Griffith UNIVERSITY
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Climate Action Beacon

# BURNING FOREST BIOMASS FOR ENERGY

## Not a source of clean energy and harmful to forest ecosystem integrity

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## KEY MESSAGES

- A major shift to using forest biomass burning for energy comes with grave risks of highly perverse outcomes, including increased $CO_2$ emissions and negative impacts on forest ecosystem integrity.
- Forest biomass is not clean energy because burning it releases $CO_2$ emissions and so does not contribute to a decarbonization pathway.
- The emissions from burning biomass are instantaneous, but their removals from the atmosphere are not and take a long time. This means there is a significant time lag between when carbon is emitted and when it is removed and stored.
- The accounting and reporting of net emissions from LULUCF Forest Land provides a false view that the forest industry is "carbon negative" and do not make transparent the gross emissions from logging.
- There is no reason to assume a power facility using biomass as a feedstock would displace coal generation elsewhere. It is more likely that total energy generation will simply continue to rise and/or displace clean energy sources.
- From an ecological perspective, there is no such thing as "residue" biomass in a forest ecosystem. Many studies show the negative impacts of intensification of logging on biodiversity including loss of habitat resources for threatened species such as the Southern Greater Glider and Koala.
- A rethink of the role of forest biomass burning for energy in national decarbonization policy is required. We argue that a global ban on using forest biomass for industrial scale bioenergy is urgently needed given its negative effects on climate mitigation and forest ecosystem integrity.

## INTRODUCTION

The climate crisis is driven mainly by the extensive use of fossil fuels but also by the emissions from widespread deforestation and degradation, plus other factors including cement production (Mackey and Lindenmayer 2014, Masson-Delmotte et al. 2021). In response, a rapid transition toward renewable energy is underway to decarbonize economies globally (IEA 2021). Some commentators have proposed that a necessary component of this transition is to burn forest biomass for energy production, including pushing for the use of energy from forest biomass burning in the generation of hydrogen through hydrolysis, claiming this as "green hydrogen" (IRENA 2020).

While the Land Use Land Use Change and Forestry (LULUCF) sector has been functioning as a net sink, there has been a significant increase in the intensification of logging in many regions (Ceccherini et al. 2020, Angelstam et al. 2021). Studies have projected a reduction in the amount of carbon stored in this sector by 2030 due to projected future increased harvest rates caused in part by greater demand for bioenergy, as well as age-class shifts in EU forests and climate change (Körner et al. 2007, Nabuurs et al. 2013, Böttcher and Graichen 2015, Jiang et al. 2020). Conversely, there can be a major turnaround in carbon accounts when there are changes in the LULUCF sector such as occurred in the Australian State of Tasmania when there was a marked reduction in wood production from natural forests (Mackey et al. 2022).

Here we argue that a major shift to using forest biomass burning for energy comes with grave risks of highly perverse outcomes, including increased $CO_2$ emissions and negative impacts on forest ecosystem integrity. A rethink of the role of forest biomass burning for energy in national decarbonization policy is therefore urgently needed. Our focus here is on naturally regenerating forests and not plantations (*sensu* (FAO 2018)).

There is growing body of scientific evidence that burning forest biomass for energy will greatly increase the amount of carbon in the atmosphere for decades and have harmful impacts on forest ecosystem integrity (Holtsmark 2013, Ter-Mikaelian et al. 2015, Searchinger et al. 2018) countering claims that forest biomass energy provides positive mitigation benefits (Favero et al. 2020, IRENA 2020).

International and national policies and programs for decarbonization and forest management should be informed by a scientific understanding of the key factors determining the emissivity of burning forest biomass for energy, the role of forest ecosystems in the carbon cycle, and the climate mitigation benefits of forest protection. We first review current and projected use of and demand for forest biomass energy and then consider five critical issues which challenge commonly held views regarding the benefits of burning forest biomass for energy. Studies which conclude that logging forests for fuel results in climate benefits tend to make highly specialized assumptions that may not be met in actuality. We then examine the impacts on, and risks to, forest ecosystem integrity and some of the consequences for the conservation of forest-dependent biodiversity. We argue that a global ban on using forest biomass for industrial scale bioenergy is urgently needed given its negative effects on climate mitigation and forest ecosystem integrity.

