MONTANARO

ASSET MANAGEMENT

RENEWABLE ENERGY: THE BIOMASS DEBATE

March 2020

INTRODUCTION

Biomass is classified as a renewable energy source by certain national and international bodies, such as the European Union and the Intergovernmental Panel on Climate Change (IPCC). Despite this, the classification of biomass as a renewable is contentious and has been an area of debate for Montanaro's ESG Committee. In this report, we summarise the biomass debate from the perspective of compressed wood pellet biomass (ignoring sources such as agricultural and livestock residues, waste and other bi-products).

"Bioenergy has a significant greenhouse gas (GHG) mitigation potential, provided that the resources are developed sustainably and that efficient bioenergy systems are used"[1], according to the IPCC. These provisions are complicated, however. The environmental impact of wood pellet production, transportation and combustion must be fully taken into account. In particular, the supply chain of the industry needs careful analysis: the US is the world's major supplier of wood pellets. A Japanese listed company in the Better World Fund, Renova, sources wood pellets from locations in the US that are similar to Drax, the UK power station that has transitioned from coal to biomass. As part of our research, we arranged a site visit to Drax in order to better understand the biomass market.

This note is split into two sections: **1) The Biomass Debate; 2) The Drax Site Visit.**

[1] Renewable Energy Sources and Climate Change Mitigation, Chapter 2 Bioenergy, The Intergovernmental Panel on Climate Change

1) THE BIOMASS DEBATE

There are a number of reasons why biomass is seen as a controversial source of renewable energy. In this section, we summarise the biomass debate from the perspective of compressed wood pellet biomass (ignoring other sources such as agricultural and livestock residues, waste and other bi-products). This should in no way be considered an extensive report into the pros and cons of biomass, but rather a high level summary of major issues. The sources section on the final page suggests further reading.

The ESG Committee debated these arguments when considering the impact case of Renova. Our understanding of the role biomass has to play in the transition to a cleaner, greener economy has been enhanced by our site visit to Drax and subsequent meeting with Dr Rebecca Heaton (a member of the UK's Committee on Climate Change). It is the ESG Committee's opinion that biomass power generation, when conducted in line with national guidelines such as those proposed by the European Union, can form part of the sustainable and renewable energy mix. In particular, biomass can help the shift away from fossil fuels and "keep the lights on" while battery storage develops to increase the viability of intermittent forms of renewable energy (solar and wind).

However, it must be acknowledged that the "carbon neutrality" of biomass continues to be debated. As a report by the European Forest Institute states, *"there is no clear consensus among scientists on the issue and their messages may even appear contradictory to decision-makers and citizens".*[2]

[2] https://ec.europa.eu/jrc/en/publication/forest-biomass-carbon-neutrality-and-climate-change-mitigation

Setting the scene

Under EU law (DIRECTIVE 2009/28/EC[3]) biomass is classified as a source of carbon neutral energy: *"energy from renewable sources' means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower,* ***biomass****, landfill gas, sewage treatment plant gas and biogases"*.

In addition, this Directive offers the following definition: *"biomass' means the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances),* ***forestry*** *and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste".*

Forestry is the main source of biomass for energy (logging residues, wood-processing residues, fuelwood, etc.). Wood pellets, mainly for heating and electricity production, have become an important energy carrier[4]. To place this in context, "forestry accounts for more than 60% of all EU domestic biomass supplied for energy purposes"[5].

The European Union has a "2030 climate & energy framework[6]" setting out a number of energy targets for members states for the period 2020 to 2030. The key targets[7] are:

1) At least 40% **cuts in greenhouse gas emissions** (from 1990 levels);
2) At least 32% share for **renewable energy;**
3) At least 32.5% improvement in **energy efficiency.**

To achieve these aims, the EU notes that *"increasing the use of biomass in the EU can help diversify Europe's energy supply, create growth and jobs, and lower greenhouse gas emissions"*[8].

However, as was explained to us at Drax, biomass has to follow rigorous standards at every stage of the process for it to qualify as renewable. Thus, we must consider that "not all biomass is equal".

As the EU policy states: *"For biomass to be effective at reducing greenhouse gas emissions, it must be produced in a sustainable way. Biomass production involves a chain of activities*

[3] DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources
[4] *Brief on biomass for energy in the European Union*, The European Commission's Knowledge Centre for Bioeconomy, 2019
[5] Ibid
[6] EU 2030 Climate & Energy Policy Framework, October 2014:
[7] The framework was adopted by the European Council in October 2014. The targets for renewables and energy efficiency were revised upwards in 2018.
[8] https://ec.europa.eu/energy/en/topics/renewable-energy/biomass

ranging from the growing of feedstock to final energy conversion. Each step along the way can pose different sustainability challenges that need to be managed".[9]

Mark Strafford, Head of Investor Relations at Drax, explained the complexities of this regulation to us during our site visit: "in our carbon reporting at Drax, we even have to account for the fuel used at the production facilities in the US". What is slightly confusing, however, is that they do not have to take into account the emissions produced at the point of combustion. Therefore, to a certain extent, we have to conclude that the sustainability of biomass is dependent on carbon accounting rules.

Biomass guidance became more detailed following the European Commission's November 2016 proposal (amended in February 2017) for a revised Renewable Energy Directive[10] which included updated greenhouse gas emission accounting rules and default values.

In summary, the EU's non-binding recommendations on sustainability criteria for biomass:

- Forbids the use of biomass from land converted from forest, and other high carbon stock areas, as well as highly biodiverse areas;
- Ensures that biofuels emit at least 35% less greenhouse gases over their lifecycle (cultivation, processing, transport, etc.) when compared to fossil fuels. For new installations this amount rises to 50% in 2017 and 60% in 2018;
- Favours national biofuels support schemes for highly efficient installations;
- Encourages the monitoring of the origin of all biomass consumed in the EU to ensure their sustainability.

9 Ibid

10 DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the promotion of the use of energy from renewable sources, 23 February 2017

AGAINST biomass:

Regulatory support isn't enough for some, however. To its critics, biomass can release more greenhouse gas emissions into the atmosphere than the fossil fuels it replaces and threatens the maintenance of natural forests and connected biodiversity systems. Should impact investors not favour directing capital to less controversial areas of the renewable energy matrix?

In 2019, a group of plaintiffs (largely made up of NGOs) in Estonia, France, Ireland, Romania, Slovakia, Sweden and the US filed a lawsuit[11] against the European Union to challenge the inclusion of forest biomass in the bloc's renewable energy directive. While there is little to suggest their case will be successful, it highlights the challenges posed by an energy source which currently accounts for 60% of the renewable energy mix in Europe.

