PLAYING WITH FIRE

An assessment of company plans to burn biomass in EU coal power stations

EMBER

COAL TO CLEAN ENERGY POLICY

Executive summary

Supported by EU legislation, biomass (mostly wood in the form of pellets or chips) is increasingly used as a fuel to generate electricity, including in a number of large former coal power plants.

This practice continues **despite scientific consensus that burning biomass instead of coal in power stations risks accelerating climate change**.

This report assesses the possible growth in biomass burning across Europe as a result of a fleet of planned coal-to-biomass power plant conversions. We map every project and estimate the scale of the threat to global forests.

Unsustainable

These expansion plans are being driven by some of Europe's major utilities, including RWE and Vattenfall. If European coal companies are allowed to complete these conversions, it would **double global demand for wood pellets**.

To fuel these planned biomass power plants, *every single year* suppliers would need to **cut down the equivalent of most of the forest in the Netherlands, or half of Germany's Black Forest**.

Expensive

These projects all require large public subsidy, and yet we find they would produce just 2% of the EU's electricity. In comparison, every year Europe adds an equivalent amount of new wind and solar capacity - much of it now effectively subsidy-free.

Even In the UK - which pioneered large coal-to-biomass conversions - the government now states that carbon savings from these projects are *"low or nonexistent"* and that the *"cost of any savings is high"* when compared to wind and solar.

But elsewhere in the EU, these lessons are being ignored. We highlight the **five countries (Finland, Germany, Ireland, Spain & the Netherlands)** which are responsible for most of the potential growth in biomass burning in coal power stations.

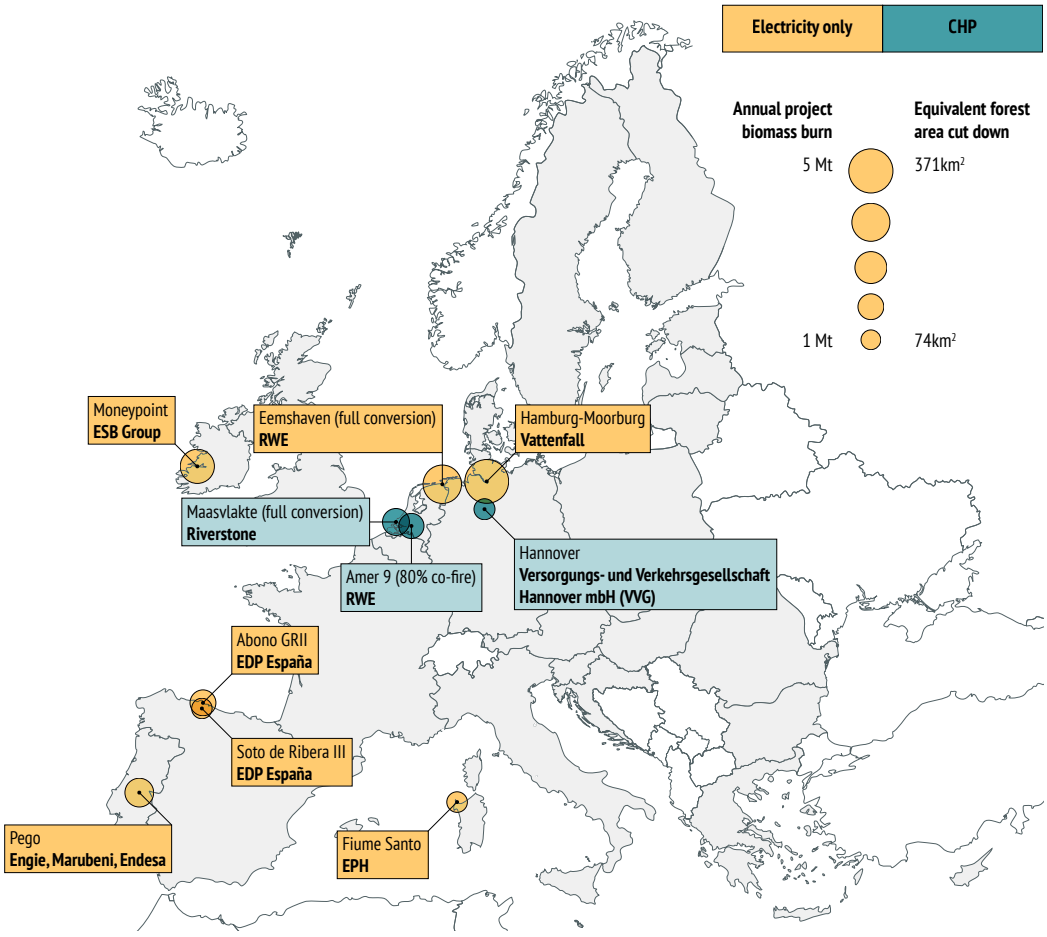
Key findings

- **Proposed EU coal-to-biomass projects could increase biomass consumption by 607 petajoules (PJ) p/a. This is equivalent to five new Drax[1] power stations.**
- As a result, biomass burnt in current and former coal power plants could triple vs. current levels.
- **36 million tonnes (MT) of wood pellets** would be needed, similar to current global wood pellet production.
- Approximately **2,700km²** of forest would need to be cut down every year to feed this demand - equivalent to most of the forest in the Netherlands or half of the Black Forest in Germany.
- These projects would produce just 64 TWh of electricity, less than 2% of the EU's electricity production. In comparison, every year Europe adds an equivalent amount of new wind and solar capacity.
- Burning biomass in the identified coal-to-biomass projects would emit ~ **67 MT** of CO2 per year - the same as half of the emissions from Poland's coal power stations. This CO2 is unlikely to be reabsorbed by biomass (e.g. forest) regrowth over timescales relevant to meeting commitments under the Paris Agreement.
- We identified 67 coal-to-biomass projects. Of which, just **10** projects account for over half of the total biomass that could be burnt in all 67 projects.

1. Drax Power station has used government subsidies to convert four of its coal-fired units to burn biomass in the United Kingdom.

FIGURE 1:

10 projects account for over half of the total biomass that could be burnt in all identified coal-to-biomass projects



Source: Sandbag research. Assumes 70% project load factor and a net calorific value of 17GJ/tonne for biomass. The calculations of the forest area cut down assume biomass is sourced from the forests of the U.S. south, please see the "Forest impact" chapter for more details.

More detail

- Coal-to-biomass projects in Finland, Germany, Ireland, Spain & the Netherlands account for most of the identified volume.
- The Netherlands alone accounts for a quarter.
- Just five coal operators (**RWE, EDP Espana, ESB Group, Riverstone & Vattenfall**) are responsible for over half of all potential growth in biomass consumption in coal power stations.

Key policy recommendations

1 **Governments should focus policy support on renewable energy sources which deliver near immediate carbon and cost savings vs. fossil fuels - such as wind and solar - rather than on biomass, which delivers questionable carbon savings, perhaps not realised for many decades (if at all), at a cost much higher than that of fossil fuels.**

2 The true effect of biomass burning on the climate must be understood. Governments must assess the net effects of switching from coal to biomass with an integrated approach: carbon flows along the complete life cycle (including combustion emissions) in the bioenergy scenario should be compared with carbon flows in the absence of increased harvesting for bioenergy (a reference or counterfactual scenario). Such analyses should include reduction in the carbon stock and foregone sequestration from biomass harvested.

3 As recommended by the European Academies' Science Advisory Council (EASAC), a coal-to-biomass project should not be regarded as a renewable energy source unless the operators can demonstrate that the project will lead to a net reduction in atmospheric carbon levels within a decade. Projects that fail to meet this threshold should be subject to a carbon price and not be eligible for any subsidies.

Published in December 2019 by Sandbag.

Data
A full version of the database and the data behind the charts in this document are available to download on our website at https://sandbag.org.uk/project/playing-with-fire/.

Disclaimer
Our research was completed on the 15th November 2019, subsequent project developments will not be accounted for in this document. Identified future coal-to-biomass projects are correct to the best of our available knowledge based on sources in the public domain. If coal operators identify projects in our database (released alongside this report) where there are no longer any plans to substitute coal for biomass or if the parameters of a proposed project have changed, we invite them to contact us and we will update the database.

Sandbag Contributors
Charles Moore - lead author, contact: charles@sandbag.org.uk
Małgorzata Kasprzak - data support & research.

Thanks
The author would like to thank Almuth Ernsting, Kenneth Ritcher, Keith Allott, Phil Macdonald & Dave Jones for their time providing feedback on earlier drafts of this report.

Image credits:
Front & rear cover - photo by Reto Gerber from Pixabay; p.7 - Oregon Department of Forestry via Flickr; p.14 - Pok Rie via Pexels; p.17 - Public Domain Pictures via Pexels; p.19 - Yaroslav Maltsev via Unsplash; p.27 - Josh Bean via Unsplash; p.30 - StockSnap via Pixabay;

Report design:
Wilf Lytton

Contents

Introduction

Under current EU law[2], biomass is classified as a source of renewable energy. As a result, energy production from biomass is both eligible for public subsidy and exempt from CO2 emissions charges under the EU Emissions Trading System (EU ETS)[3]. To meet renewable energy targets, many EU governments have therefore promoted the use of biomass as a substitute for fossil fuels in power and heating plants. These policy decisions are reflected in the consumption trends. See Fig. 2.

