock issues. Enviva claimed to be mostly burning materials that would otherwise be left to rot in the forest, be burned in piles at landings (where the logs are collected for transport from a logging area), or waste from sawmills - however it also remained reliant on whole trees. Competing in the market for whole trees against other buyers of solid wood was part of Enviva's 'bad bet'. (This was in itself a dilemma, because its marketing materials claimed it did not rely on whole trees.) Meanwhile, pellets made from less-dense 'after-market' materials don't make very good pellets. Pellets are evaluated primarily on their heat value which is a function of density, and high-density pellets cannot profitably be made using low-density feedstocks. Utilising these different wood streams (sawdust, shavings, slash, whole trees) also creates significant operational challenges for grinding machines, sorters, dryers, etc.

The issue of air pollution and Compliance Costs are impacting the entire wood pellet industry, with the notable biomass corporation, Drax, paying multi-million-dollar fines in two southern US states. The Southern Environmental Law Center has compiled a list of over 50 state agency enforcement actions from large-scale industrial pellet mills there. The release of hazardous pollutants hasn't been small deviations from permitted levels, but in some cases orders of magnitude difference between what's modelled and what's measured. Possibly all major wood pellet mills in the United States will have to be retrofitted to meet air quality standards associated with the emission of hazardous pollutants - a costly undertaking. Continued viability of these mills is threatened by their poor track record of emissions of toxins (acrolein and methanol) and particulate matter (PM2.5).

Increasing awareness of the energy intensive processes within the woody biomass pellet supply chain, their embedded emissions, and how this is at odds with the 'low-carbon' claims of this industry are coming to light. Research on supply chain emission profiling, created a detailed picture of biomass power's GHG emissions profile (separate to the emissions of combustion of biomass at the smokestack).[62] They showed significant 'embedded emissions' in the pellet production supply chain - from logging, transport to the mill, processing, and transport from the mill to the site of combustion. The largest emissions component associated with production is feedstock drying. Transport and logging are also significant, so that in total these 'embedded emissions' (a permanent, ineradicable feature of the wood pellet production process) are roughly 400 kg/MWh. That's a permanent competitive disadvantage with wind, solar, and geothermal from a 'clean energy' perspective.

7. Negative impacts of biomass energy industry expansion

> Burning woody biomass for large-scale energy plants is associated with a number of negative climatic, environmental and social impacts. The development of biomass energy is, in theory, motivated by the need to protect the climate. However, energy from burning woody biomass produces greenhouse gas emissions comparable to those of fossil fuels, per unit of energy generated.

Trees regrow too slowly for the carbon dioxide emitted to be sequestered again within the time frame needed to tackle climate change. Increased demand for wood due to the expansion of the bioenergy sector is contributing to an increase in timber harvesting and intensification of forest management, which translates into negative impacts on biodiversity and forest health. Intensification of forest management can result in, among other things, a reduction in dead wood stock and the resulting threat to saproxylic species, a depletion of soil nutrients, a reduction in soil organic carbon stocks, and a decrease in ecosystem productivity. What's more, the pressure for wood extraction contributes to the conversion of natural ecosystems, including forests, into monoculture tree plantations and related grabbing of Indigenous Peoples' and local communities' land. Burning biomass also has a negative impact on air quality, contributing to emissions of many harmful pollutants with consequences for human health.

Chipping whole trees in a Natura2000 site, Switzerland. ***health-and-forest.org***