A report by Chatham House, *The Impacts of the Demand for Woody Biomass for Power and Heat on Climate and Forests*, is often referenced by those arguing against biomass. While Drax pointed out to us some issues with the report – it has not been peer reviewed for example – it summarises many of the key arguments against biomass:

- Woody biomass is less energy dense than fossil fuels, and contains higher quantities of moisture and less hydrogen, **at the point of combustion burning wood for energy usually emits more greenhouse gases per unit of energy produced than fossil fuels**;
- **At the point of combustion, [biomass] is of course not carbon-neutral** – if biomass is burnt in the presence of oxygen, it produces carbon dioxide – and the argument is increasingly being made that its use can have negative impacts on the global climate;
- **The harvesting of whole trees for energy** will in almost all circumstances increase net carbon emissions very substantially compared to using fossil fuels, both because of **the loss of future carbon sequestration from growing trees and because of the release of soil carbon consequent upon the disturbance**. This is particularly true for mature trees in old-growth forests, whose rate of carbon absorption can be very high;
- One reason for the perception of biomass as carbon-neutral is the fact that, **under IPCC greenhouse gas accounting rules**, its associated emissions are recorded in the land use rather than the energy sector;
- **It is often argued that biomass emissions should be considered to be zero at the point of combustion because carbon has been absorbed during the growth of the trees**, or because the timber is harvested from a sustainably managed forest, or because forest area as a whole is increasing (at least in Europe and North America);

[11] https://www.euractiv.com/section/energy/news/eu-dragged-to-court-for-backing-forest-biomass-as-renewable-energy/1319143/

- The [above] methodology specified, for example, in the EU Renewable Energy Directive (and many national policy frameworks) for calculating emissions from biomass **only considers supply-chain emissions, counting combustion emissions as zero**;
- These arguments are not credible. **They ignore both what happens to the wood after it is harvested** (emissions will be different if the wood is burnt or made into products) **and the carbon sequestration forgone from harvesting the trees if left unharvested**, they would have continued to grow and absorb carbon;
- Furthermore, even if the forest is replanted, **emissions of soil carbon during harvesting may delay a forest's return to its status as a carbon sink for 10–20 years**;
- The **many attempts that have been made to estimate carbon payback periods** suggest that they vary substantially, from less than 20 years to many decades, and in some cases even centuries.

In addition, it must be recognised that the regulatory framework around biomass is not without weakness. A European Commission paper[12] notes that *"regulatory failures may occur because renewable energy policy encourages Member States to support the use of more biomass, while rules or pricing mechanisms for biomass production do not take into account negative externalities, such as deforestation".* No policy framework or tool can give certainty that forests will be regenerated after biomass is harvested.

In our conversations with Drax about the arguments against the classification of biomass as a renewable energy source, we were pointed in the direction of Dr Mary Booth[13], a US academic who has argued vehemently against the renewable classification of wood pellet biomass. She has argued that "biomass as a renewable" should be considered a regulatory failing and a climate accounting fraud.

If proven correct, the implications for biomass companies are obvious, as she writes: *"the paradox of Drax's investment…is that it will likely make the company more vulnerable when the bioenergy scam inevitably fails. In the meantime, though, Drax receives renewable energy subsidies funded by the British public to the tune of about a billion dollars a year, or $2.78 million per day, as of 2017"*[14].

Certainly, some of the accounting mechanisms used to calculate the carbon neutrality of biomass are confusing, if not a little troubling. Booth's arguments are worth understanding and are discussed on the following pages.

[12] *Report from the Commission to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling*, European Commission 2010
[13] https://www.leonardodicaprio.org/authors/mary-s-booth-ph-d/
[14] The Great Biomass Boondoggle, Mary S. Booth

Booth suggests that the classification of biomass as a renewable has originated out of country level greenhouse gas reporting (that has increased in scope following the Paris Climate Accord of 2015): "Countries all over the world report their greenhouse gas emissions annually to the United Nations. **International carbon-accounting rules require carbon loss from forest harvesting to be reported in the "land sector**."

This has resulted in a number of problems (the following bullet points are direct quotes[15]):

- The first "is that harvested forest wood is not reported as an emission, even if it is burned for energy, but simply shows up as a reduction in that country's reported forest carbon uptake year to year.
- … since the lost forest carbon has ostensibly already been noted in the land sector, energy sector emissions of CO_2 from burning the resulting biomass are counted as zero, to avoid counting the carbon loss twice.
- Although it inevitably undercounts forest-harvesting impacts, this system by and large works as a way of characterizing gross fluxes of forest carbon *at the national level*.
- The problem is that in justifying subsidies for renewable energy, policymakers and forest industry representatives (who may sometimes be the same people) have reified the concept of bioenergy as *counting as zero* when burned, to bioenergy actually *having emissions of zero* globally. This means that when it comes to financial support, bioenergy is usually treated as equivalent to zero-emissions technologies such as wind and solar as a way of mitigating climate-warming.
- When the pellet industry ran out of road for its false claims about residues, it came up with a new rationale to justify biomass as instantly carbon-neutral: as long as forests are growing more wood than is being cut, and are thus harvested "sustainably," burning any of that wood has zero net emissions.
- **The concept of carbon neutrality is so central to the biomass industry that if it were overturned, the entire rationale for the industry would virtually disappear**
- Enviva's [a major supplier of wood pellet biomass] claim that burning its pellets "reduces" greenhouse gas emissions compared to burning fossil fuels. The company does not reveal that **this claim relies on reporting only fossil-fuel CO2 emissions from manufacturing and transporting pellets, and on simply not counting the CO2 coming out of the smokestack when the pellets are burned**.

In fairness to Drax, they were very clear to us on this point: when accounting for the carbon emissions of biomass, the calculation stops at the moment of combustion. This doesn't feel right or plausible, but current regulation supports this.

[15] The Great Biomass Boondoggle, Mary S. Booth

Booth quotes a warning from the European Academies Science Advisory Council to then EU's president, Jean-Claude Juncker, in January 2018[16] that:

> "**The legal mandate to record forest biomass-fired energy as contributing to the EU's renewable energy targets has had the perverse effect of creating a demand for trees to be felled in Europe** or elsewhere in order to burn them for energy, thus releasing the carbon into the atmosphere which would otherwise stay locked up in the forest, and simultaneously drastically reducing the carbon sink strength of the forest ecosystems… **[T]he current use of imported pelleted forest biomass was leading to increased greenhouse gas emissions** with no guarantee of when (or even if) the additional carbon released to the atmosphere would be offset by forest regrowth.

Booth concludes: "rather than conclude that the biomass subsidy program is based on a fraud, the EU policymakers' response was to devise a Potemkin set of "sustainability" criteria for biomass that will do almost nothing to protect forests and the climate. The revised directive claims that the new constraints will "continue to ensure high greenhouse gas emissions savings compared to fossil fuel alternatives" and "avoid unintended sustainability impacts"[17].

Booths conclusions are troubling as they get to the heart of one of our deepest concerns about biomass: that its classification as a renewable source of energy relies on climate change accounting mechanisms and sustainability requirements that may be difficult to enforce.

[16] https://easac.eu/fileadmin/user_upload/180108_Letter_to_President_Juncker.pdf

[17] The Great Biomass Boondoggle, Mary S. Booth

FOR biomass:

The simplest reason in favour of biomass as a renewable energy is that it is classified as such by the European Union, as long as certain sustainability standards are met. If this classification were changed, then it would seem likely that the EU would fail to meet its 2030 renewable energy targets.