Definition: biomass

Biomass is a solid, organic, non-fossil material of biological origin (plants and animals) which may be used as fuel for heat production or electricity generation. The most typical example is wood, which is the largest biomass energy source. Biomass used for non-energy purposes is excluded from the scope of this report

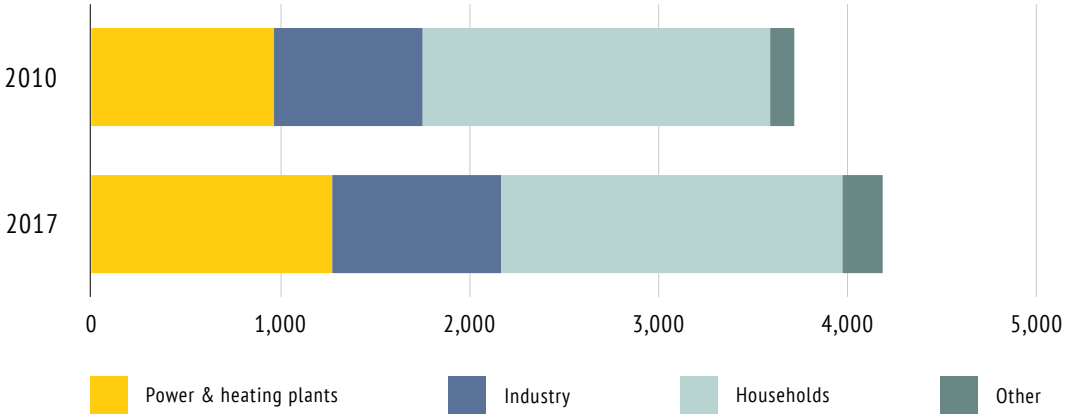
EU-28 biomass consumption for energy has grown 466 PJ (13%) this decade, primarily driven by a rapid expansion (301 PJ) in the power and heating plants sector.

Biomass now accounts for approximately 3% of all electricity generation and 19% of *derived heat*[4] production across the EU. Biomass remains a relatively modest share of all renewable electricity but is a very significant contributor to renewably sourced derived heat.

2. Originally the Renewable Energy Directive (RED) 2009/28/EC and subsequently the revised renewable energy directive (REDII) 2018/2001/EU adopted in December 2018.
3. Annex IV of the EU ETS directive 2003/87/EC: "*The emission factor for biomass shall be zero.*"
4. Derived heat is heat produced in heating plants and combined heat and power plants (CHPs).

FIGURE 2:

EU-28 biomass consumption for energy 2010 & 2017 [PJ]



Biomass consumption for energy = inland consumption of primary solid biofuels[5]. Source: Eurostat Supply, transformation and consumption of renewables and wastes (nrg_cb_rw).
Sandbag's own categorisation by sector.

Biomass produces more electricity and significantly more derived heat than the other forms of bioenergy - liquid biofuels[6] and biogas[7]. See Fig. 3 and Fig. 4.

Biomass growth in the power and heat sector has partly been driven by demand from coal power plants[8]. There are three different ways coal power plants can lead to an increase in biomass demand: *co-firing*; a coal-to-biomass *conversion*; or a biomass *replacement* (see box for details).

Co-firing: the coal power plant replaces some coal with biomass in the input fuel while retaining coal as the primary fuel. Generally, but depending on the boiler technology, low percentages of the coal fuel mix can be replaced with biomass for only a modest investment.

Conversion: the primary fuel in a power plant unit is switched from coal to biomass. Generally, a conversion will require significant investment to adapt the boiler and the fuel handling facilities to use biomass rather than coal.

Replacement: a new primary fuel biomass facility is built to replace the power (and possibly heat) supply of a former coal power plant, often using the same physical site and part of the existing infrastructure, such as grid connections.

5. Under Eurostat definitions, *primary solid biofuels* is the sum of the following categories: fuelwood, wood residues and by-products, black liquor, bagasse, animal waste, other vegetal materials and residuals and renewable fraction of industrial waste.

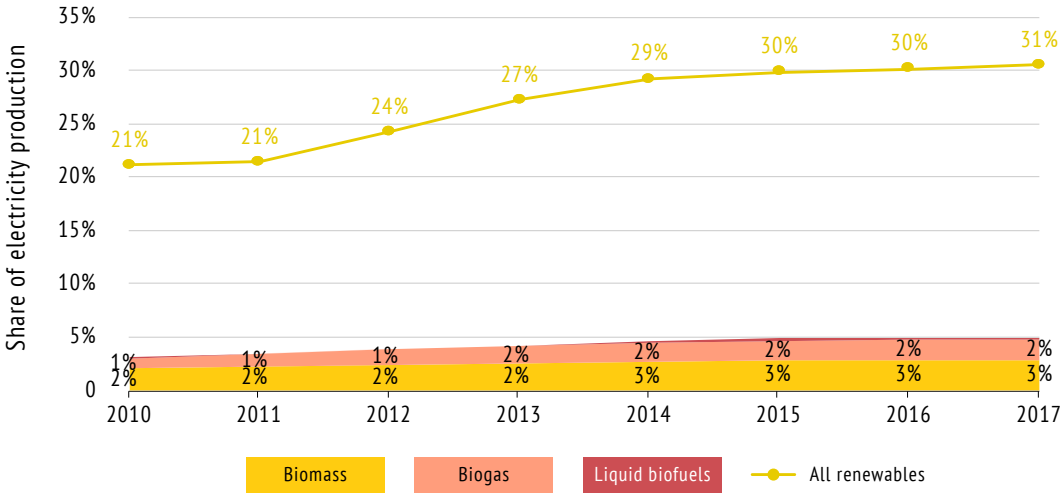
6. Liquid biofuels includes all liquid fuels of natural origin suitable to be blended with or replace liquid fuels from fossil origin. Liquid biofuels are classified as a renewable energy source. Definition *Eurostat*.

7. Biogas is a gas composed principally of methane and carbon dioxide produced by anaerobic digestion of biomass or by thermal processes from biomass, including biomass in waste. Biogas is considered a renewable energy. Definition *Eurostat*.

8. Both current and former coal power plants.

FIGURE 3:

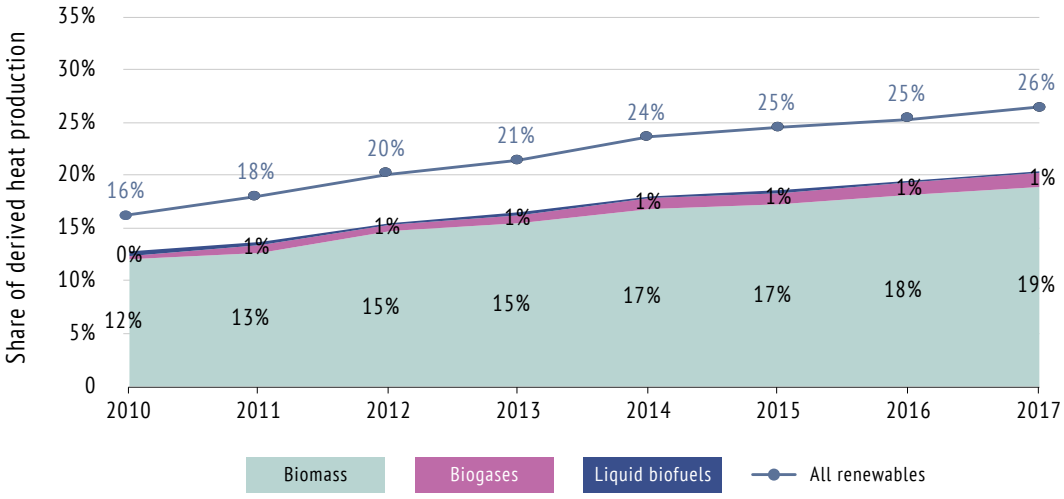
All renewables, biomass, liquid biofuels and biogas as a percentage of total EU-28 gross electricity production from 2010-2017 [%]



EU-28 gross electricity production in 2017 was 3294 TWhe.
Biomass = primary solid biofuels.
Source: Eurostat production of electricity and derived heat by type of fuel (nrg_bal_peh).

FIGURE 4:

All renewables, biomass, liquid biofuels and biogas as a percentage of total EU-28 derived heat production from 2010-2017 [%]



EU-28 gross derived heat production in 2017 was 670 TWh.
Biomass = primary solid biofuels.
Source: Eurostat production of electricity and derived heat by type of fuel (nrg_bal_peh).

A typical coal power station produces much more electricity than a purpose-built biomass power station and so requires significantly more input fuel. Continuously sourcing the amount of biomass required to fuel a coal power station presents serious technical and logistical challenges. For most coal power plants, the only viable option[9] is to burn wood pellets.

Wood pellets are made by drying, pulverising and compacting biomass derived from trees. Wood pellets are more uniform and have a higher energy density than other types of biomass; these properties make it possible to transport them in the volumes required to fuel coal power stations. Even so, significant government subsidies are still required to burn wood pellets in a coal power station, without which projects would be uneconomic. The subsidies are needed to cover the capital cost of retrofitting coal plants for biomass burning, and the ongoing high feedstock cost.