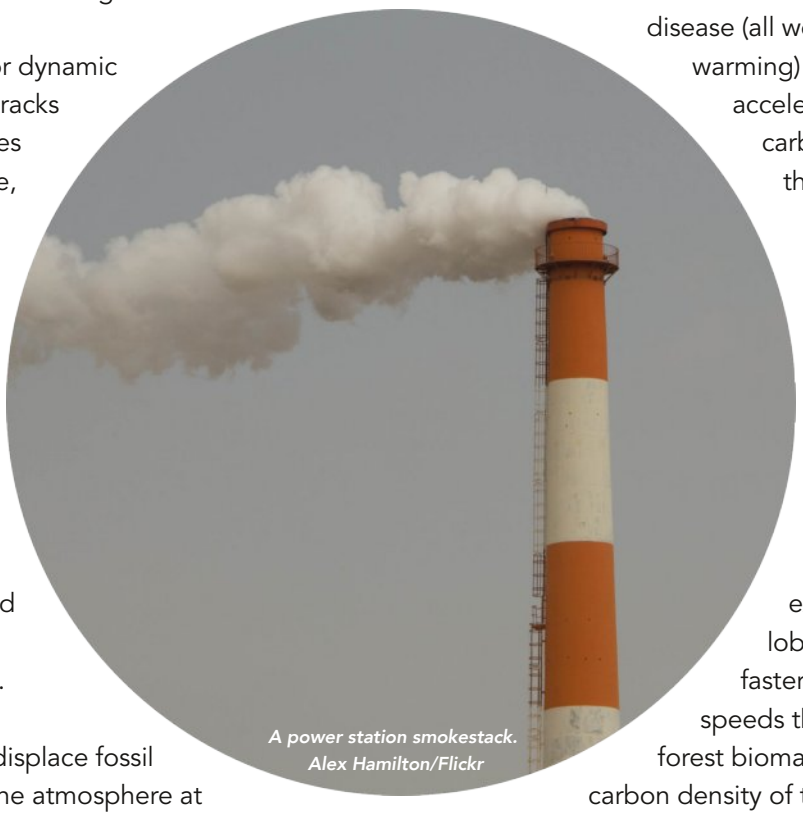
7.1 Climate

7.1.1 Debunking the carbon neutrality claims of burning biomass

Global expansion of the biomass energy industry is booming under a presumption that it will help cut greenhouse gas emissions. When Europe declared biomass energy to be carbon neutral it led to a surge in wood use. But is biomass energy actually carbon neutral?

A molecule of CO_2 emitted today has the same impact on the atmosphere whether it comes from coal or biomass. The net primary productivity of the land from which the biomass came, that is, its subsequent growth and sequestration of carbon after logging, is the only thing that could possibly achieve the claimed benefit in tackling climate change.

An important model for dynamic life cycle analysis that tracks carbon stocks and fluxes among the atmosphere, biomass and soils and is extensible to multiple land types and regions, has been developed by Sterman *et al*[63] and used to simulate substitution of wood for coal for power generation, yielding important findings cited below that debunk the carbon neutrality myth.



A power station smokestack. Alex Hamilton/Flickr

1. Biomass burned to displace fossil fuels injects CO_2 into the atmosphere at the point of combustion and during harvesting, processing and transport. Reductions in atmospheric CO_2 can only come later, and only if the logged land is allowed to regrow.

2. The combustion and processing efficiencies of wood in electricity generation are lower than for coal, so that the immediate impact of displacing coal with wood is an increase in atmospheric CO_2 relative to continued coal use. A carbon debt has been created.

3. Whilst the forest is regrowing and moving towards recovering the carbon debt, carbon in the atmosphere is higher than it would have been without the use of biomass energy, adding to climate change. Potentially irreversible impacts may arise before any long-term benefits are realised.

4. Burning biomass can only be beneficial in the long run if the logged area is allowed to regrow to the full extent of its pre-logged biomass and maintained there. It is important to understand that natural forests have a high carbon density compared to pasture, cropland, developed land and managed tree plantations. The carbon debt may never be repaid if development, unplanned logging, erosion or increases in extreme temperatures, fire, disease (all worsened by global warming) limit regrowth or accelerate the flux of carbon from the soils to the atmosphere.

5. Logging existing forests and replacing them with fast growing species in managed plantations can worsen the climate impact. In the US, for example, although loblolly pine grows faster than hardwood and speeds the initial recovery of forest biomass, the equilibrium carbon density of the resulting managed plantations is lower than that of the unmanaged hardwood forest. So, carbon sequestered in plantations never offsets the carbon taken from the original forest. This is true even if the plantation is never logged, and worse if the plantation is periodically harvested.

6. Growth in the amount of wood harvested for biomass energy causes a steady increase in atmospheric CO_2 because the initial carbon debt incurred each year exceeds what is repaid. In the US example , growth in the wood pellet industry to displace coal exacerbates global warming at least

Woodchip at a biomass power station in the USA. ***CANFR/Flickr***

through to the end of this century, even if the industry stops growing by 2050.