## CURRENT AND PROJECTED USE AND DEMAND

While emissions from deforestation and degradation have long been considered a problem for developing nations with ongoing land use change, emissions due to forest management is an increasingly critical mitigation issue for developed countries, including those in the European Union (EU28), USA, Canada, Russia and Australia. In addition to the conventional and long-established uses of forest biomass (such as for timber and pulpwood production), we are now witnessing – as discussed below - a significant increase in its use for energy production. In addition to harvesting from a country's own natural forests, there is an accelerating international trade in biomass as feedstock for energy production.

The situation in the European Union (EU) is of particular importance given the proportion of wood-based biomass used for energy (in 2016, about 6% of gross final energy consumption in the EU (Camia et al. 2021). In response to incentives provided under the European Union's Renewable Energy Directive, the use of solid biomass in the EU more than doubled between 1990 to 2020, with the largest contribution coming from wood (Booth 2022). The overall EU target for Renewable Energy Sources consumption by 2030 was raised to 32% in 2018 (E.U. 2018) and the EU is currently considering raising it to 40%; a decision that will be finalized at the end of 2022 (E.U. 2022). About half the wood harvested in the EU is currently burned for energy (Camia et al. 2021). Biomass for energy (bioenergy) continues to be the main source of renewable energy in the EU, with a share of almost 60% and the heating and cooling sector being the largest end-user, using about 75% of all bioenergy (EC 2021). While characterizing the amounts and types of wood burned for energy is challenging, current use of wood for energy in the EU is likely upwards of 400 million tonnes per year (JRC, 2021). An increasing amount of wood is converted to wood pellets used for both residential heating and heat and electricity generation in powerplants. In addition to its use for bioenergy and electricity production, biomass can also be used as feedstock for the chemical industry (Goldstein 1979).

The impact from the use of wood-based biomass for energy is not limited to the EU. Global wood pellet markets grew from 19.5 million tonnes in 2012 to 35.4 million tonnes in 2018, an average annual growth rate of 12%. In 2019, the aggregated size of the global wood pellet markets was estimated to be USD8.9 billion and is expected to reach USD18.2 billion by 2027. Major wood pellet producing countries include Canada, where British Columbia produced 2.52 million tonnes of wood pellets in 2019, accounting for 56% of Canada's total production, of which 99% was exported, predominantly to the United Kingdom (71%), Japan (14%), Belgium (7.4%), and Italy (3.1%) (Yun et al. 2022). The U.S. exported over 7.2 million tonnes of wood pellets to overseas markets in 2020, which was about three-times higher than the exports in 2012 (Parajuli 2021). Estimates have also been made of the potential to produce bioenergy from various high forest cover countries including: Russia 2,225.4 PJ per year with forest residues comprising 23% (Namsaraev et al. 2018); Australia 2,600 PJ per year, with the forestry sector accounting for 22% of total feedstock resource potential; and China with a projected trend peaking in 2030 with total forest biomass delivering 354.96 EJ (one EJ = 1 000 PJ) (Yan et al. 2020). However, these national estimates are likely not comparable to each other due to different methods including what kinds of biomass are included, and therefore should only be considered indicative.

## CRITICAL SCIENCE FOR CLEAN ENERGY POLICY

The production, trade and use of forest biomass for energy is now a major growth industry globally, adding to a larger volume of timber being harvested from increases in the area and/or intensity of logging (Riddle 2018, Hethcoat et al. 2020, Zhang et al. 2020, Shvetsov et al. 2021). This has significant consequences for the integrity of forest ecosystems (Beckmann et al. 2019, Munstermann et al. 2022). Increasing land use pressures come at the very time the natural resilience and adaptive capacity of forests is needed in the face of escalating human-influenced climate change impacts (Barber et al. 2020, Pörtner et al. 2021).

To date, however, policy on using forest biomass for energy has been based on misleading advice that forests constitute a renewable energy source that is carbon neutral (Kumar et al. 2021). Claims of carbon neutrality are based on the simplistic assumption that emissions from burning forest biomass will be removed by future tree growth. Despite repeated and well documented scientific critiques of this claim and its related assumptions (Searchinger et al. 2018, Norton et al. 2019), policies continue to be advanced that promote and enable burning forest biomass to be included in renewable energy schemes. The consequences of these policies for forest ecosystem integrity are dire given the documented ecological damage in areas where intensive forest management for commodity production is practiced (DellaSala et al. 2021, Lindenmayer et al. 2022).

In the following section we discuss five key, science-based reasons why using forest biomass should be not included in renewable energy policies.