Buoyed by the demand from European coal power stations, a global industrial wood pellet production business has developed and expanded rapidly. Global wood pellet production has risen from 15.7MT in 2010 to ~ 36MT today[10]. The EU now imports 8.2 MT[11] of wood pellets annually, primarily from the United States, coal power stations are the main customers.

However, the current scientific consensus indicates that burning biomass instead of coal in power stations risks accelerating climate change.

In the most recent review of the scientific literature[12], the European Academies' Science Advisory Council (EASAC)[13] writes thus:

> *Far from reducing GHG emissions, replacing coal by biomass for electricity generation is likely to initially increase emissions of CO2 per kWh of electricity as a result of the lower energy density of wood, emissions along the supply chain, and/or less efficient conversion of combustion heat to electricity [..]. The resulting increase in atmospheric concentrations of CO2 increases radiative forcing and thus contributes to global warming. This initial negative impact is only reversed later if and when the biomass regrows. Research has shown that the time needed to reabsorb the extra carbon released can be very long, so that current policies risk achieving the reverse of that intended—initially exacerbating rather than mitigating climate change.*

9. Unless co-firing only a small percentage of biomass in the fuel-mix.

10. 2016 annual wood pellet production estimated at 36.2mt. Source: *European Biomass Association Statistical Report 2017* (pg.8).

11. 2017 data. Source: Eurostat - Roundwood, fuelwood and other basic products (for_basic).

12. European Academies' Science Advisory Council: *Serious mismatches continue between science and policy in forest bioenergy*

13. The EASAC applies the scientific expertise in Europe's 27 science academies to analysing topical issues where science interacts with European policy.

In response to the scientific consensus, the two pioneers of large-scale biomass burning in coal power stations - the UK and Denmark - are beginning to recognise the error that has been made. The UK's Committee on Climate Change (CCC)[14] has urged the UK government not to provide further policy support for large scale biomass without CCS[15] while the Danish Council on Climate Change (Klimaraadet) [16]writes that: "*Denmark already consumes much more biomass per capita than is likely to be sustainable if the rate were repeated on a global scale. In this particular regard, Denmark is unlikely to be a positive example for other countries to follow.*" [17]Unfortunately, in Denmark, this increased awareness has not yet been translated into any policy change.[18]

But the same mistakes look set to be made again with disastrous impacts for the climate.

A growing number of EU governments have committed to phase out coal power over the next decade or so. See Fig. 5. In phase-out countries, coal power plant operators must close their assets or adapt them to burn a different fuel. **Biomass is one of the alternative fuels being considered.** And governments can support this transition with renewable energy subsidies.

Coal to biomass projects are being considered despite the availability of significantly cheaper renewable alternatives such as wind and solar. While the cost of wind and solar was initially high, already by 2016, generating electricity from coal-to-biomass conversions was more expensive than onshore wind or solar[19]. In 2017, the UK Government summarised these developments with the following statement:

> *Other renewable generation technologies have matured to the point where they can be deployed reliably at large scale, and they are becoming increasingly affordable. When compared with these technologies, carbon savings from biomass conversion or co-firing are low or nonexistent, and the cost of any savings is high.*
>
> UK Department for Business, Energy & Industrial Strategy (BEIS) 2017[20]

14. The Committee on Climate Change (the CCC) is an independent, statutory body established under the Climate UK Change Act 2008. Its purpose is to advise the UK Government on emissions targets and report to Parliament on progress made in reducing greenhouse gas emissions and preparing for climate change.

15. Biomass in a low-carbon economy (pg.15): "*Do not provide further policy support (beyond current commitments) to large-scale biomass power plants that are not deployed with CCS technology*". CCS stands for carbon capture and storage.

16. The Climate Council is an independent expert body that advises the Danish Government on how the transition to a climate-neutral society can be done in a cost-effective way, while maintaining welfare and development. The Climate Council was incorporated by the Danish Climate Act.

17. The Role of Biomass in the Green Transition

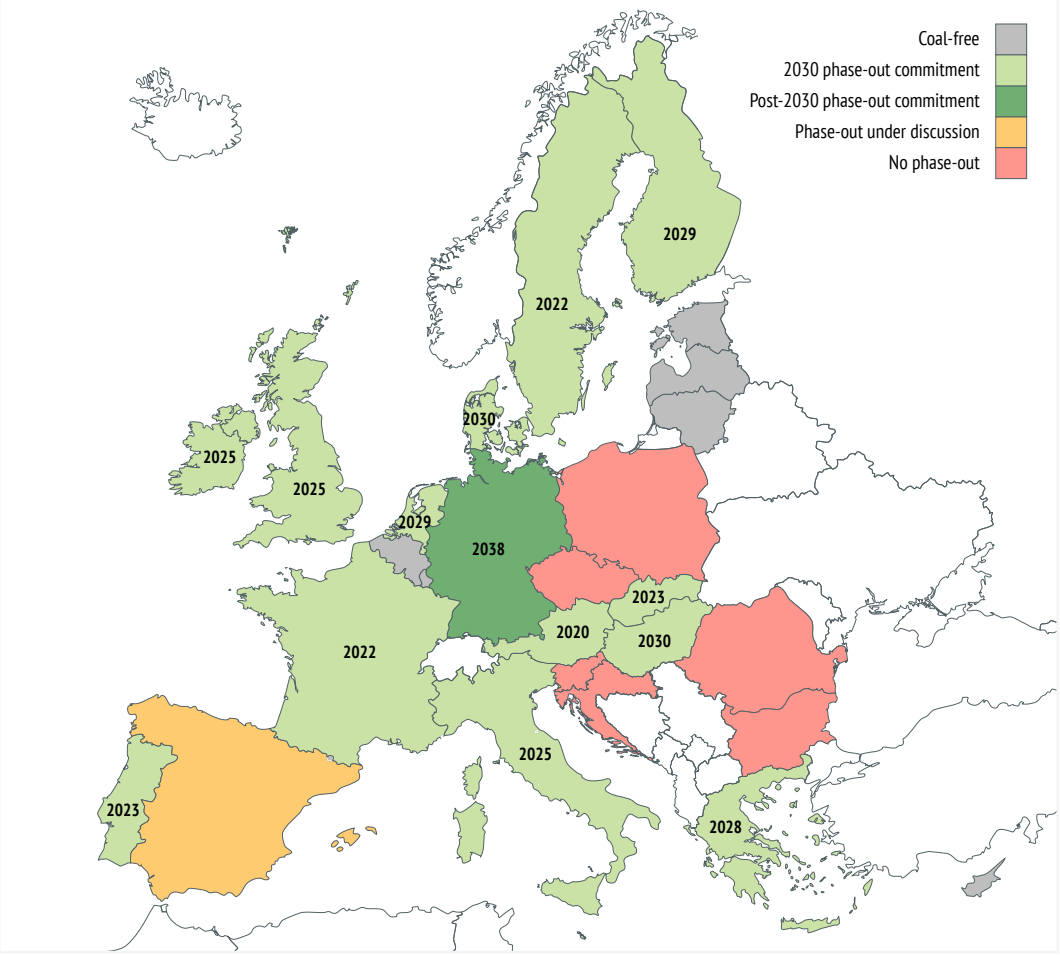
18. In the UK, the government has stopped almost all subsidies for new biomass power plants but is committed to expensive contracts for coal-to-biomass conversions which do not expire until 2027.

19. BEIS Electricity Generation Costs (November 2016). Table 6, pg.29, central estimates.

20. Controlling the costs of biomass conversion and co-firing under the Renewables Obligation, Sep-17.

FIGURE 5:

Coal power phase-out status by EU Member State & phase-out date



Dates indicate coal phase-out. Status as at 15.11.19. Source: Europe Beyond Coal Data

The gap has only widened since. In the UK, by the early 2020s, it will be cheaper to build new offshore wind farms than operate existing coal-to-biomass power plants.[21]

There is now a real risk that the phase-out of coal power in Europe will fuel a further expansion in biomass burning, most likely in the form of industrially produced wood pellets. This outcome would ignore lessons learnt from the UK and Danish biomass experiments, would waste valuable financial resources better deployed on wind and solar and, according to the latest scientific consensus, risks accelerating rather than mitigating climate change.

21. 2612 MW of offshore wind will be delivered in 2023/2024 under the UK's 3rd CFD auction at a price of £46.43/MWh (2019 prices). The cost of delivering energy from biomass at Drax is ~ 75 pounds per megawatt-hour (MWh). Drax is targeting a reduction to £50/MWh in the next decade, even in the very unlikely event that these cost reductions were achieved by the early 2020s (if at all), offshore wind would still be cheaper.

Objective, Scope & Methodology

Objective

Assess the possible growth in EU biomass consumption as a result of proposed coal-to-biomass fuel substitution in power stations. Identify the key players at a national, company and project level. Evaluate how much of the growth in EU biomass use this decade has come from coal power plant co-firing and conversions.

Scope

N.b. throughout this report we use the term coal as catch-all term for solid fossil fuels including hard coal, lignite (brown coal), peat and oil shale.