7. Using woody biomass in electricity generation worsens climate change for decades or even more, even when a suite of favourable assumptions towards wood are used. Relaxing any of those assumptions worsens the climate impact.

In conclusion, the first impact of burning biomass for energy is an increase in CO_2, worsening global warming over the critical period to 2100, even if the wood offsets coal, the most carbon intensive fossil fuel. This is well beyond time frames set by the Paris Agreement for action by 2030 and 2050.

Declaring biomass energy to be carbon neutral wrongly assumes that forests regrow quickly and fully offset the emissions from biomass production and consumption. The neutrality assumption is not valid because it ignores the decades to centuries long increase in CO_2 caused by burning biomass, and that the burning continues year on year.

A spurious claim that forests growing somewhere else will make up for the emissions from burning biomass is also frequently made by proponents of biomass. This is not good science. Those forests were growing anyway, whether or not wood was logged and burned elsewhere. The IPCC was very clear about this when it stated:

"If bioenergy production is to generate a net reduction in emissions, it must do so by offsetting those emissions through increased net carbon uptake of biota and soils."[64]

There is no claim from industry, nor effort to quantify, any such additional uptake of carbon. They simply rely on a free ride contributed by an undefined forest, ignoring that every bit of carbon sequestration offered by such forests is already valuable in removing carbon from the atmosphere and increasing terrestrial carbon stocks. It is not sound policy to trade off valuable forest carbon storage and sequestration against wood-fired power. Furthermore, nobody is officially checking the assumption that the forests or plantations will grow back to what they were before. Observations from on the ground, are that they often are not.

7.1.2 BECCS an unproven technology

Bioenergy with Carbon Capture and Storage (BECCS) is finding its way into ever more countries' climate plans, and numerous offtake agreements for future "negative emissions" carbon offsets from BECCS project have been concluded. Support for BECCS took off after the IPCC started including BECCS in its mitigation pathways. As one scientific article points out, *"Surprisingly, even a scenario framed as 'sustainable'... relies strongly on BECCS and associated land demand of nearly 1 M km^2"* – i.e. 100 million hectares of land covered in dedicated plantations.[65]

In reality, however, it is unlikely that large amounts of CO_2 will be captured from burning biomass any time soon. The largest carbon capture project at any biomass plant to-date was a demonstration project by Toshiba in Japan that was stopped after less than four months in 2021.[66] The largest BECCS projects proposed so far are by Drax in the UK and RWE in the Netherlands. Neither company has carried out any substantial tests, nor are they planning any research and development work into a technology that has not been proven at scale with regards to biomass flue gases (which are very different from those of coal plants). Furthermore, after decades of attempts to capture CO_2 from coal plants, there are only two such schemes worldwide and both have faced major technical problems.[67]

The real threat arising from BECCS as far as forests and land conversions to plantations are concerned, is that companies will successfully use promises of future carbon capture to obtain investments and, above all, public subsidies that they could not otherwise get. This is especially true in the UK and Netherlands, where governments have ruled out new subsidies for large biomass plants, but are considering lifting that rule to allow BECCS to be developed. Similar promises of future carbon capture were used by the coal industry to win permits for new plants in the 2000s, successfully so in the Netherlands. Promises of BECCS thus threaten to become a means for winning more public support for business-as-usual biomass plants.

Clearcuts for biomass energy in British Columbia, Canada. ***Michelle Connolly for Conservation North***

Clearcut in BC, Canada, where wood was sourced from for pellet production. ***Michelle Connolly for Conservation North***

7.2 Environmental impacts

7.2.1 Biodiversity and the condition of forest ecosystems

Burning woody biomass in large-scale energy plants has several negative impacts on biodiversity and the condition of natural ecosystems, especially forests. As evidenced by the examples described in this paper, the expansion of the biomass industry is contributing to a significant increase in the demand for wood. The additional demand leads to intensified and increased logging, which can contribute to deforestation, forest degradation and the conversion of forests and other types of natural ecosystems into monoculture tree plantations.

