New Civil Engineer

Crunching Carbon | Converting Drax from coal to biomass

4 February, 2016 **By** Katherine Smale

Redesigning freight trains, learning about dust as an explosive, building inflatable storage domes on a heavily congested site this is the story of how Drax power station has gone from coal fired power station to biomass.

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Projects such as this surely do not come up very often. Drax, a 4,000MW coal fired power station in Selby, North Yorkshire was once one of the biggest carbon emitters in the UK. But after the government announced plans to close coal fired power stations by 2025, its owners made the do or die decision to convert three of its six boilers from coal to low carbon biomass.

The journey saw the chief engineers on site having to break down the whole fuel delivery and energy production process from scratch – from setting up a sustainable fibre processing plant in the United States, building new infrastructure at four ports in the UK, to redesigning the freight trains the power station uses and working with Network Rail to maximise the volume of material it could transport. It also had to design and build a vast new processing unit, threading around the existing infrastructure on site.

All this, while maintaining 8% of the UK's power supply to the grid.

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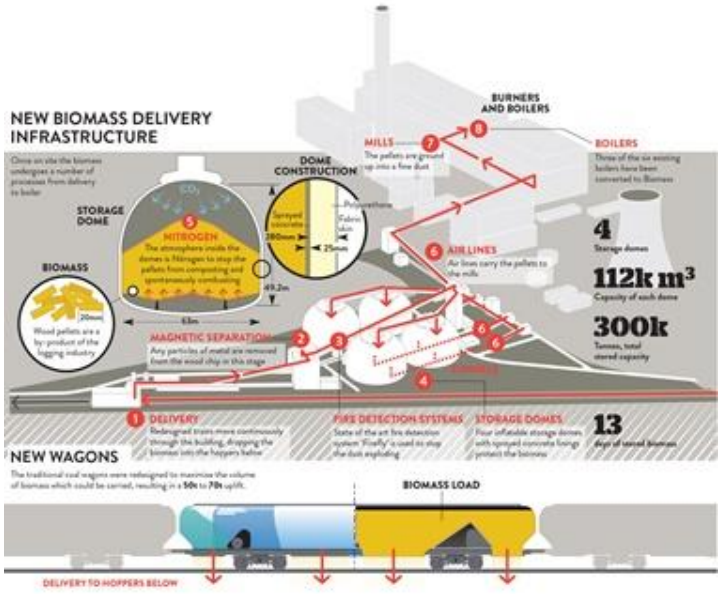
From the moment the power station's operator Drax Group decided to convert its boilers to biomass, its team faced a steep learning curve. The engineers, who had spent years working with the coal industry, had to examine every aspect of the new biomass process with huge challenges at every stage. Lessons from examples of other biomass power stations were drawn on, but all had subtle differences which made the application of the technology in the UK very difficult.

One of the first steps was to find a source of biomass fuel. This caused some controversy, when it was suggested in the press that the power station was using entire trees as a source of wood chip. However Drax says that this is not the case and sustainability has been at the heart of the project from its very conception.



The raw material which the power station will actually use is a by-product of the logging industry. In fact the wood that is used is from the tops of trees, weedy branches and bent trees which have no value to saw mills and would typically be burned or left to rot. And it only uses wood that comes from sustainably managed forests.

"There are good ways and there are bad ways to buy biomass," says Drax Group chief executive Dorothy Thompson. "Good biomass is low carbon all the way along the chain. All the biomass we buy is good biomass. We take our wood from large working

drax biomass process

forests from sustainable sources and we measure the carbon cost at every single stage from the ships to our processes on site, and it delivers an 86% saving compared to coal."

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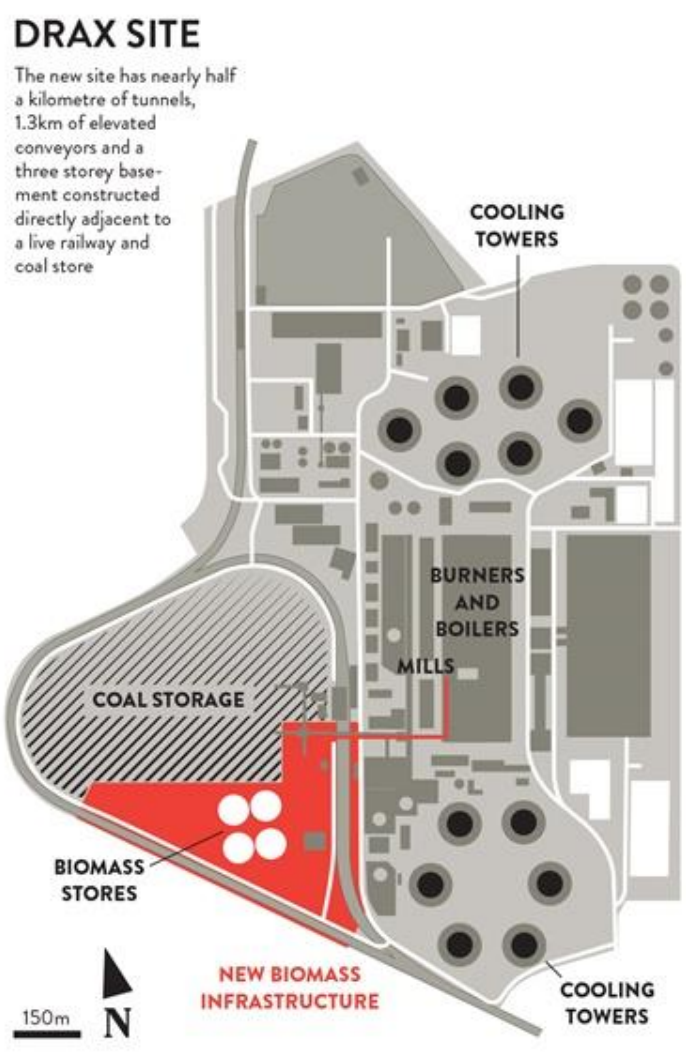
> Jason Shipstone