In this analysis, we define a **coal power plant** as a power plant with a capacity of at least 15MWe (net) with a primary input fuel of solid fossil fuels (coal, lignite, peat or oil shale). All CHP plants with a power output of at least 15MWe (net) are included, heat only plants are out of the scope of the analysis. Coal power plants producing electricity primarily for co-located industrial processes (i.e. *autoproducers*) are excluded from the analysis unless exporting at least 15MWe (net) to the electricity grid.

When we say **biomass** we include all solid, organic, non-fossil material of biological origin (plants and animals) used for energy purposes. However, in the context of coal power stations, this is mostly wood in the form of pellets or chips. Municipal waste and biomass used for non-energy purposes are excluded from the scope of this report.

METHODOLOGY

Historic analysis

All combustion facilities with a rated thermal input greater than 50MW (~15MWe for coal) must report input fuel data (including fuel type) to the Large Combustion Plant Database (LCPD)[22]. We identified all current coal power plants in the database using the mapping provided in the *Europe Beyond Coal database*[23] and via desk-based research for coal power plants outside the scope of the *Europe Beyond Coal database* (i.e. peat & oil-shale). We further identified all former coal power plants that have converted from primary fuel coal to primary fuel biomass using the historic input fuel figures in the database, where conversions occurred prior to 2004 (the first available data in the LCPD) we have identified former coal plants by cross referencing a number of datasets including (the *Europe Beyond Coal database*, the *Environmental Paper Network database*[24] and previous Sandbag research in this area[25]) along with additional desk based research. Having identified all current and all former coal power plants in the LCPD we aggregated their reported biomass input fuel figures.

Forecast

For each in-scope (see above) coal power plant we searched publicly available information (including company reports, news stories, draft National Energy & Climate Plans[26] and the Environmental Paper Network database) to identify any proposals to substitute coal for biomass as an input fuel. The information was cross-referenced with local partners in the Europe Beyond Coal network.

Identified projects were grouped into three basic types defined as follows:

Co-firing: the power plant will replace some coal with biomass in the input fuel while retaining coal as the primary fuel.

Conversion: the primary fuel of a unit(s) at the power plant will switch from coal to biomass.

Replacement: a new primary fuel biomass facility is built to replace a closed primary fuel coal power plant unit(s).

Each project was assigned a risk of proceeding under the following definitions:

Very likely: the project has reached final investment decision (FID) or is already under construction, conversion or undergoing operational trials.

Likely: pre-FID, biomass is the preferred post-coal option. A conversion, co-firing or replacement plan is in development. The project is aligned with national government policy objectives.

Possible: pre-FID, the project is either of the following categories:

1. Confirmation that biomass is being considered as one of a range of possible alternative fuel options.
2. Biomass is the preferred post-coal option but the project is not aligned with national government policy objectives.

22. Reported data on large combustion plants covered by the Industrial Emissions Directive (2010/75/EU)
23. Europe Beyond Coal data
24. Environmental Paper Network, *Mapping the Biomass Industry*
25. Sandbag: *Something nasty in the woodshed*
26. Draft National Energy and Climate Plans (NECPs) for all Member States are hosted on the EC website.

For each identified project we calculated the expected growth in biomass input fuel consumption using the project rated thermal input, the percentage biomass in the input fuel and an average utilisation of **70%**. For coal power plants already burning some biomass we subtract the 2017 biomass input figure from the LCPD to avoid double counting growth that has already been accrued. For a small number of database entries, where additional information is available that allows an improved estimate of the growth in biomass input fuel consumption (e.g. where load factors are expected to be significantly lower than our baseline estimate) the deviations are clearly noted in the database.

The primary source of the rated thermal input was the LCPD, where another source was used, this is noted individually in the dataset provided with this report. For projects where only the rated capacity output (power and/or heat) was available, we converted the figures to a rated thermal input using the assumptions provided in Table 1.

TABLE 1:

Project type	Efficiency (NCV/LHV)
New Biomass Combined Heat & Power Plant	80%*
New Biomass Electricity Only Power Plant	38%
New Biomass Heat Only Plant	90%

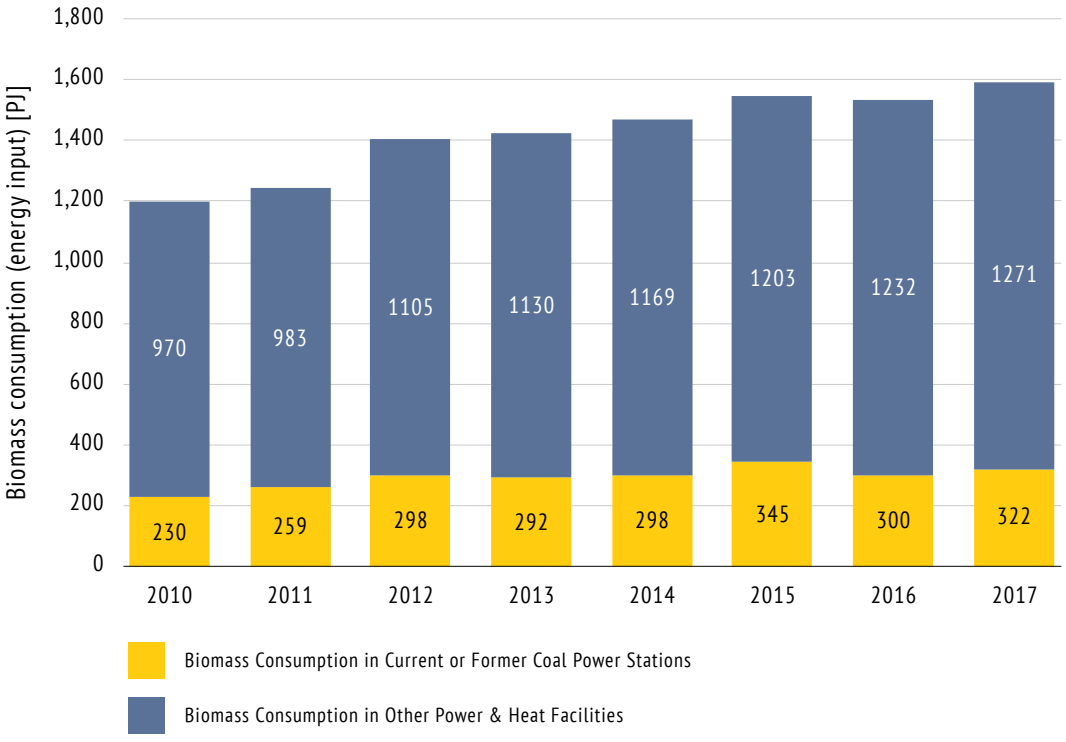
*The figure stated here is in the lower third of the range provided in the large combustion plant Best available techniques Reference document (BREFs) developed under the IPPC Directive and the IED, these levels may not be achievable if the potential heat demand is too low.

Historic analysis

Our historic analysis of the Large Combustion Plant Database (LCPD) reveals that biomass burnt in current or former coal power plants has grown by 40% this decade, reaching 322 PJ of energy input in 2017, the latest year for which there is available data. Please see the methodology for more detail on how we calculated this figure.

FIGURE 6:

EU-28 biomass consumption for electricity and derived heat production split by facility type [PJ]



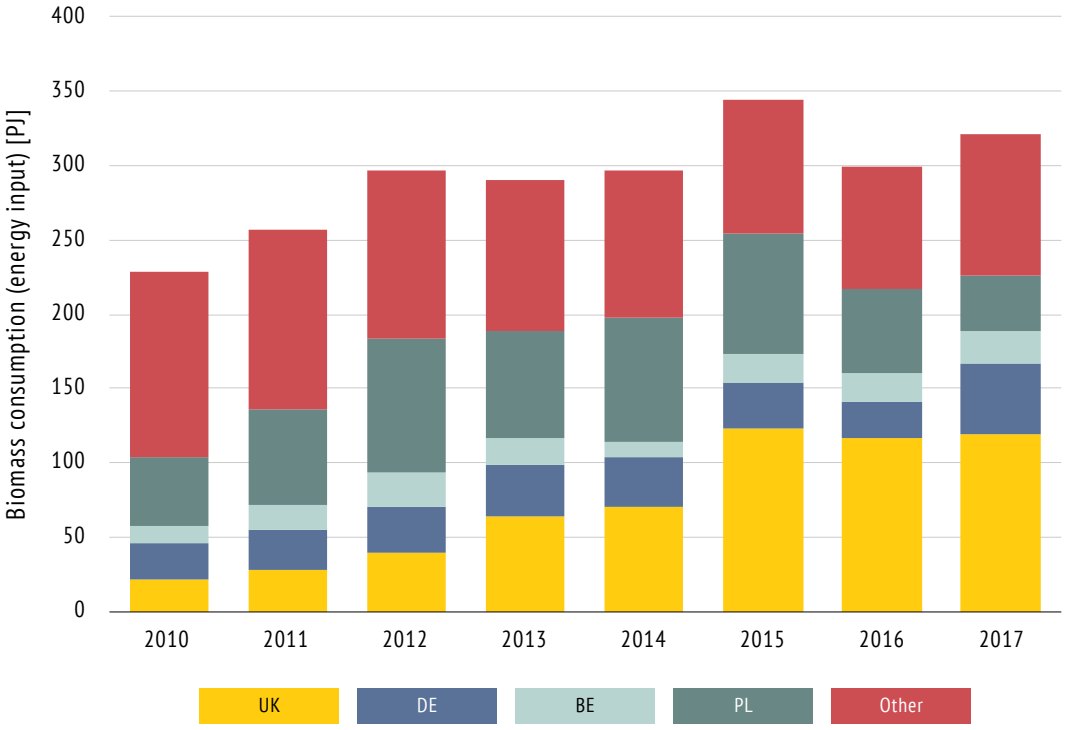
Source: Eurostat supply, transformation and consumption of renewables and wastes (nrg_cb_rw), Large Combustion Plant Database, Sandbag calculations - see methodology for more detail.