Although characterised as comprising 'residues' or 'waste', biomass for energy frequently comprises a significant amount, or even the majority, of a harvest. Clearcutting regimes inevitably log vast quantities from a forest that are not suitable for sawn timber and the income stream derived from these lower value products, justifies use of this destructive method and often is a major income source from the operation.The advent of biomass energy has contributed to a shift towards such integrated logging operations and the associated damage to biodiversity and forest ecosystems.

Moreover, the term 'residues' is meaningful only from the perspective of usefulness to the wood processing industry. Meanwhile, woody biomass, which is considered a "residue" from the point of view of the possibility of processing it into economically viable wood products, is priceless from the point of view of biodiversity and the health of the forest ecosystem. For example, in the European Union, logging residues are defined as *"The wood left in the forest after forestry logging operations.*[iii] *These residues generally include woody debris from final felling (e.g. branches, leaves, stumps, roots, tops, bark), small trees from thinning and clearing operations and generally un-merchantable stem wood."*[68] A literature review carried out by the Joint Research Center at the European Commission has shown that the harvesting of almost every type of logging residue listed in this definition is associated with the risk of negative impacts on forest biodiversity. Extraction of logging residues reduces the forest's stock of dead wood. This can have negative impacts on a forest's saproxylic species' population and community composition, deplete nutrients, reduce soil organic

[iii] Many jurisdictions apply a much less restrictive definition, and such flexibility allows a large proportion of wood from logging operations to qualify as 'residues' or 'waste'.

carbon and may lead in some cases to reduced productivity of the ecosystem.[69]

An example that perfectly illustrates the negative environmental impacts of the biomass industry is Europe (primarily the EU and the UK), where the demand for wood fuels has been a key driver of increased timber harvesting[70] and woody biomass imports in recent years. At the same time, according to the European Environment Agency, forestry is the main pressure on, and threat to, EU-protected valuable Natura 2000 habitats, of which only a fifth have favourable conservation status.[72] There are many concrete examples of the negative impact of biomass energy on forests within Europe. Unsustainable demand for wood has contributed to, among other things, clear-cutting in Romania's old-growth forests and in Estonian and Latvian protected areas. However, the negative impact of European biomass energy on forests goes beyond the continent's borders. As mentioned earlier, European countries such as the UK, the Netherlands, and Denmark import large quantities of wood pellets from North America. The production of pellets exported to Europe has been associated with, among other things, clear-cutting in Canada's primary forests[73] and deforestation in the south-eastern United States (see box below).[74]

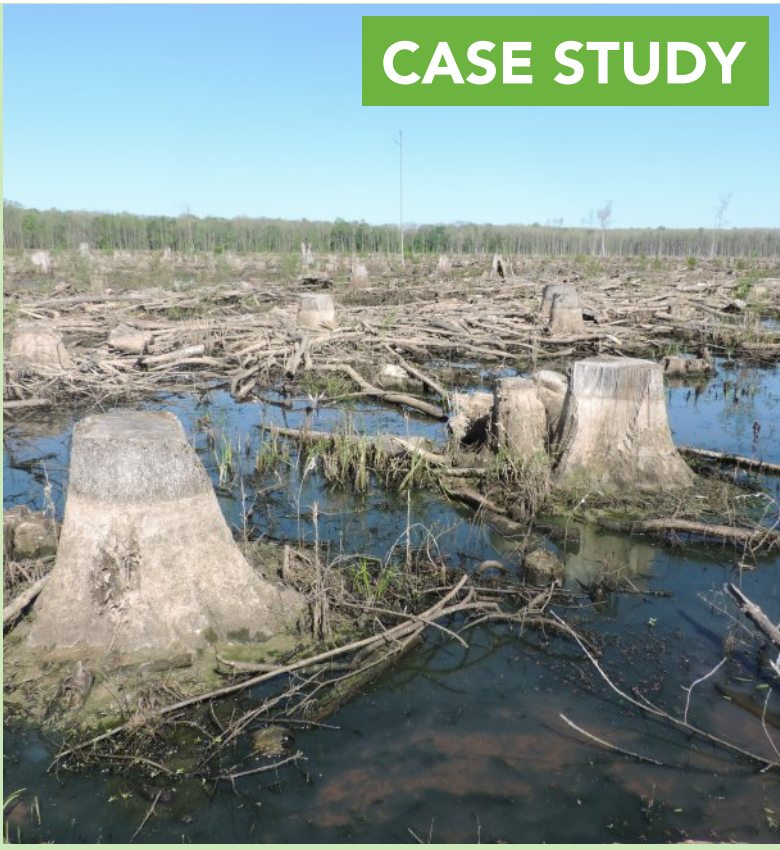
As in Europe, the surging demand for woody biomass in Asia is translating into deplorable consequences for forest ecosystems. Korean and Japanese power plants are meeting their growing demand for woody biomass by importing wood pellets from Vietnam, where they are produced from, amongst other things, wood harvested from natural forests[75] and acacia plantations established on land converted from natural forests. Indonesia has begun implementing a biomass co-firing programme, which it plans to roll out to its coal-fired power plants in 52 locations.[76] This has already resulted in reports of an imminent deforestation threat[77] and full implementation of the programme could result in the conversion of up to nearly 10 million hectares of Indonesian rainforest into energy plantations.[78]