### 1. Forest biomass is a carbon-based energy source

Approximately half the dry weight of trees is carbon, and burning woody biomass for energy therefore results in instantaneous $CO_2$ emissions. Whilst burning forest biomass constitutes renewable energy because trees regrow after being logged, it is not clean energy but "dirty" energy because of the emissions it produces. Burning green wood chips emits 50% more $CO_2$ per megawatt hour of energy produced than burning coal, although the exact emissions rates vary depending on chemistry of the fuels and the energy production efficiency of a given facility (Booth 2018). Woody biomass used for fuel from a natural forest contains moisture levels ranging from about 15% to 25% for seasoned air-dried logs to over 50% for freshly cut green timber (Bryś et al. 2016). At a moisture content of 45%, burning forest wood emits just over one tonne of $CO_2$ for every tonne of wood burned (Booth 2018).

## 2. The lag time between emissions and forest regrowth

The emissions from burning biomass are instantaneous, but their removals from the atmosphere are not. This means there is a significant time lag between when carbon is emitted and when it is removed and stored. From a common-sense perspective, this lag can be understood simply as the decades it would take after burning the biomass, for example, from a 40-year old tree, for a tree of the same age to regrow. However, cumulative emissions from a power plant are not just from that first year's harvest of 40-year-old trees, but the next year's and the year after that, etc. The inputs to the atmosphere accumulate faster than the removals from regrowth and this condition persists for decades to centuries. The critical factor here is the "cumulative net emissions", i.e., the additional $CO_2$ emitted and accumulated in the atmosphere by burning biomass over time compared to the alternative fate of trees being left to continuing growing and sequestering and storing carbon in a forest ecosystem, including the carbon incorporated in the soil organic matter (Keith et al. 2022). Burning forest biomass for energy is an ongoing activity over the life-time of the power plant with continued $CO_2$ emissions. Forest regrowth could eventually "catch up" and remove an equivalent amount of carbon to that which had been emitted up to a given point in time, but only long after the power plant ceased operations and the forest continued to grow.

## 3. GHG net accounting and reporting

Under the United Nations Framework Convention on Climate Change (UNFCCC), national governments submit annual reports of national greenhouse gas (GHG) inventories. These inventories recognize two primary sectors - fossil fuel and Land Use, Land Use Change and Forestry (LULUCF) - and within the later, various sub-sectors including Forest Land (Dong et al. 2019). Under the UNFCCC rules and protocols, governments can report on annual net emissions, i.e., the difference between emissions to the atmosphere – from fossil fuel use plus emissions and removals from agriculture and LULUCF. While LULUCF includes all forested lands, the emissions and removals are accounted for only from the part of the forest estate that is defined by a country as being "managed" – which typically means managed for wood production, i.e., for commercial logging. The removals from forest in protected areas such as national parks are therefore not typically accounted for (Mackey et al. 2022). For many high forest cover countries, annual net carbon reporting shows net emissions are negative (i.e., there have been more removals than emissions) from LULUCF Forest Land despite extensive commercial logging (Mackey et al. 2022). This is because in a given year, a relatively small fraction (typically <2%) (NFISC 2019) is logged of the total area of forest managed for wood production. The accounting and reporting of net emissions from LULUCF Forest Land provides a false view that the forest industry is "carbon negative" and do not make transparent the gross emissions from logging.

## 4. Biomass energy displaces other clean energy not fossil fuel

There is no reason to assume a power facility using biomass as a feedstock would displace coal generation in the absence of an enforceable commitment to reduce a proportional amount of coal generation elsewhere. It is more likely that total energy generation will simply continue to rise. While it is frequently claimed that bioenergy can be used in place of coal-fired generation, thereby resulting in a net mitigation benefit (Gustavsson et al. 2017), substitution arguments have been strongly criticized for: (i) underestimating carbon footprints, (ii) overestimating benefits, and (iii) that substitutions are effective only if an increase in wood product consumption implies verifiably a global reduction in non-wood production and energy (Leturcq 2020). Furthermore, policy and institutional arrangements play a major role in determining mitigation benefits. For example, in Australia, a renewable energy policy required a prescribed amount of electricity to be obtained from renewable energy sources each year through to 2030. The effect of this policy means that bioenergy generation would not normally increase the quantity of renewable energy or lower emissions because if a generator participates in a scheme, then it displaces other forms of renewable generation (Macintosh et al. 2015).