The reason for this is that bioenergy is the main source of renewable energy in the EU (in terms of gross final consumption), despite the growth of wind and solar power over the past decade. As per the below, bioenergy in Europe accounts for 59% of all renewables and 10% of all energy sources (based on 2016 data):

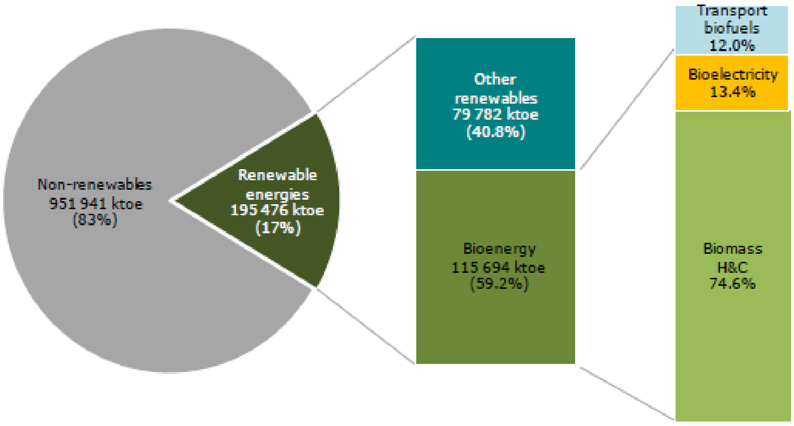


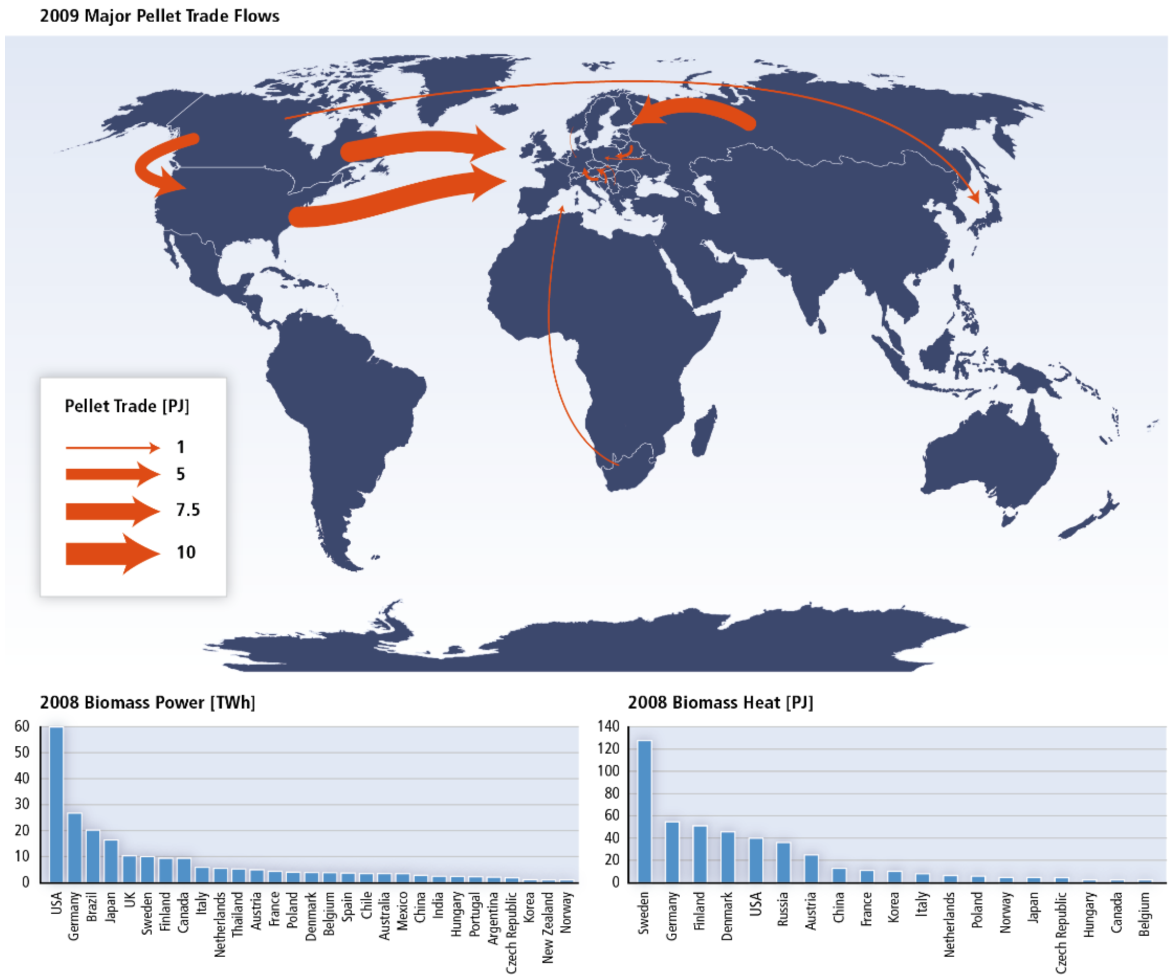
Figure 1. Share of renewables in the EU's gross final energy consumption for 2016 and breakdown of the bioenergy contribution. Source: Eurostat 2018b and NREAP Progress Reports.

We can assume that other countries, such as Japan, would also fail to transition economies sufficiently towards renewables if the classification of biomass was changed. Clearly, however, "not all biomass is equal" as we stated earlier in this report.

This classification can be referenced if certain conditions are met, namely the "sustainability" of biomass sourcing and the production of wood pellets. Investors need to ensure that they are investing in companies who produce energy from biomass in a responsible and sustainable way. This requires careful attention. As the EU's *Brief on biomass for energy* notes, wood pellets have "become an important energy carrier traded on a large scale and over long distances, due to their high energy density and stable characteristics".

Just as we have seen with Renova in Japan and Drax in the UK, wood pellets have to be sourced from overseas by countries who do not have sustainable forest industries of their own.

This is big business: global production of wood pellets reached 29 million tonnes in 2016[18]. The below image, taken from the IPCC Special Report on *Climate Change and Land* (SRCCL), shows the major trade flows of wood pellets, as of 2009. The major sources of wood pellets continues to be the forests of the US, Canada and Russia (Drax informed us that they do not source from Russia due to traceability issues).



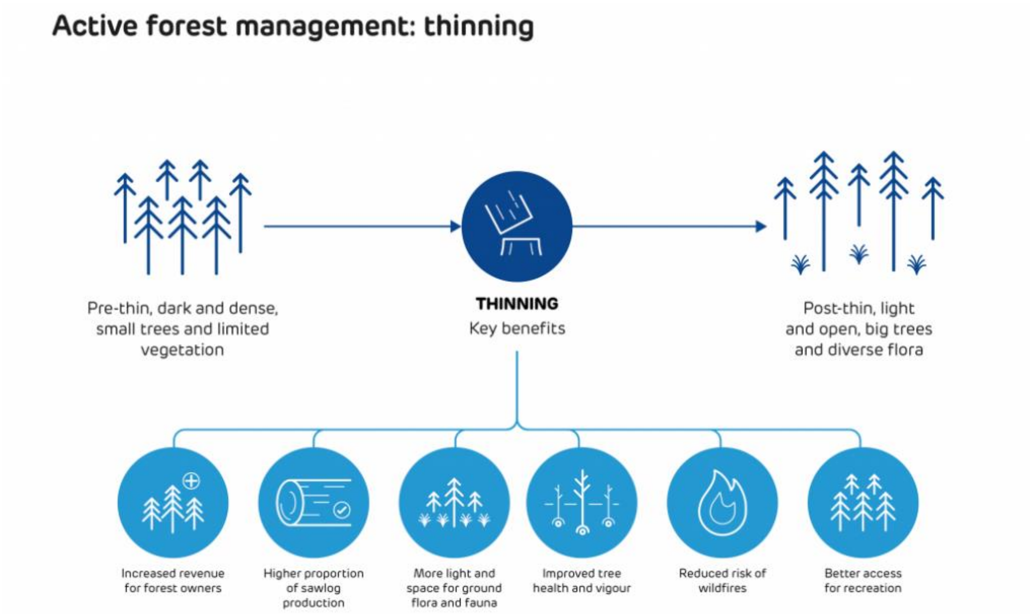
The sourcing of sustainable wood pellets is paramount to the sustainable and climate mitigating impacts of biomass energy. An IPCC Special Report on *Climate Change and Land*[19] (SRCCL), notes that *"bioenergy has a significant greenhouse gas (GHG) mitigation potential, provided that the resources are developed sustainably and that efficient bioenergy systems are used"*.