Coal power plants have been responsible for approximately one third of the growth in biomass use in power and heating plants this decade. However, they remain a relatively small proportion (~25%) of the total biomass burnt to generate electricity and derived heat. See Fig. 6. Despite this relatively modest contribution, coal power plants have been the key driver of EU wood pellet imports (and the associated infrastructure build-out) - see introduction for more details.

In this decade, most of the growth in biomass burn in current or former coal power plants took place in the UK[27] but there were also notable contributions from Denmark[28] and Belgium[29]. Consumption peaked in 2015 and has plateaued since. From 2015, reductions in co-firing in Polish coal power stations[30] have more than offset new biomass demand in coal power plants elsewhere. See Fig. 7.

FIGURE 7:

EU-28 biomass burnt in current & former coal power plants split by Member State [PJ]



Source: Large Combustion Plant Database, Sandbag calculations, see methodology for more details.

27. Mostly at Drax power station which has converted four of six coal-fired units to fire only biomass. However, there were also notable contributions in the early part of this decade from coal-to-biomass conversions at Ironbridge and Tilbury, both have subsequently closed.

28. Including coal-to-biomass conversions at Amager, Avedøre & Studstrup

29. A coal-to-biomass conversion at Rodenhuize

30. The economic incentive to co-fire decreased as the value of Polish green certificates (effectively renewable subsidies) declined due to oversupply, the government also tightened requirements to receive green certificates.

Analysis of proposed coal-to-biomass projects

For each in-scope (see page 13) coal power plant, Sandbag has conducted a thorough search of publicly available information to identify company proposals to substitute coal for biomass as an input fuel. For each identified project we calculated expected biomass consumption and assigned a likelihood (*very likely, likely* or *possible*) that the project reaches completion based on a number of considerations. Please see the methodology for further information.

The aggregate figures detailed below include all three likelihood categories. These figures should therefore not be treated as a forecast of what *will* happen but what *could* happen if all currently proposed projects are realised.

Results

- Proposed coal-to-biomass substitutions in coal power plants could increase biomass consumption by up to **607 petajoules** (**PJ**) p/a. This is equivalent to approximately 50% of current biomass consumption in all power and heating plants.
- If all 607 PJ of new biomass demand was met with wood pellets, ~ **36 million tonnes** (MT)[31] would be required p/a. This figure is similar to the current total ***global*** annual wood pellet production[32].
- Including ~ 52 PJ p/a biomass input in coal-to-biomass projects that started operation in 2018, biomass consumption in current or former coal power plants could reach **981** PJ[33], **three times current levels**. See Fig. 8.

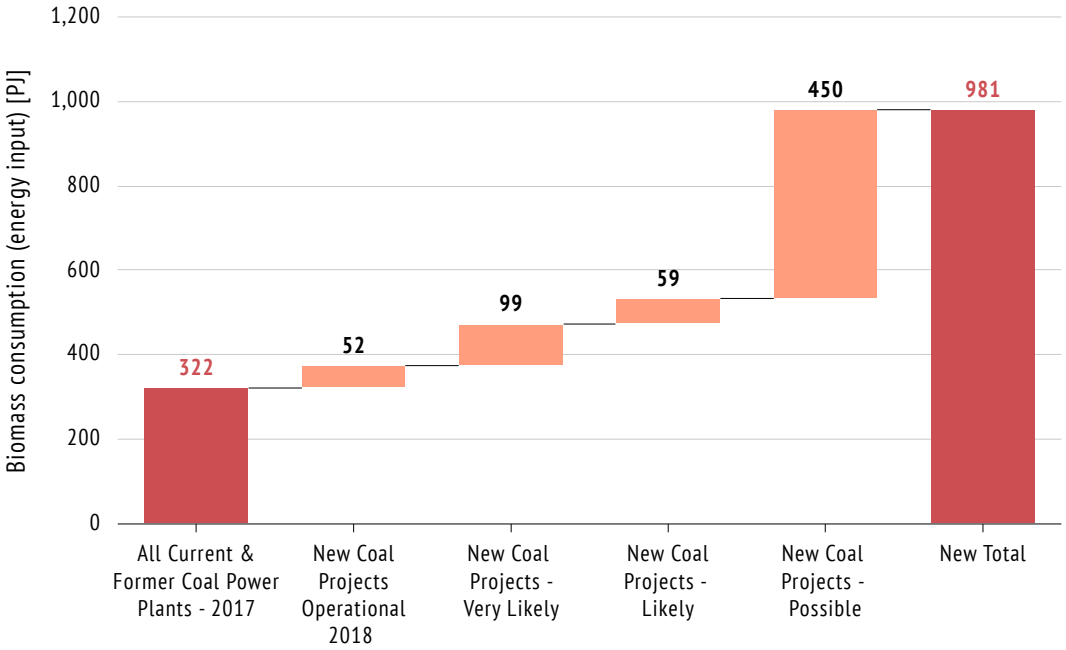
31. Assuming 17 GJ/tonne (NCV/LHV). Source: Forest Research.

32. 2016 annual wood pellet production is estimated at 36.2mt - source: European Biomass Association statistical report.

33. Assuming biomass consumption in active projects in 2017 remains constant.

FIGURE 8:

EU-28 potential biomass consumption growth due to coal-to-biomass substitutions in coal power plants, grouped by project risk [PJ]



Source: Large Combustion Plant Database, Sandbag research & calculations - see methodology for more detail (including how we assess the risk that a project will be completed).

There remains a large volume of coal capacity in the EU for which there are no plans to phase-out coal. Therefore, by definition, biomass is not being considered as a post-coal fuel and therefore is not included in the figures above. However, with coal phase-out across the EU just starting to gather pace (see introduction), the 607 PJ p/a of biomass consumption growth identified could represent just the tip of the iceberg.

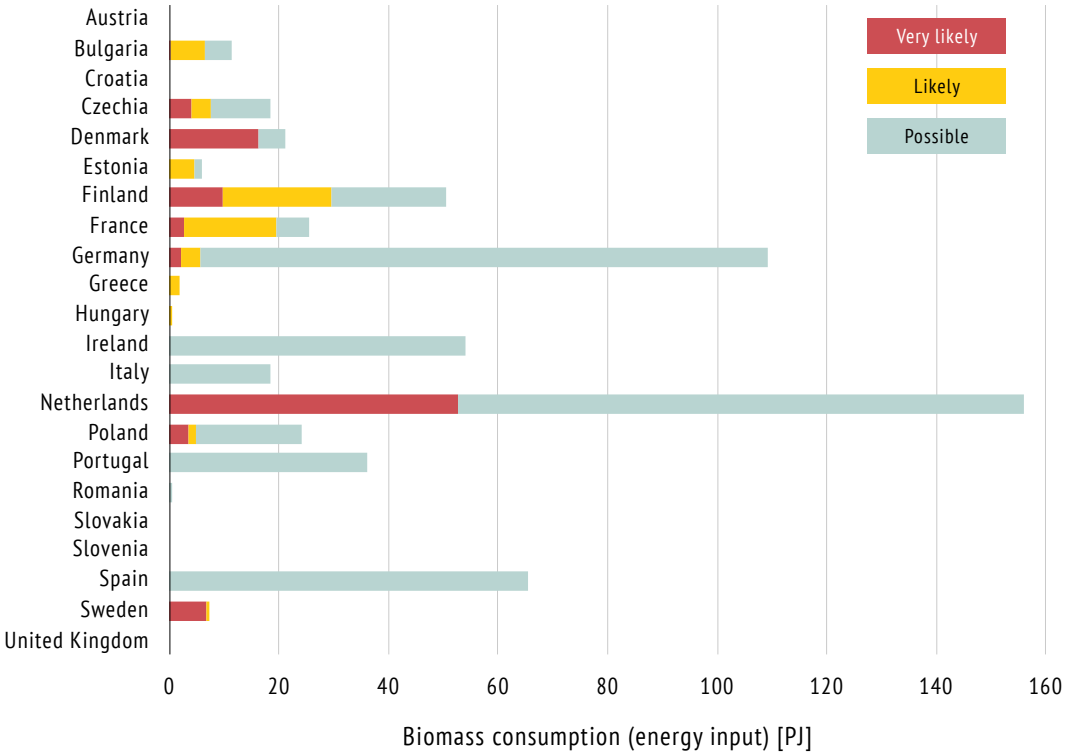
Country detail

The current coal-to-biomass proposals are far from evenly spread. Unsurprisingly, it is in the countries planning to phase-out coal where we found the highest potential growth in biomass use in coal plants. Projects in Finland, Germany, Ireland, Spain & the Netherlands account for over 70% of the potential growth. The Netherlands alone accounts for 25%. See Fig. 9.