## 5. Forestry residue is not waste

Where the feedstock for bioenergy is logging residues (i.e., residue "waste" from conventional logging operations), burning of forest biomass for energy is claimed as a climate change mitigation strategy (Loeffler and Anderson 2014, Brander et al. 2021). However, this neglects the impact on the integrity of the forest ecosystem. This argument as a justification for burning forest biomass for energy is problematic on two accounts. First, from an ecological perspective, there is no such thing as "residue" biomass in a forest ecosystem as all biomass, living and dead, is pivotal to an ecosystem's carbon-nutrient-water stocks and flows (Schimel et al. 1997). There is increasing evidence that removing forestry residues significantly depletes soil and ecosystem carbon stocks (Hamburg et al. 2019). The so-called biomass residues would have a longer residence time if they remained in the forest and were not combusted for bioenergy (Hudiburg et al. 2019). If biomass remains in the forest to decompose, it would be incorporated into the soil carbon stock or slowly emit $CO_2$ over decades. Using this biomass for bioenergy therefore reduces inputs of carbon and nutrients to the soil and brings forward emissions in time (Booth 2018, Hudiburg et al. 2019). In addition, fallen timber on the forest floor often provides vital habitat for an array of elements of forest biodiversity (Lindenmayer et al. 2002).

Second, burning so-called forest residues increases demand for high volume, low value wood products as the result of the industry being controlled by market forces (Ajani 2007). In the case of the Australian woodchip industry, the market for pulp and paper drove harvesting intensity and was not sourced entirely from residues of sawlog harvesting. Creating an additional market can result in two effects: (a) supporting and prolonging an otherwise low profitability industry; and (b) supporting an increase in the wood harvesting industry and area of forest, intensity, or frequency of harvesting (Ajani 2007). These effects create a greater amount (area and biomass) of forest harvested, and hence, emissions to the atmosphere. Therefore, assessments of mitigation benefits of biomass burning should be based on both levels of bioenergy production and the increased amount of harvesting, compared with the current harvesting level.

## RISKS TO FOREST ECOSYSTEM INTEGRITY AND BIODIVERSITY CONSERVATION

There is clear evidence that a biomass energy industry results in an intensification of logging with increasing negative impacts on forest ecosystem integrity – referring here to the ability of ecosystems to maintain their biodiversity and associated key ecological processes, recover from disturbance, and adapt to new conditions (IPCC 2022). Creating markets for high volume, low value residues can result in a lot more biomass being removed from a given area of wood production forest than would otherwise have occurred. Generating high volume, low value wood products can distort markets and flows of particular forest products (Lindenmayer 2017). For example, in south-eastern Australia, in the 1960s, an export woodchip industry was established to take so-called residues (logs that were then wood chipped) from the forest with the stated aims of rejuvenating forest structure and converting poor quality stands of trees to extensive forests with high quality sawlogs (Routley and Routley 1975). However, a different outcome eventuated with hundreds of millions of tonnes of woodchips exported to Asia; at times in excess of 90% of wood harvested from the forest was diverted to the woodchip stream (Ajani 2007). This intensification of management did not regenerate a forest with extensive areas of high-quality sawlogs. Rather, it reinforced wood chipping operations with the end result that now there is a marked decline in the region's sawmilling industry, and just five small, marginally economic native forest sawmills now operate across the entire 1.75 million ha region (Frontier Economics and ANU 2021).

The intensification of logging operations combined extraction of sawlogs and residues, has led to a significant loss of stand structural complexity (*sensu* (Lindenmayer and Franklin 2002) with forests dominated by younger regrowth stands. In south-eastern Australia, this has resulted in major impacts on biodiversity, such as significantly altering forest tree composition with, for example, the loss of food tree resources for iconic species such as the iconic Southern Greater Glider (*Petauroides volans*) and Koala (*Phascolarctos cinereus*) (Au et al. 2019) which are now formally listed as endangered. Many studies show the negative impacts of intensification of logging for biodiversity (Felton et al. 2003, Betts et al. 2022) and for forest function (Bowd et al. 2021).

## CONCLUSION

While a push to eliminate the use of fossil fuels is critically important, what those fossil fuels are replaced with is equally important. If they are replaced by forest biomass for energy generation, there will be major perverse impacts in terms of both elevated anthropogenic carbon emissions and substantial negative impacts on forest ecosystem integrity and increased biodiversity loss. Using forest biomass, including so-called forestry residues, should not be included as an eligible renewable energy source in renewable energy policies including directives, regulations, targets and other instruments.

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