[18] The EU is also the main consumer globally (23 million tonnes, of which 32.6% is consumed in the UK, 9.1% in Italy, 8.7% in Germany, 8.7% in Denmark and 7.4% in Sweden). In some Member States, the consumption of wood pellets relies mostly on imports, e.g. the UK (94.7%) and Italy (81%). Wood pellets are mostly used in the residential sector for heating (in Italy, Austria, etc.) or for electricity production (in the UK, Austria, etc.). The European Commission's Knowledge Centre for Bioeconomy, Brief on biomass for energy in the European Union

[19] Special Report Climate Change and Land, IPCC, August 2019

With this in mind, it is worth stating the arguments in favour of sustainable forest management, namely that sustainably managed forests absorb more CO_2 than forests left to grow naturally. One reason given for this is that young trees absorb higher levels of CO_2 compared to mature trees that have stopped growing[20]. This is something we learnt more about at Drax and also in our conversation with Dr Rebecca Heaton.

The practice of "thinning" is key to the sustainability of managed forests: trees that are competing for light and other resource (water / earth minerals) do not grow to their optimal potential: as a result, CO_2 absorption is limited. Thinning helps: "weaker trees" are cut down or trimmed, allowing the remaining forest to develop. This is illustrated in the below image from Drax:



Sustainably managed forests that involve cutting down trees and thinning can also help to *protect* the forest as a whole from events like fire. There has been some speculation that the fires in Australia at the end of 2019 were exacerbated by poor forest maintenance: the denser a forest and the more debris left on the forest floor, the faster a fire may spread. In addition, sustainably managed forest can provide an economic reason for a forests existence: if a forest is uneconomic, pressure increases to repurpose the land for other uses (e.g. agriculture).

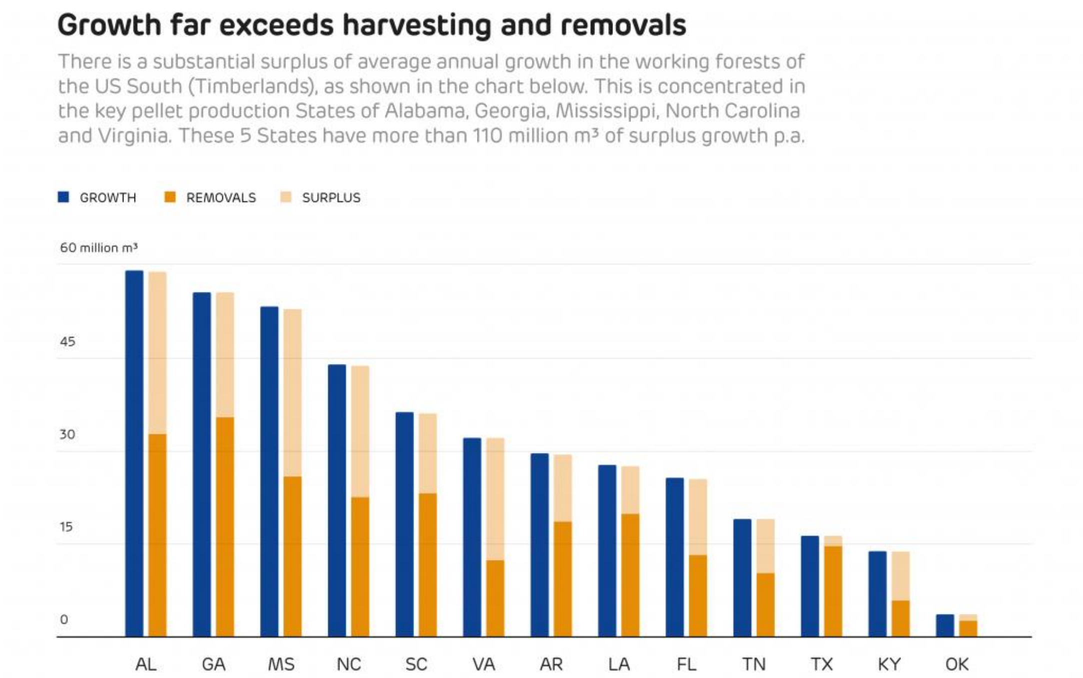
Nevertheless, the above must be understood in the context of climate change. A study published in the *Science* journal, *The global tree restoration potential*[21], found that "the restoration of trees remains among the most effective strategies for climate change mitigation". Despite the demands of industry, forests need to grow in aggregate: the IPCC

[20] It is important to note that scientific evidence on this is argued both ways
[21] The global tree restoration potential, Science, July 2019

suggests that an increase of 1 billion hectares of forest will be necessary to limit global warming to 1.5°C by 2050.

In our conversations with Drax, it was argued that increasing demand for wood pellets for biomass is supporting the sustainable forest industry, which in turn is supporting the *growth* of the US forest.

In areas like the US South, traditional markets for forest products have declined (e.g. paper), whilst forest growth has significantly increased. According to the USDA Forest Inventory and Analysis (FIA) data, there is an average annual surplus of growth in the US South of more than 176 million cubic metres compared to removals – that's enough to make around 84 million tonnes of wood pellets a year, from just one supply region, according to Drax figures.