In the boxes below, we provide more detail on the five largest potential consumers of biomass in coal power stations identified in our analysis.

FIGURE 9:

Potential growth in EU Member State biomass consumption in coal power stations split by risk [PJ]



Source: Sandbag research and calculations - see methodology for more details.

Finland

Plans to phase-out hard-coal power plants by 2029. Coal power plants typically provide district heat, ensuring heat supply continues after hard coal is phased-out is a key driver of coal-to-biomass proposals. Our research identified a large number of projects, although, on average, projects are smaller than in the other key countries identified in this section. Projects include: a number of proposals to replace hard-coal combined heat and power plants (CHPs) with heat only biomass plants; the conversion of a peat fueled power plant (Haapavesi) to a biomass fuelled industrial CHP with a new co-located bio-refinery; and increasing the biomass share in peat fired power plants that currently also co-fire biomass.

More generally, Finland also has a number of multi-fuel CHPs which co-fire peat and biomass, the burning of peat is even more damaging for the climate than coal[34], and the public opinion in Finland is moving against peat burning[35].

34. Both from direct emissions - the emissions intensity is per unit of electricity produced is greater than that of coal due to the high moisture content in the fuel, and from indirect emissions - natural peatland is an important carbon sink, draining the peatland for harvesting releases this carbon into the atmosphere.

35. Most Finns support a ban on peat burning, according to the latest polls.

If a ban was forthcoming, there is a risk that these plants would switch to fire 100% biomass instead - this could add a further **14 PJ**[36] of biomass consumption to the figures displayed in Fig. 9.

Germany

Plans to phase out coal power by 2038 at the latest. Two projects - a conversion of the Hannover (VVG) and Hamburg-Moorburg (Vattenfall) hard coal power stations account for most of the volume identified in Fig. 9. Both proposals are in early-stage discussions where biomass is just one of a range of post-coal fuel options. There are also a number of smaller coal-to-biomass CHP projects planned by the *Stadtwerke* (municipal utilities).

In general, there's still a great deal of uncertainty in Germany regarding the coal phase-out and the implementation of the Coal Commission's[37] recommendations. For example which coal plants will have to close by when? Understandably, there are many coal plants for which post-coal plans are yet to be developed and by definition these are not included in our analysis but could represent upside risk to the biomass volumes as the coal phase-out progresses. Enviva, the largest international supplier of wood pellets is marketing hard in Germany and thinks 1-4GW of coal-to-biomass conversion are realistic[38], the project proposals identified in our analysis represent ~ 2GWe.

Coal-to-biomass conversions will face a number of challenges, most notably the likely need for subsidies. In Germany subsides are only available to new biomass projects under 20 MW in size[39]. The German draft National Energy and Climate Plan (NECP)[40] - while admittedly preceding the coal phase-out commitment - indicated that the government considers electricity from biomass as poor value for money vs. other renewables such as wind and solar, even when accounting for the need for variable output and flexibility[41].

36. Assuming 2017 peat consumption (LCPD) is replaced with biomass at multi-fuel peat biomass plants including: Keljonlahti, Rauhalahti, Haapaniemi, Kajaani, Napapiirin, Kokkola Energy & Seinäjoki.

37. On June 6, 2018, the Federal Government decided to set up the Commission Growth, Structural Change and Employment (WSB). Task of the WSB commission was to develop concrete proposals for a future-oriented, sustainable development structure and thus future-proof jobs in the brown coal regions affected by the structural change. In the general reporting, the Commission was therefore widely called the coal commission. After seven months of negotiations, the Commission on Growth, Structural Change and Employment presented its final report on 26 January. The final report can be found here.

38. https://www.energie.de/euroheatpower/news-detailansicht/nsctrl/detail/News/ist-das-aus-fuer-die-kohle-die-grosse-chance-fuer-biomasse-2019495/

39. http://www.res-legal.eu/search-by-country/germany/single/s/res-e/t/promotion/aid/tenders-auctioning-the-feed-in-support-for-ground-mounted-installations/lastp/135/

40. All draft National Energy and Climate Plans can be here.

41. EC courtesy translation of the German National Energy & Climate Plan (pg.34): "*The downward trend for biomass in the electricity sector is attributable to the fact that it is a relatively cost-intensive renewable source of energy compared to other technologies such as wind and photovoltaics. This applies in particular to the generation of electricity from renewable feedstocks, and also in view of the need to provide variable output and flexibility.*"

Ireland

Plans to phase out hard coal and peat from the power mix by 2025 and 2030 respectively. The identified biomass growth in coal power stations is from the proposed conversion of ESB Group's Moneypoint hard-coal power station and Bord na Móna's Edenderry peat-fired power plant. Both projects face economic and environmental headwinds, but the Irish draft NECP provides some respite, indicating 181-355MW of biomass co-firing by 2030 (vs. ~ 50MW today). This is significantly less than the combined capacity of Moneypoint and Edenderry (~ 1000MW). Proposed peat-to-biomass conversions at the Lough Ree and West Offaly power stations have been scrapped with the power stations due to close instead[42].

Spain

Coal is expected to be off the grid by 2030. The identified potential biomass growth is mostly at two coal plants (Aboño 2 and Soto de Ribera) owned by EDP España, who are considering biomass as one of a range of post-coal fuel options[43], discussions are at early stages.

More generally, although the Spanish Ministry for the Ecological Transition make it clear it is mainly a business decision, it has said that "*within the plans of ecological transition, any new life for the coal plants is contemplated with approval, including biomass*"[44]. The Spanish draft NECP envisages a 1GW increase in biomass-fuelled electricity generation capacity to 2030 with generation increasing ~ 6-7TWhe (~ **62 PJ biomass consumption**[45]). It is however unclear how this will be achieved. The *Environmental Paper Network database*[46] indicates ~ 200MW of small electricity-only biomass plants are in planning/construction but this leaves plenty of room for a coal plant conversion.

The Netherlands

Plans to phase out coal power by 2030. Four coal plants owned by RWE (x2), Riverstone & Uniper have been awarded 3.6 billion euros in subsidies to co-fire biomass with coal over 8 years[47], preparatory work for the plants to co-fire biomass is either almost complete or operational trials are already

42. https://www.irishmirror.ie/news/irish-news/esb-powerplant-closures-offaly-longford-20839775

43. https://www.elcomercio.es/economia/empresas/edp-estudia-reemplazar-carbon-gas-biomasa-abono-20190321002127-ntvo.html

44. https://www.energias-renovables.com/biomasa/el-miteco-ve-con-buenos-ojos-que-20190218

45. Assuming 38% efficiency.

46. https://plattform-wald-klima.de/wp-content/uploads/2019/06/bioenergy-plants.html

47. All Dutch renewable subsidy awards can be found here. N.b the co-firing at Amer is ~ 80% of the input fuel, under the definitions of this report, this counts as a conversion.

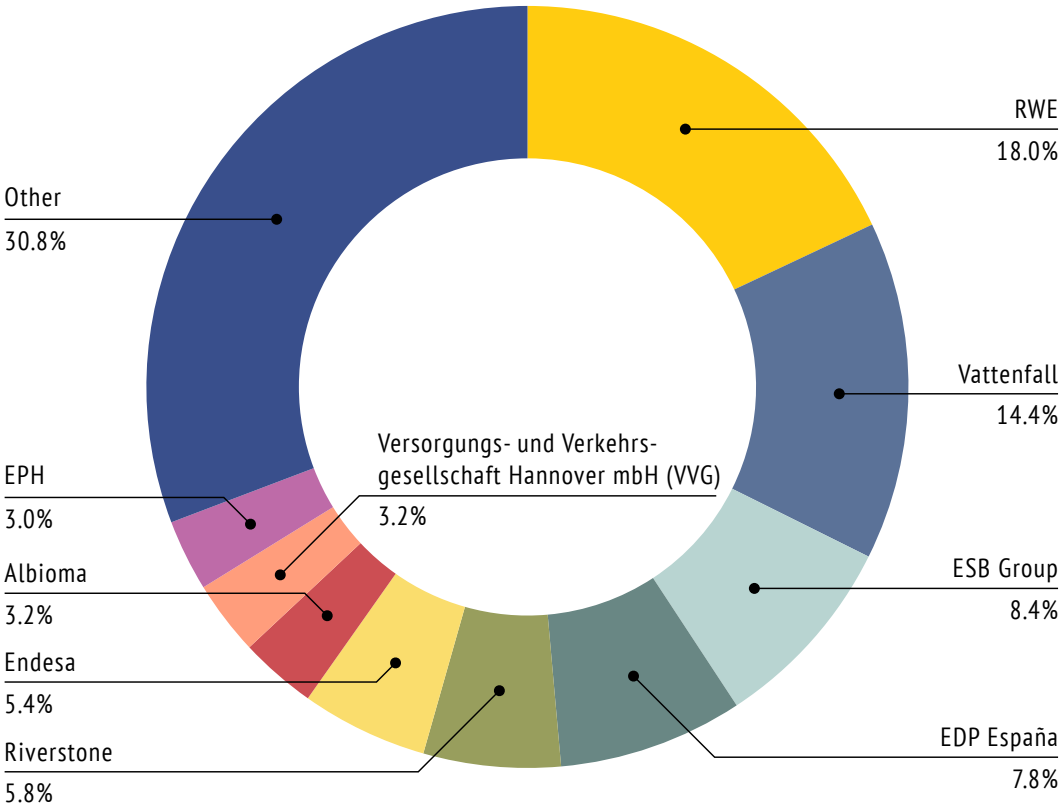
underway; these projects make up our identified volume tagged as *very likely*. The potential growth in biomass consumption tagged as *possible* relates to proposals to convert three of these same coal plants - Amer (RWE), Eemshaven (RWE) & Maasvlakte (Riverstone) to fire only biomass. While the proposed full conversions do not have subsidies, and may never receive any[48], both operators continue to include the conversion projects in their corporate planning[49].