Impacts on biodiversity in North American forests

CASE STUDY

The United States and Canada are in the top three biggest wood pellet producers in the world and the implications of this for their forests are huge. It has been estimated that the US alone has lost more than a million acres of forests to wood pellet production.[79]

In the Southern US, a study found that many existing, as well as proposed, pellet mills are located within the harvest range of unprotected, natural bottomland hardwood forests. This type of forest (also referred to as swamp forest) is found in floodplains along large rivers and lakes and is home to many unique species of flora and fauna. In North Carolina, 120,000 acres of bottomland hardwood forests have already been lost to logging and the threat is growing. The same study found that the potential sourcing area for nearly every proposed pellet mill included critical habitat for species on endangered lists.[80]



Clear cut wetland forests in North Carolina. ***Dogwood Alliance***

Across Canada, both boreal forests and inland temperate rainforests are currently threatened by pellet industry logging. British Columbia (where Drax owns seven pellet mills) supplies the vast majority of Canada's wood pellet export market. It is also a place well known for its old growth forests - home to woodland caribou, an endangered species, which rely on large areas of old and intact forests for their survival. The growth of the wood pellet industry is threatening these ancient and important forests as well as compromising the future survival of iconic animals like the caribou.[81]

Industrial pine plantation landscape near Ngodwana pulp mill, South Africa. ***GeaSphere***

7.2.2 The expansion of monoculture tree plantations in the Global South

Around the world, but particularly in the Global South, growing demand for biomass is leading to the expansion of large scale monoculture tree plantations. Tree plantations are a 'high impact' land use resembling commodity agriculture. Fast growing, often non-native species, are favoured in order to increase rotation rates and yields. However, replacing native ecosystems or displacing agricultural land with monoculture plantations comes at a high environmental and social cost.

In Africa, the establishment of tree plantations has led to the displacement of communities, loss of biodiversity, and severe soil erosion.[82] Local residents near to the Ngodwana biomass plant in Mpumalanga Province, have expressed concern over the high water use of eucalyptus plantations, which have replaced native, biodiverse grassland habitats in parts of South Africa.[83] Eucalyptus trees are extremely deep rooting and can penetrate to, and extract, groundwater up to 60 metres into the soil profile. In dry months, they place incredible strain on water resources and exacerbate drought conditions.

In Chile, where a monoculture timber plantation model has long been established by the pulp and paper industry, the territories that have the highest concentration of plantations also have the lowest Human Development Indices and the worst income distribution. In the Los Rios region of southern Chile, the transformation of vast areas into eucalyptus and pine plantations has resulted in the loss of livelihoods and food sovereignty of the Mapuche Indigenous People.[84] Similar impacts on a regional scale have led a coalition of Latin-American NGOs to declare that *"The forestry model for the production of bioenergy is an investment in the destruction of diversity and of what we are"* and to the creation of an International Day of Struggle Against Monoculture Tree Plantations.[85]