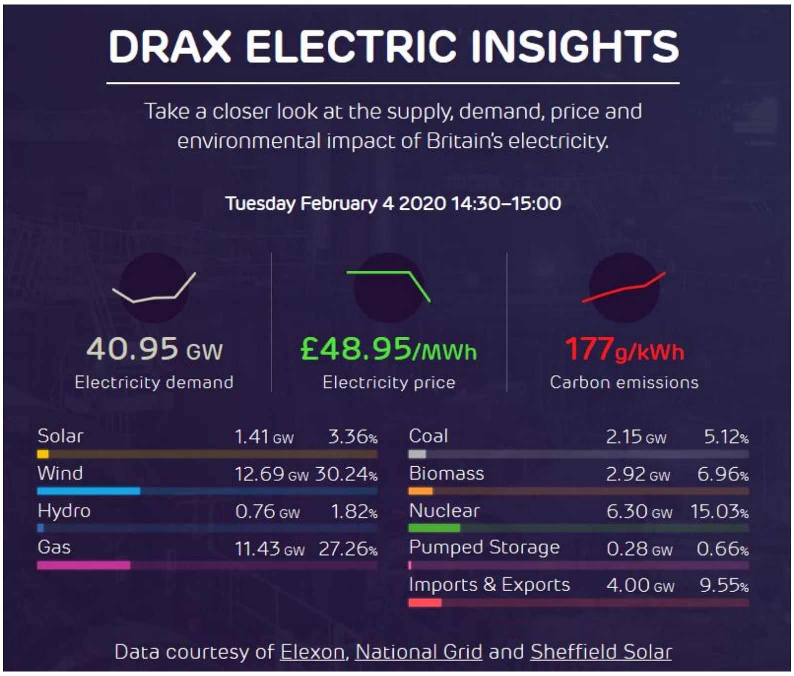
It must be noted that this argument faces challenges. Counterfactual modelling studies argue that the world's forests have not acted as a "carbon sink" in recent years; rather they are a source of emissions. This modelling works on the following assumption: *if the world's forests hadn't been cut down over the last XX years, what carbon would have been absorbed during this time?* In other words, what natural carbon capture has been lost?[22]

Again, this seems to come down to the sustainability of forest management. If managed for "resource and growth" – such as appears the case in the US South – then it seems difficult to

[22] See: https://www.carbonbrief.org/tropical-forests-no-longer-carbon-sinks-because-human-activity

argue against the use of wood pellets for biomass, particularly if at least a third of wood pellets are manufactured from residual shavings.

A final positive to note in this section is that, once installed, biomass power generators have a further advantage over solar and wind: they are 'dispatchable'. Biomass power stations can be turned on or off depending on the weather. For example, at the time of writing (February 2020) it is a grey, cold day in the UK. It is therefore little surprise that just over 3% of the UK's electricity is being generated by solar:



One could imagine that in the summer, fossil fuel energy production could fall to zero, (see *Britain's electric grid goes coal-free for entire week*, *Financial Times,* May 2019) while biomass is reduced as solar and wind meet more of the demand. The balancing role biomass can play is an important one as we transition to a lower carbon / green economy. This could become even more attractive if biomass is used in combination with carbon capture and storage technology to generate negative emissions at some point in the future.

CONCLUSIONS:

The simplest reason for supporting the use of biomass is that it is classified as a renewable form of energy by the European Union, if certain standards are met. There is therefore some legal and regulatory basis for considering investment in companies with biomass operations within an impact fund that has "Green Economy" as one of its six themes.

It is possible to conclude that energy sourced from biomass has an important role to play in the transition to a greener economy. However, biomass must be produced, processed and used in a sustainable and efficient way in order to optimise greenhouse gas savings and maintain ecosystem services, all without causing deforestation or degradation of habitats or loss of biodiversity. For now, the North American market is the primary source for both sustainable and economically viable wood pellets. Dr Heaton informed us that European markets are either too expensive, cannot produce enough volume or – in the surprising case of Scandinavia – have lower sustainability standards than those of the US and Canada.

A further point to make is that tackling climate change is in the interests of sustainable forestry. As per the IPCC report, *"impacts of climate change through temperature increases, rainfall pattern changes and increased frequency of extreme events will influence and interact with biomass resource potential"*. In other words, if global temperatures breach the 2^{o}C limit, then sources of sustainable forest may be placed at risk.

Engagement

Yet a clear weakness, as the EU acknowledges, is that *"no policy tool can give certainty that forests will be regenerated after biomass is harvested"*. Mary Booth's arguments on this point are persuasive. This is where active and engaged investors have an important role to play.

Arguably, Montanaro Asset Management ("MAM") is fulfilling this role. Since the consideration of Renova for the Montanaro Better World Fund, MAM has conducted the following research and engagement, with the expressed objective of understanding the biomass debate and ensuring that the companies we invest in are involved in sustainable practices:

- Renova site visit (Japan, December 2019)
- Drax site visit (UK, January 2020)
- Meeting with member of UK Committee on Climate Change (February 2020)

We need to understand that biomass is just one part of the complex global energy matrix. To achieve national and multi-national targets, further innovation is needed. Drax's carbon capture and storage pilot project is one example of this. As the IPCC report notes, *"combining biomass conversion with developing carbon capture and storage (CCS) could lead to long-term substantial removal of GHGs from the atmosphere".* The lack of an international carbon pricing mechanism/market continues to be a major stumbling block to these developments, in our opinion. As renewable subsidies end, companies and other stakeholders may need to be incentivised to achieve net zero or negative emission levels and thus turn climate mitigation into a source of potential revenue.

In the short-term, the key condition for bioenergy development is the availability of reliable, affordable and sustainable biomass. It is only this that can help to alleviate an uncomfortable reality that sits at the heart of the biomass industry: accounting mechanisms stop the carbon equation at the point of combustion. Ostensibly, this is to remove an issue of double counting, but as the world moves towards deeper analyses of company supply chains and negative externalities, pressure on this may grow. This is also the case with other forms of renewable energy: there are question marks about the cradle to grave impact of solar and wind (see Bloomberg article).

Biomass power generation can play a balancing role in the transition to a Green Economy. Ideally, this is used in conjunction with solar and wind – biomass power can be flexed according to weather conditions and demand. This should be our "impact aim" with Renova as they develop biomass power generation to complement solar and wind options. The ESG Committee is therefore comfortable with its impact recommendation for Renova. Drax, by contrast, would fail our impact assessment. In part this is because 25% of power is still sourced from coal, but the Committee would have more difficulty recommending the impact case of a pure play biomass operator. The diversified mix of Renova is preferable.