Company detail

Just five coal operators (RWE, EDP España, ESB Group, Riverstone & Vattenfall) are responsible for over half of the potential increase in biomass burn in coal power stations across the EU.

FIGURE 10:

Company share of potential growth in biomass consumption in coal power stations [%]



Source: Sandbag research and calculations - see methodology for more details. Endesa's share includes ½ of the potential volumes from Pego as per the ownership structure of the power station.

48. The Dutch senate wants the cabinet to stop issuing proposed subsidies for wood-fired biomass plants as quickly as possible. Story here.

49. RWE see here. The Riverstone plant is the site of an EU funded research project to test the use of Arbaflame steam-exploded black pellets. Arbaflame have an agreement with the power station to deliver 70,000tpa with a MoU to rise to 200,000tpa as quickly as possible and then gradually increase to 1.8MT, which is the amount needed for 100% bio-conversion.

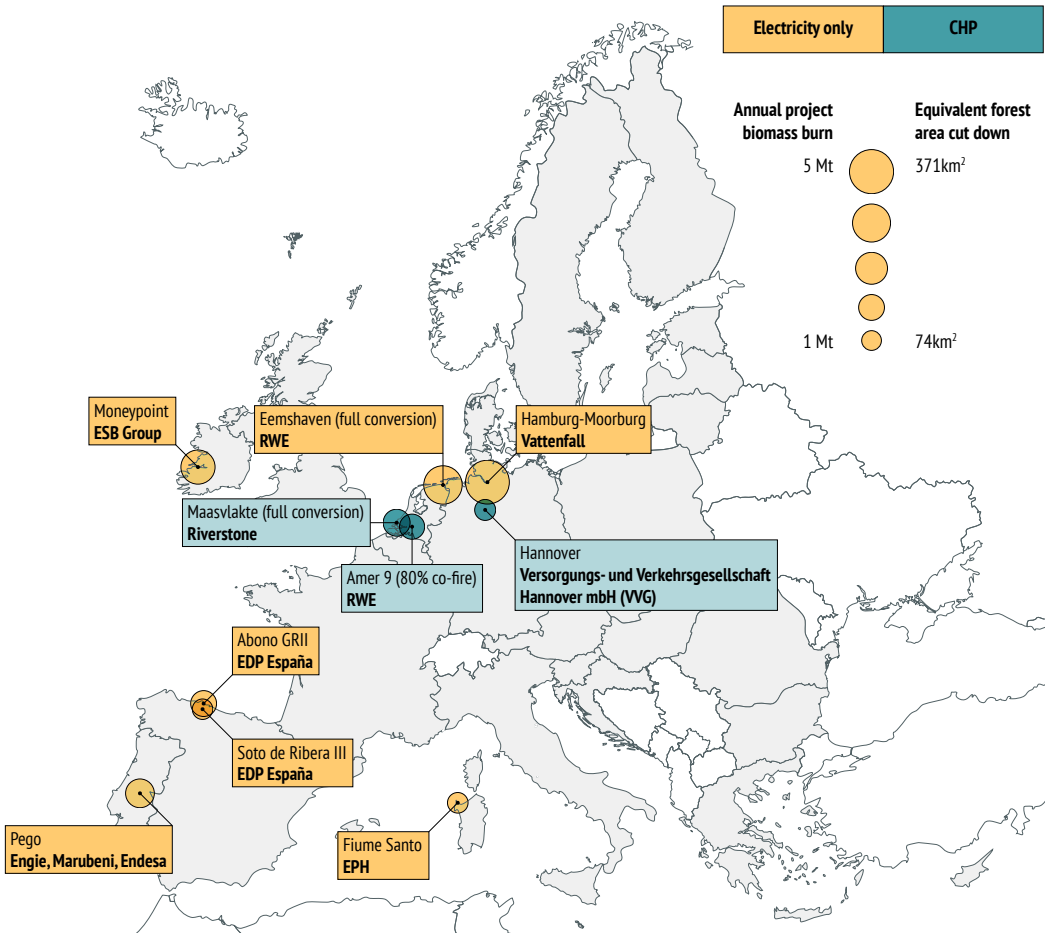
Project detail

We identified 67 coal-to-biomass projects. Of which, just 10 projects account for over half of the total biomass that could be burnt in all 67 projects. See Fig. 11.

Of these ten, seven are electricity-only projects likely to achieve efficiencies of less than 40%. Modern, purpose-built biomass CHPs can achieve efficiencies of > 80%[50]. Biomass is a scarce resource, burning it inefficiently in old, converted coal power plants, just to extend the life of the asset is staggeringly wasteful.

FIGURE 11:

10 projects account for over half of the total biomass that could be burnt in all identified coal-to-biomass projects



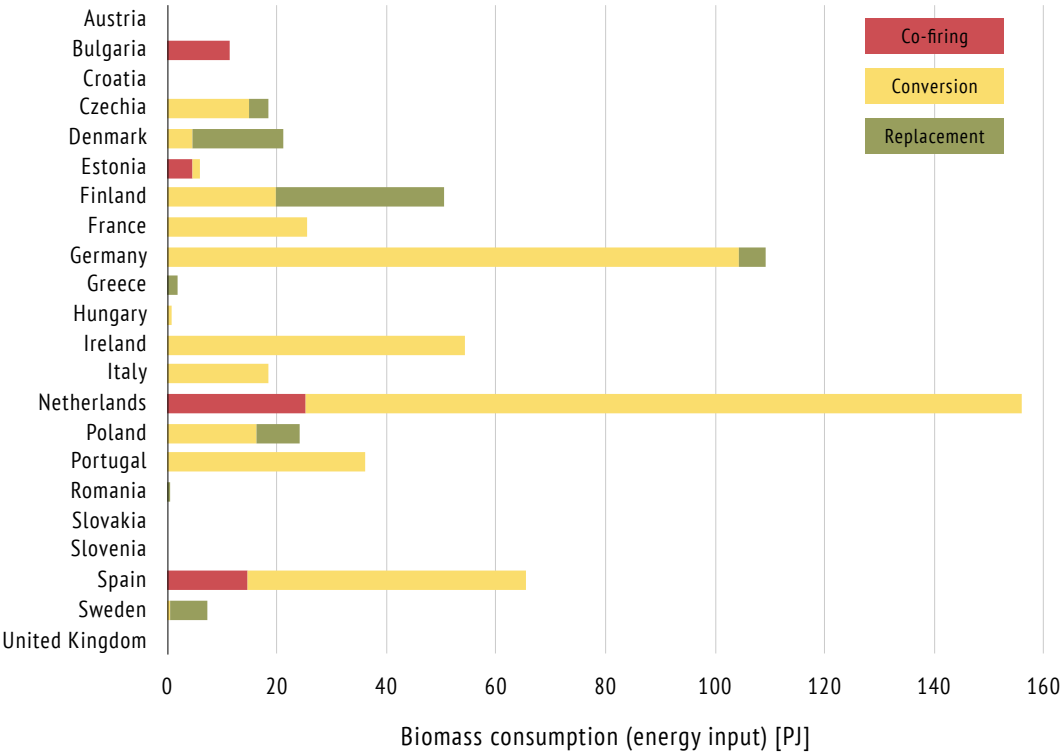
Source: Sandbag research. Assumes 70% project load factor and a net calorific value of 17GJ/tonne for biomass. The calculations of the forest area cut down assume biomass is sourced from the forests of the U.S. south, please see the "forest impact" chapter for more details.

50. The figure stated here is in the lower third of the range provided in the large combustion plant Best available techniques Reference document (BREFs) developed under the IPPC Directive and the IED, these levels may not be achievable if the potential heat demand is too low.

While co-firing biomass with coal has historically been a notable driver of new biomass consumption, the majority of the new projects identified in our analysis concern the full conversion of coal power station units to fire only biomass. See Fig. 12. We identified projects to expand co-firing in just four[51] countries: Bulgaria, Estonia, Spain and the Netherlands.