In Indonesia, "energy plantations" have emerged as yet another industrial pressure on fragile tropical forests. Bioenergy companies are clearing highly biodiverse forest areas and replacing them with monocultures of non-native gliricidia trees (*Gliricidia sepium*) for wood pellet production for both domestic and foreign consumption. Investigations have revealed that areas targeted for conversion include the forests of Kalimantan in Borneo, home to some of the highest plant diversity on earth.[86] Research predicts that the "energy plantations" that replace them, will be made up of just six tree species. The loss of these forests has implications not just for nature, but also for the estimated 50 - 70 million indigenous people who rely on them for survival.[87]

CASE STUDY

Eucalyptus plantation for charcoal production in northern Minas Gerais, Brazil. ***Federica Giunta***

Biomass-based charcoal for the iron and steel industry in Brazil

Brazil is the world's largest producer of charcoal and produced 5.2 million tons in 2017, 90% of which was used by the iron and steel industry, with 80% of the charcoal being produced from wood from plantations. The iron and steel sector is also the largest industrial source of carbon dioxide emissions in the country.

Approximately 70% of Brazil's iron and steel production occurs in the State of Minas Gerais, and the sector is unique because 34% of iron production uses charcoal instead of mineral coke/coal, and charcoal is widely used in steel production too. Historically this has been due to a lack of mineral coke in Brazil and an abundance of forests from which to produce charcoal.

Iron and steel companies have invested heavily in the establishment of plantations to secure charcoal production. Over the past decades, eucalyptus plantations have been responsible for dramatic deforestation rates of up to 200,000 hectares per year. In 2018, Brazil had 5.7 million hectares of eucalyptus plantations, and Minas Gerais continues to have the largest area of plantations in the country, accounting for 24% (1.4 million hectares) of Brazil's eucalyptus.

Demand for charcoal has contributed to the progressive destruction of the forests and savannas of the Cerrado biome, the world's most biodiverse savanna, and its replacement with extensive commercial monoculture tree plantations.[88]

7.3 Human impacts

7.3.1 Land grabbing in the Global South

As demand for biomass increases, so too, does the area of land required to supply it. In the Global South, communities face land grabbing and forcible eviction from their traditional lands, in order to turn them into commercial tree plantations for the biomass industry. Even simple speculation over increased demand for biomass has led to large land-acquisitions in the Global South, in some cases causing serious conflicts with local communities.[89]

In Brazil, land grabbing by forest industries for commercial tree plantations has forced thousands of peasant farmers out of areas regarded as common land, where cattle were grazed and other wild products could be gathered. The change in land use has led to a loss of cultural and economic diversity due to impacts on biodiversity, such as a decrease in the availability of medicinal plants used by communities. The loss of livelihood for farming communities has resulted in large reductions in rural populations and emigration to urban areas.[90]

In Ghana, the acquisition of 42,000 hectares of land in the Bono East Region by Norwegian company APSD to plant eucalyptus, has directly impacted community rights. Local people have described how they are now forced to walk huge distances around the plantation area, where previously they had right of way, putting women at particular risk as they gather firewood for cooking. The plantation itself is guarded by private security who come into local villages to check that no one has been hunting animals in the plantation for food. Locals have reported incidents of physical abuse, invasion of privacy and harassment at the hands of the company.[91]

7.3.2 Health impacts of combustion and pellet production

Burning wood in energy plants releases a range of pollutants into the air, at levels comparable to burning coal in energy plants. The main pollutants released are oxides of nitrogen (NO_x), carbon monoxide (CO), small particulate matter (PM10 and PM2.5), sulphur dioxide (SO_2) and carbon dioxide. However there are many others and the full list depends on the type of wood burned (whether virgin or waste wood) and how it has been treated.[92]

The impacts of these pollutants on human health are well documented. Multiple investigations have found that exposure to air pollution from burning solid biomass causes cancer and cardiac and respiratory diseases. A study[93] conducted in 2018 found evidence that tens of thousands of EU citizens are dying prematurely every year as a result of exposure to air pollution from burning solid biomass and in 2022, the WHO Regional Office for Europe commented that:

"Air pollution can affect human health directly through exposure to pollutants such as particulate matter (PM), but it also has a climate impact, as some air pollutants are also short-lived climate pollutants. Combustion of fossil fuels and biomass to generate energy is the greatest contributor to air pollution and the source of emissions of greenhouse gases. Reduction or phase-out of fossil and biomass fuel combustion will reduce emissions of both greenhouse gases and health-relevant air pollutants. This will improve air quality for better health and enhance climate change mitigation efforts, which will further protect health in the long term."[94]

The people most at risk are those living within close proximity to power plants, especially vulnerable groups, including babies, children, elderly people and people with underlying health problems such as asthma or heart disease. Research in the UK has documented how proposed and existing biomass power plants are predominantly built in areas with high levels of social deprivation, places where pre-existing health issues are already above national averages (see more on this in the Environmental Justice section 7.3.3).[95]

Workers are impacted too. A 2018 scoping review in the National Review of Medicine found that, in terms of health impacts, energy generation with biomass is comparable with the fossil fuel industry and has more negative implications for workers than the wind and solar sector.[96]

Trailer park community Blackmon Hole in Gloster, Mississippi, sits just feet away from Drax's Amite Bioenergy pellet plant. The People's Justice Council

Pellet mills (which process wood destined for power plants) also harm human health. They emit a similar range of health harming pollutants as biomass power plants, at every stage of the supply chain.[97] In 2023, a pellet mill in the USA received a notice of violation from The Mississippi Department of Environmental Quality, accusing it of being a major source of hazardous air pollutants.[98] And that was not the first time - In 2021 the same pellet mill, owned by Drax inc, was fined $2.5m for breaching air pollution rules.[99] Its pellet mills in Canada have violated environmental law 189 times and in several cases inspectors found they were emitting more than double the legal PM limits.[100] Unfortunately, the fines it has received pale in significance to the amount of money Drax gets from the UK government in the form of subsidies to burn biomass, so they have done little to curb the industry. Meanwhile, people living in the communities located next to these facilities are relying on oxygen tanks to survive.[101]

7.3.3 Environmental justice - disproportionate impacts on disadvantaged communities

Environmental justice communities are typically defined as neighbourhoods that are subjected to a disproportionate burden of environmental hazards and experience a significantly reduced quality of life relative to surrounding or comparative communities. These communities are often already disadvantaged, due to systemic oppression.

An example of this is the Southeast U.S, a climate vulnerable region which is home to the highest percentage of persons of colour and the lowest income population in the U.S. This is where the overwhelming majority of wood pellet industries are choosing to locate their facilities.[102]

To give historical context to the systemic racism inherent in this - the southeastern U.S. is made up of most of the former slave states that supplied cotton during the UK's Industrial Revolution. Map comparisons of the former cotton trade states with the current wood pellets trade states, which also supply the UK, are almost identical.

The industry takes advantage of the high rates of poverty and the desperate need for jobs. They come into poor communities with unfulfilled promises of economic prosperity. Ultimately, these communities never achieve the jobs nor economic boost that they were promised. Instead, exposure to dangerous levels of emissions have led to declining environmental health issues and left them far worse than before.[103]

Resident of Gloster, Mississippi, stands in front of a Drax pellet mill, which began operations next to her community in 2014. ***Andy Sarjahani/Unearthed***

A logging truck near the Ngodwana pulp mill and biomass plant inSouth Africa. ***GeaSphere***

8. Conclusion

Since 2000, there has been a massive expansion of the biomass energy sector on a global scale. A wealth of evidence (some of which has been presented here) documents that this rise in woody biomass production and consumption results in a significant escalation in pressure to increase the amount of wood logged for energy, with devastating consequences for the climate, for nature, and for people. A further tripling of the supply of woody biomass for energy, assumed to occur between 2021 and 2030 according to the IEA's Net Zero Scenario, cannot be allowed to go ahead.

Members of the Biomass Action Network share a vision of a world in which thriving natural forests play a significant role in tackling climate change and contribute to a clean, healthy, just and sustainable future for all life on earth. Burning woody biomass for large-scale energy production cannot be part of that future for all of the reasons outlined in this report. Instead we must protect and restore natural forests, thereby reducing emissions and removing atmospheric carbon dioxide while supporting biodiversity, resilience and well-being.

Add your voice to the call and become a member of the Biomass Action Network: https://environmentalpaper.org/biomass/the-biomass-delusion/

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