2) THE DRAX SITE VISIT

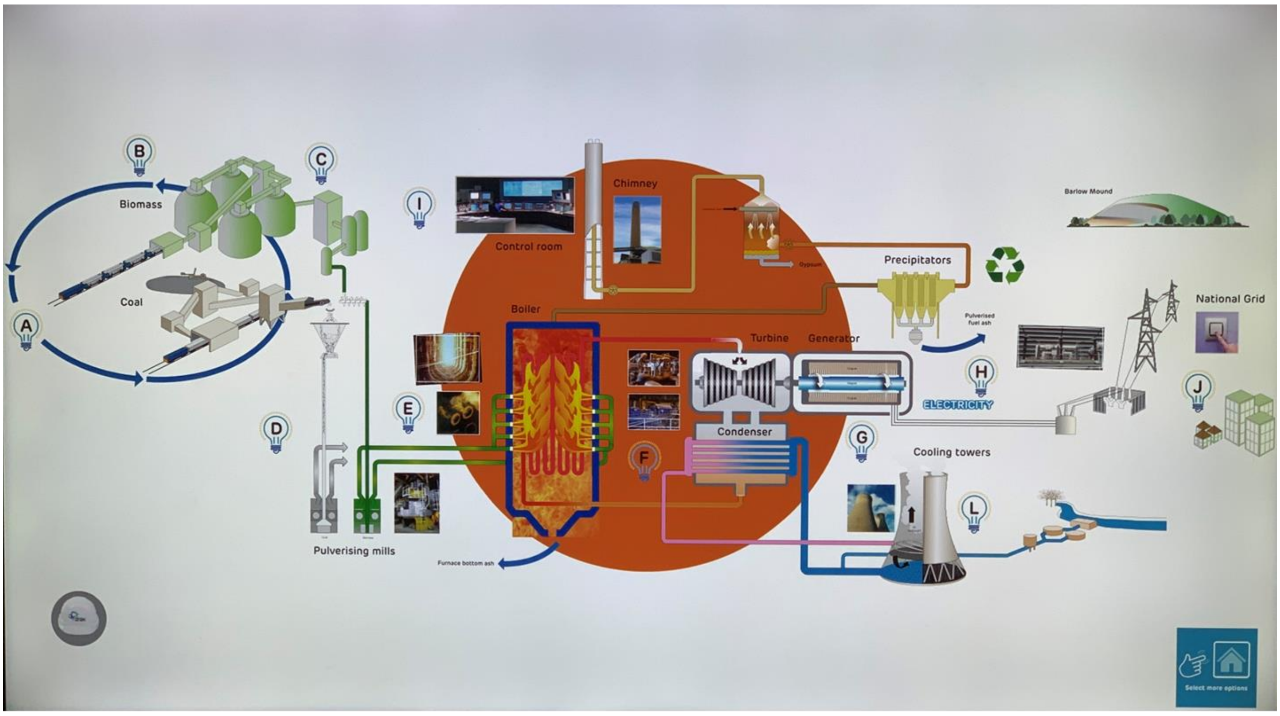
Drax is located in North Yorkshire close to the River Ouse which, a few miles east, empties into the Humber Estuary south of Hull. We took a train from Kings Cross to Doncaster and from there it was a 40 minute taxi ride due north. The landscape is very flat and dotted with windfarms and fields of solar panels. We could see Drax's iconic cooling towers from quite some distance, billowing water vapour into the air and creating a large blanket of cloud over the surrounding area. Apparently, the locals complain that Drax causes it to rain more than it should, although our guide on the tour said that scientists had disproved this: "it rains a lot because it is Yorkshire".

We also noticed that the last coal fired chimney was in operation, a result of the bout of cold weather that has increased energy demand. Our taxi dropped us off very close to the enormous cooling towers. The size and scope of the site hit us immediately.

The cooling towers:

The Drax cooling towers are icons of 20th century architecture. There are 12 towers at Drax. Each is 115 metres tall – big enough to house the dome of St Paul's Cathedral or the Statue of Liberty, with room to spare. The noise that they make is similar to that of a waterfall as the cooling water pours down the inside of them. Just 2% of water vapour escapes out of the top: you think it must be much more than this when you see the clouds billowing out across the landscape. The majority of water is returned to the River Ouse.

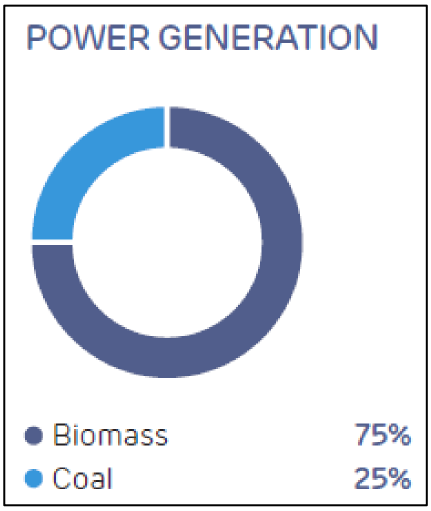
We saw almost every step of the biomass power generation process on our tour.

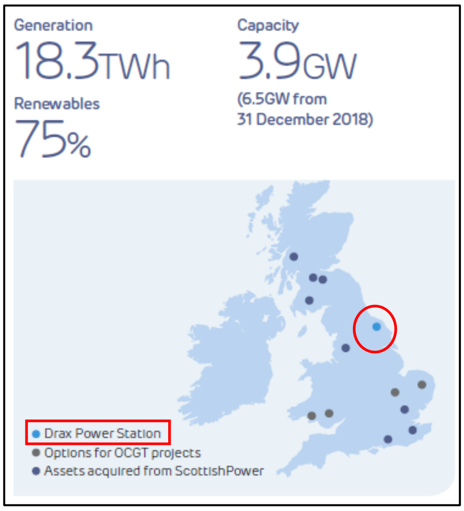


The biomass electricity production process

History

We were met by the Head of Investor Relations, Mark Strafford, in front of a screen showing the current power output of the site. While we were there, Drax was producing almost 7% of the UK's electricity. In 2018, energy production was split as follows:





We were then introduced to Hannah, our very knowledgeable guide who took us around the site. We began in the small museum where the history of Drax was explained to us.

The coalfield at nearby Selby was discovered in 1967 and soon afterwards, the Central Electricity Board began construction on the Drax Power Station. Electricity generation began in 1974 and Drax was officially opened a year later. At the time, it was the most efficient coal-fired power station in operation in the UK and capable of generating almost 2,000 megawatts (MW) of power – enough to service 2 million homes. Capacity was doubled in 1986 making Drax the largest power station in the UK.

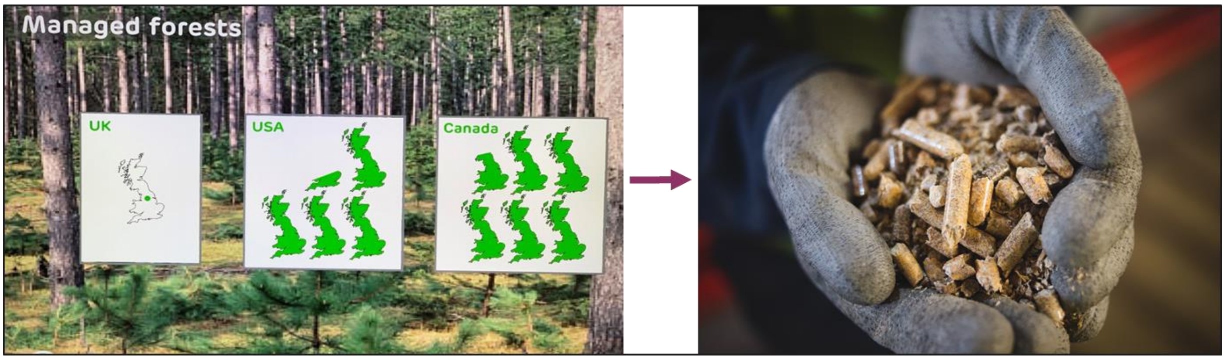
Drax came under the ownership of National Power in 1990 following the privatisation of the UK electricity market; American ownership in 1999; various financial institutions in 2003; and listed on the London Stock Exchange in 2005. Drax introduced energy from biomass in 2003. The reasons for this is that power stations in the UK have a carbon limit. In 2003, Drax was a single entity business so if it wanted to survive, the power station had to move away from fossil fuels and "live" beyond its carbon budget. Other coal stations in the UK, which formed part of large company portfolios, were simply closed as the owners focused on other assets with the portfolio. A result of this is that innovation has been integral to Drax for many years.

Today, Drax is a thermal power plant, where fuel (biomass/coal) is used to heat demineralised water and turn it into high pressure steam which spins turbines to generate electricity.