FIGURE 12:

Potential growth in EU Member State biomass consumption in coal power stations split by project type [PJ]



Co-firing: the power plant will replace some coal with biomass in the input fuel while retaining coal as the primary fuel.
Conversion: the power plant primary fuel will switch from coal to biomass.
Replacement: a new primary fuel biomass facility will be built to replace the power (and possibly heat) supply of a former primary fuel coal power plant.
Source: Sandbag research and calculations - see methodology for more details.

51. Perhaps five. The Polish government is holding "migration" auctions to move Polish renewable generators from the old green certificate scheme to the new auction scheme. It is possible that coal power stations that used to co-fire on the green certificate scheme before it became uneconomical to do so may start co-firing again. In the Nov 2019 auctions, existing biomass is competing for up to 2.26 TWhe p/a over 15 years ~ 22 PJ p/a biomass input fuel. However, it is unclear if existing coal/biomass co-firing units (that are not currently co-firing) will win the auction (or bid) - the price cap (350PLN/MWh) may not be high enough there is a requirement to reach >15% biomass in the fuel mix and other technologies such as dedicated biomass and biogas are competing for the same volume. We therefore concluded that these volumes were too uncertain to include in our analysis, however, auction results will need to be monitored. More details here.

Forest impact

It is important to get a sense of the scale of biomass harvesting that would be required if all the current coal-to-biomass projects in the EU came to fruition. We have therefore estimated the annual forest area that must be harvested (cut down) each year to feed the potential new demand identified in our analysis.

To do so requires specific knowledge of forests and tree plantations[52], forestry practices[53] and sourcing practices[54] of the wood pellet industries in each region where the biomass would be sourced from. Given that many of the projects identified in this research are in the early stages of development, it is impossible to say exactly where the biomass will be sourced from at this time.

Therefore in our calculation of the required forest area we have assumed biomass is sourced only from the forests of the U.S south. To reiterate, while the U.S is the largest exporter of biomass to the EU, we do not expect that the U.S south would provide all of the potential biomass demand growth identified in our analysis - we make this assumption to allow a ballpark estimate of the scale of biomass harvesting required.

Spencer Phillips, an economist for *Key-Log Economics*, has conducted research[55] commissioned by the U.S non-profit organisation *Dogwood Alliance* and developed an equation for estimating the number of acres of forest that must be harvested in the U.S south to produce the amount of wood pellets for export to Europe in a given year. We have used the equation and the sample allocation to management regime (the relative proportion of the different sources of forest biomass that goes into making the pellets) provided in this research to make the calculations, for full details see the calculations section below.

52. E.g. species composition - different species grow at different rates.
53. E.g the number of years in a rotation - how long trees are left to grow before harvest.
54. E.g the ratio of forest biomass to forestry residues used.
55. Key-Log economics. Acreage required to meet projected biomass pellet demand from the European Union, 2016-2030.

Results

Proposed coal-to-biomass substitutions in coal power plants could increase biomass consumption by up to **607 PJ** p/a. If all 607 PJ of new biomass demand was met with wood pellets sourced from the U.S south, **~ 270,000 hectares (2700km^2) of forest would need to be cut down every year**.

270,000 hectares is equivalent to most[56] of the forest in the Netherlands or Wales or just under half of the Black Forest in Germany. These vast swathes of forest area would be needed to provide the biomass fuel for just 64 TWh of electricity, less than 2%[57] of the EU's gross electricity production. In comparison, new wind and solar capacity that can generate a similar amount of electricity is currently being added every year[58].

Calculations

The equation used for the calculation is republished below.

$$Harvest\ (Acres)_t = \frac{\left[(\text{dry tonnes Pellet Exports}_t) \times \left[\frac{\text{green tons furnish}}{\text{dry tonnes pellets}}\right] - \text{green tonnes residue}\right]}{\text{harvest yield (green tons biomass / acre)}}$$

The numerator combines metric tons (tonnes) export demand in year t with a furnish to pellet conversion factor to yield the number of short tons of furnish (input biomass) needed. From this amount, we subtract the share of total furnish that comes from mill and logging residues. This leaves green tons of biomass that will come directly from forest harvest. Dividing required biomass harvest (in tons) by the yield rate (in tons per acre) gives the number of acres that must be harvested in year t to meet that year's pellet export demand.

The following assumptions are made:

Biomass can be converted to pellets at a rate of **2.24** green tons of pulpwood per dry metric ton of pellets. Therefore in the equation above, the furnish to pellet conversion factor (green tons furnish / dry tonnes pellets) = 2.24.

Biomass growth per acre per year, rotation age, tons harvested at the end of the rotation and the allocation to management regime (the % of input biomass by source) are provided in Table 2. All of the assumptions stated, included the allocation to management regime are the same as those used in the Key-Log Economics research note.[55]

56. 70% and 84% for the Netherlands and Wales respectively. Data sourced from the World Bank and Forest Research Woodland Statistics.

57. *Assuming input biomass was used for electricity generation at 38% efficiency. In reality the real percentage of EU electricity generation would be lower as a number of the identified projects also produce heat. 2017 gross electricity production was 3294 TWh in 2017. Source: Eurostat*

58. Average annual growth of wind + solar this decade is 42TWh. *Source: Eurostat & Sandbag's Euorpean Power Section in 2018 report*: https://sandbag.org.uk/project/power-2018/

TABLE 2:

Growth rate, rotation harvest, and allocation to management regime

	Annual Growth	Rotation	Harvest	Allocation to Management Regime
Management Type	Green tons / acre / year	Years	Green tons	% of all pellet-fuel source acres
Planted Pine	4.0	25	100	**38%**
Natural Pine	2.0	45	91	**20%**
Mixed Hardwood & Pine	1.5	50	77	**13%**
Hardwoods (lowland & upland)	1.6	55	86	**5%**
Residues				**24%**

Using the assumptions stated above, the equation simplifies to:

$$Harvest\ (Acres) = \frac{[2.24 \times (\text{dry tonnes pellet exports}) \times 76\%]}{92.78}$$

Using the 36 MT of dry tonnes pellet requirements identified in the analysis yields ~660,000 acres (or 2700 km^2).

Climate impact

Biomass is treated as a renewable energy source because it is assumed that the CO2 emitted when it is burned to generate electricity will be reabsorbed by biomass regrowth (e.g. of the forest).

However, burning biomass delivers carbon into the atmosphere near instanously, while it takes time for new trees to grow. Furthermore, where additional trees are cut down, future carbon absorption from these trees is foregone. There is therefore a carbon 'payback period' between this initial net addition of CO2 to the atmosphere and its reabsorption through biomass regrowth. This payback period matters. The Paris Agreement now commits signatories, including the EU, *"to pursue efforts to limit the temperature increase even further to 1.5°C"*. The Intergovernmental Panel on Climate Change (IPCC, 2018) projects that average surface temperatures are likely to exceed 1.5°C between 2030 and 2052 on current trends, payback periods of decades therefore increase the risk of overshooting Paris Agreement targets[59].

> *Time matters. Placing an additional carbon load in the atmosphere for decades means permanent damages due to more rapid melting of glaciers and thawing of permafrost, and more packing of heat and acidity into the world's oceans. At a critical moment when countries need to be "buying time" against climate change, this approach [allowing the harvest and burning of wood] amounts to "selling" the world's limited time to combat it.*
>
> Letter from 800 scientists to the EU Parliament regarding forest biomass. 2018.[60]

The European Academies' Science Advisory Council now recommends that forest biomass should not be regarded as a source of renewable energy under the EU's Renewable Energy Directive **unless the replacement of fossil fuels by biomass leads to net reductions in atmospheric concentrations of CO2 within a decade or so.**

---

59. *Paraphrased from EASAC Serious mismatches continue between science and policy in forest bioenergy.*
60. Letter from 800 scientists to the EU Parliament regarding forest biomass. 2018.

The potential growth in biomass burn in coal power stations identified in our research would release ~ **67 MT of CO2**[61] annually if all projects came to fruition. This is equivalent to half of the annual CO2 emissions from Poland's coal power stations.

Assessing the 'payback period' of the 67 MT of CO2 that would be emitted annually from switching from coal to biomass (inc. wood pellets) requires an integrated approach whereby carbon flows along the complete life cycle (including combustion emissions) in the bioenergy scenario are compared with carbon flows in the absence of increased harvesting for bioenergy (a reference or counterfactual scenario).

There is no requirement under current EU law to conduct such an assessment.

However, an assessment of this nature was recently carried out for three wood pellet mills located in Louisiana and Mississippi and owned by Drax Biomass, a subsidiary of Drax Power, which has used government subsidies to convert four of its coal-fired units to burn biomass in the United Kingdom. According to the analysis[62], burning wood pellets from these mills for electricity in the U.K. increases CO2 levels in the atmosphere for more than **40 years** vs. a counterfactual scenario without the Drax pellet mills.

Given the current scientific consensus, it is reasonable to conclude that **switching coal for biomass in coal power stations in the projects we identified will likely result in a net increase in CO2 in the atmosphere over timescales relevant to achieving the goals of the Paris Agreement.**

61. 110 kg CO2/GJ for solid biomass, IPCC (2006).

62. Southern Environmental Law Centre & Spatial Informatics Group: Burning wood from 'sustainably managed' forests increases carbon pollution for 40+ years.


sandbag
smarter climate policy