The need for trees

As explained later in this note, sustainably sourced biomass is classified by the European Union as a renewable energy and one that is essential to transitioning economies away from fossil fuels.

One issue for wood based biomass in the UK is the lack of trees: we simply do not have the required landmass to support a large sustainable forestry industry. To put this in context, we were shown the below image. The green dot in the middle of the UK represents the size of managed forest land in the UK. By contrast, the US and Canada have managed forestry industries that are almost six times the land mass of England, Scotland and Wales. So there is little choice: to do biomass at scale, the UK has to import wood pellets.



Drax imports from sustainably managed working forests located in Louisiana, Mississippi and Arkansas (this is also where Renova source their wood pellets from). Drax suppliers have struck deals with a number of timber companies, who produce wood for other industries such as the building sector, and buy the leftovers from their operations. As a result, ~40%[23] of biomass wood pellets are made of sawdust, which would otherwise be burnt. Other forest debris, such as branches and cuttings taken during the management of the forest, are also sourced. When a tree is cut down, a new one is replanted, which takes about 25-30 years to reach maturity. Due to the wet and warm climate in the southern US, this regeneration cycles was referred to as "quick". In the UK it would take a tree far longer to reach maturity. We were also told that young growing trees absorb more CO_2 than fully mature trees. The US grows more trees than it harvests, a trend that has persisted for over half a century.

Drax source wood pellets from 11 mills in the US, three of which they own through Drax Biomass, a manufacturer of compressed wood pellets. The pellets are physically compressed together – no artificial binding is needed, something that surprised us when we saw the tightness of the pellets up close. They are then loaded onto ships and sent from the Port of Greater Baton Rouge, on the Mississippi River, across the Atlantic, arriving at the ports of

[23] We were told different numbers for this figure ranging from 37-45%.

Tyne, Hull, Immingham or Liverpool. This journey takes about 19 days and Drax are working hard to improve inefficiencies in the supply chain, both in terms of time and environmental cost. Once in the UK, biomass pellets are loaded onto specialist freight wagons and make the journey by rail to the power station. One issue Drax faces is the sheer inefficiency of the northern rail system. A cargo train from Liverpool to Drax currently takes 9 hours (for context Google Maps suggests it takes 2.5 hours by car).

Each ship from the US typically holds 62,000 tonnes of biomass pellets. Each train carriage holds 70 tonnes of pellets, so the trains are long. These numbers start to get scary when you consider that each biomass unit at Drax gets through 8,000 tonnes of pellets a day. There are 4 of these biomass units: so every two days they get through a ship's worth of biomass. Or to put it another way: each freight wagon holds just 5 minutes' worth of fuel.

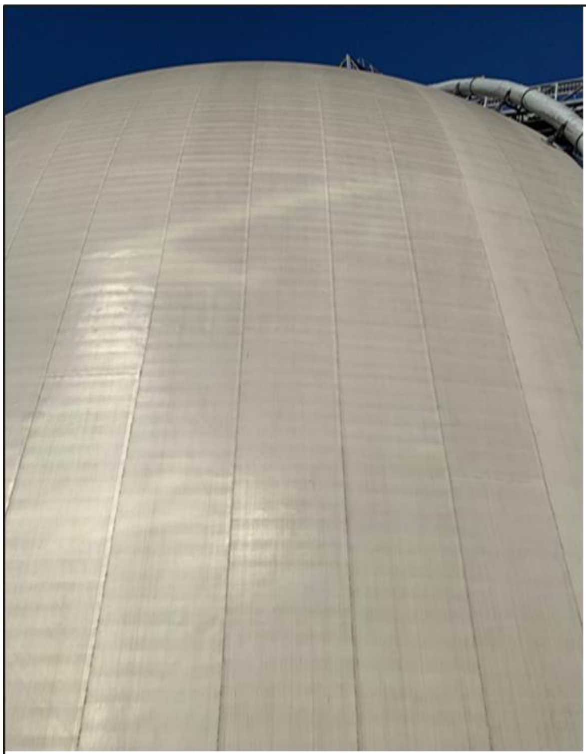
Each Drax freight wagon holds 70 tonnes of biomass pellets, equivalent to just five minutes' worth of fuel.

Unlike coal, which can be stored in the open air, biomass must be kept dry. The ships and trains therefore need to be covered. While we were at the site, we saw a train unloading its biomass load by driving through a special warehouse. Travelling at a steady 1mph, sensors automatically opened doors at the bottom of the carriages and the biomass pellets fell out onto a large conveyor running beneath the train which whisked the pellets off to the four biomass storage domes (not to be confused with the four "biomass units" which burns the stuff).

Bouncy castle domes

There are four biomass domes on site. Each is bigger than the Royal Albert Hall in London. We saw a video of them being installed. The outside is made from the same plastic material as a bouncy castle – and just like a bouncy castle, they were inflated before being reinforced with concrete and wiring on the inside. It only took 55 minutes to inflate them but they soon discovered one slight problem: there was no doorway, so no way of getting inside the domes to do the reinforcement work. The solution was simple: they used a stanley knife to open a hole, later turning it into a proper doorway. This approach seems to sum up Drax: they are innovating across a complex site and problems arise the entire time – solutions are needed quickly and often just require a bit of common-sense thinking.

Each biomass container has a capacity of 80,000 tonnes, enough fuel to power Leeds, Manchester, Sheffield and Liverpool for a number of days. Just like the trains, the biomass domes empty from the bottom and the biomass pellets are then transported across the site via a covered conveyor system.



One of the four "bouncy castle" biomass storage domes

The covered conveyor belt emerges from the ground transporting pellets away from the biomass domes

All of the six cooling towers were in operation during our visit. It is only during the warmer summer months when energy demand reduces that the station slows down enough for proper maintenance work to take place.

Coal and innovation

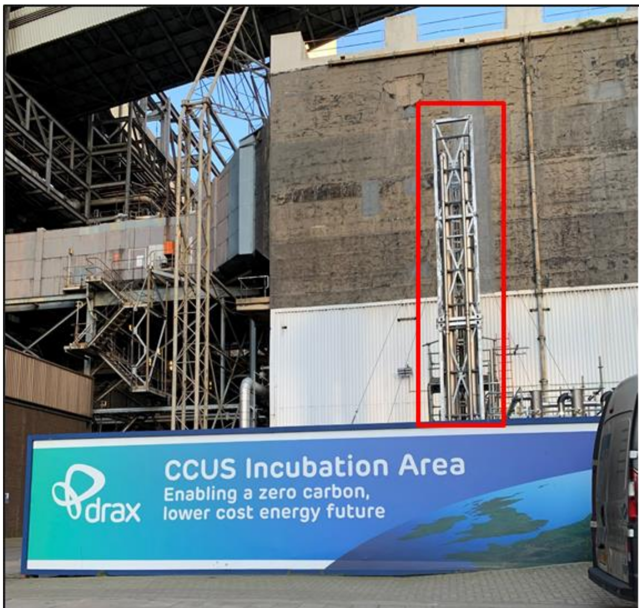
When it is really cold, Drax have to supplement energy produced from biomass with coal-powered energy. The tall thin coal chimney was smoking during our visit. The coal piles are show in the foreground of the picture.

The transportation of biomass from the other side of the Atlantic is one of the major criticisms biomass energy faces, so it was interesting to hear that the coal on site is shipped from wherever makes most economic sense. The coal that we saw came from Colombia.

After the biomass pellets leave the storage domes they are filtered for impurities before making their way into the furnaces. We drove around the site (in an electric vehicle) and the scale and complexity of what you are seeing really strikes you. It is easy to imagine the station being constructed with lots of trial and error, in an age when you couldn't use computer simulation to experiment with designs. As a result, you get the sense that you are in a maze of pipes, tunnels and chimneys. We were told that it was incredibly complex to reassign various parts of the system to biomass from coal.

Drax are continuing to innovate. A project launched last year is capturing carbon dioxide from part of the biomass energy process. Currently, this is a small scale pilot project run in conjunction with Econic Technologies and Deep Branch Biotechnology. The project currently captures (and then releases) 1m tonnes of carbon dioxide. It is all about developing viable technology that can be scaled up. If they can roll this out across the site, then they could start to capture over 10 million tonnes of CO_2 a year which would then be stored under the North Sea. Power stations are only allowed to emit a certain amount of carbon over their lifespan, so this could increase Drax's lifespan, safeguarding an important energy source for the UK and making it cleaner. Looking further ahead, this could become a revenue stream: if Drax can scale up carbon capture to a point where their own are emissions are "negative" then they may be able to trade this or receive carbon credits versus companies whose emissions are carbon positive (it is forecast that some industries will never be able to fully eradicate their carbon emissions completely).

However, they have a long way to go to upscale the technology. The pilot project, shown in the left-hand image below, needs to work in the flue gas desulphurisation pipes show in the right-hand image (which currently removes 90% of sulphur dioxide (SO2) from emissions). For context, these are bigger in diameter than the channel tunnel:



The red box indicates Drax's carbon and capture capability.

To scale this across the site, these small pipes need to become as big as the ones shown on the right

This will not be easy. Managing the station's emissions, we were told, *"is like an octopus balancing on a pencil with a weight on each leg"*.

Controlling the furnaces

We were shown into the control rooms, where for obvious reasons we were not allowed to take photos. The main control room was vast, but surprisingly empty. The reason for this was that when the station was designed, powerful computers took up huge amounts of space. These have now been replaced by thin screens and modern computers showing every data metric possible on the site (for example a sonar system on the inside of the biomass domes feeds back data on how full the domes are, while video monitors show every stage of the biomass conveyor belt journey). Despite this technology, we did notice a desk with a master-key in it in case the site needed to be manually shut down.

Inside the heart of the station, we began to get closer to where electricity is actually generated. The images below (from left to right) show the enormous wood pulverising machines which compress the wood pellets to dust, making them much more efficient to burn. These machines are loud and thump so hard that the ground shakes beneath them with the vibrations of a small earthquake (it was slightly alarming being so close). The image in the middle shows an enclosed fan which pushes hot air through the system ensuring that the furnaces are properly heated. The final image shows one of the incinerators, suspended above our heads.


The machines pulverising the wood pellets to dust


One of the large fans


An incinerator suspended above our heads

A feature of this room was the cold. Despite the efficiency of the fans, Drax engineers worked out that warm air in the room needed to be pushed into the upper reaches of this building. The solution was to keep all of the massive warehouse doors open. This sounds counter-intuitive, but the cold air rushes in and the warm air is pushed up. Another example of a practical, common-sense solution.

We then climbed into the upper reaches of the building to the turbine hall….

The turbine is almost in sight…

… and between a spaghetti of twisting pipes we saw what this whole process – that involves the planting and maintenance of forests in America; the manufacturing of wood pellets; ships sailing across the Atlantic; trains crossing the UK; storage domes; conveyor belts; pulverising machines; fans; incinerators; and bond-like control rooms – is designed to do: **spin a turbine**.

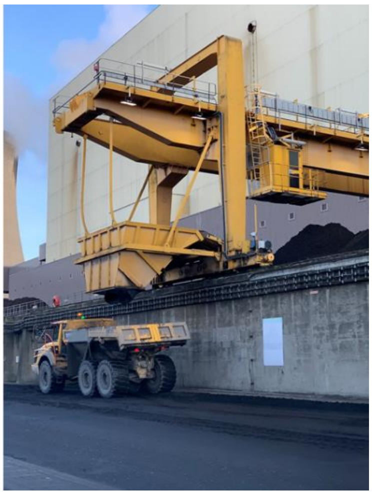
There are six of these blue turbines at Drax. Together they are capable of generating 18 terawatt-hours (TWh) of power a year. That is an awful lot: a terawatt is equal to one trillion watts of power (10^{12}), enough for over 6 million homes. Each blue turbine produces approximately 1.5% of the UK's electricity. It is quite an extraordinary feeling standing next to them and thinking about what would happen to millions of people if they failed.

This energy is transmitted directly to the energy grid. Back outside, we saw a section of the national grid.

Mark enjoyed standing in front of the section that sends power to Leeds, where his daughter lives. You could hear the crackle of electricity as it passed through the cables above our heads.

Of course, this is not totally the end of the biomass journey. Once the pellets have been burnt, a non-harmful ash residue is left over. This is collected by huge trucks and taken to be buried locally at a place called Barlow Mound.

This has been created as a means of safely storing the ash created at the power station. More than 301 million m^3 of ash is safely stored at the site, on top of which grasses and trees have been planted to allow nature to thrive. Surprisingly, it has been classified as an area of natural beauty. There are projects to see if the ash can be re-used in some way, either in the building industry or for compost.



Site Visit Conclusions:

- Visiting Drax makes you think about electricity differently: lightbulbs come on with the flick of a switch in our homes and offices, but its creation involves complex systems spanning many geographies;
- Innovation is central to the culture at Drax: it has successfully transitioned from 100% coal to 75% biomass in under two decades;
- The carbon capture project is small in scale, so it will be interesting to see if this can be successfully rolled out across the site;
- Will "BECCS" – bioenergy with carbon capture and storage – allow biomass to produce "negative emission" energy?
- We need to keep on top of developments in carbon storage: how viable is North Sea storage and what are the long term environmental impacts?
- The lack of a fully functioning carbon pricing market is a major limitation on net zero/negative emissions programmes. Companies need to be incentivised.
- Biomass provides a steady and reliable form of energy, unlike wind and solar which is weather dependent;
- Biomass can help ensure a stable energy grid during the rapid decarbonisation that needs to occur;
- Currently, biomass in the UK is only viable due to subsidies, which expire in 2027. Drax are working hard to eliminate inefficiencies in the process, of which we were told there are many;
- On top of this, Drax have committed to phase out coal production completely by 2025;
- However, the arguments against biomass continue to rage and it is important to understand these issues, which are explored in "Part 1" of this report.
- We debated the issues around biomass generation with the Head of IR over a sandwich in the staff canteen. The main takeaway was that in Drax's opinion, biomass does form part of the renewable energy mix, but only if it is sustainably sourced.
- He kindly agreed to arrange a meeting with Dr Rebecca Heaton, Drax's Head of Climate Policy who also sits on the UK's Committee on Climate Change. This meeting is referenced in Part 1.

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