Drax sources the raw wood from around the world, but its primary source is in the US, where the engineers went to great lengths to ensure that the end result was sustainable. Each stage of the process from collecting the waste product from the logging industry, processing it into pellets to remove the water, to transporting it long distances to the two ports ready to be shipped to the UK, was optimised to minimise its carbon footprint (*see box*).



drax biomass site plan

But sourcing the biomass was just the beginning of the story. The web of interconnected challenges around transporting the pellets in the UK, the logistics of how to store the biomass and building the infrastructure on site all still had to be worked out.

The starting point was the storage of the biomass on site.

"The coal stock is 72 days' worth of storage, when you work out how much equivalent biomass volume you need, you do it once, you do it again and then you do it a third time and go, that's a big number," says Drax Group production and logistics director Brian Greensmith.

"The biomass is twice the volume of coal and unfortunately you can't get it wet so it can't be stored outside."

With this in mind the team now had to come up with a way to build the huge storage facilities needed around the existing power station infrastructure. The solution lay in building four inflatable domes (*see box*).

Heavy engineering and the domes

Putting the infrastructure in place on site to cope with the new biomass fuel was no mean feat. In two and a half years, the team managed to transform an area of the site previously used to store huge quantities of coal into a colossal new industrial processing plant.

As part of the work, the team had to design and build 1.3km of new 5m wide conveyors which rise to heights of around 75m above ground. It also had to build a huge new three storey basement area directly adjacent to the live railway and large coal heaps, to process the biomass pellets which were delivered at ground level and dropped into the hoppers below.

The domes are a triumph of engineering in themselves. Each of the four 63m diameter, 49.2m high buildings were constructed and operational in just 20 weeks. Preparatory works involved construction of two 210m long, 5m high and 4m wide precast concrete tunnels underneath the domes which transport the stored fuel to the processing plant which eventually delivers the biomass to the boilers. Reinforced concrete rings were cast for the dome foundations. However this is where the normal building process stopped. "Bouncy castle" fabric 1mm thick was laid out over the area and the domes were inflated [see timelapse video here]. It took just 53 minutes for each of the domes to be inflated.

Four inflatable storage domes nearing completion

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"From starting the fans up to having a dome fully inflated was just under an hour," explains Drax construction project manager Andy Priestley. "We had an instant dome.

"While you construct the dome, there's an airlock, anything which can't be carried in by hand has to be there inside before the dome skin is laid out."

Once the domes were inflated, a 50mm thick protective and sacrificial polyurethane coating was sprayed on which allowed the 500t of reinforcing bar to be fixed to. Around 3500m^3 of sprayed concrete was then built up in 25mm layers to a thickness of 280mm. Large openings were then cut in the tops of the domes to allow the dome heads to be installed.

"Each of those four domes holds about 112,000m^3 of fuel, so we have just short of 300,000t of biomass storage verses about 2M.t of coal stock," says Drax engineering manager Jason Shipstone. "So instead of having about 70 days, we have about 13 days' supply. This power station has never worked on such a limited amount of fuel for three units before."

With the amount of material able to be stored on site reduced to just 13 days' worth of fuel, the team was determined to streamline the transportation process.

"The logistics in the railways, the infrastructure that supplies coal to Drax, it just wasn't geared up for that amount of pressure and that intensity of time," says Shipstone.

> Basically we told the men assume you're handling gunpowder
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> Jason Shipstone

The first stage was to work with Network Rail to move the freight trains on to a passenger train-like timetable. This was crucial to making sure that the rail network didn't disrupt its supply and vice versa.

"Traditionally the freight operating companies controlled where the assets were moving. Our vision was to make our logistics perform like a passenger train," says Greensmith. "We've done a lot of work on site to make our turnaround times more predictable."

Realising that simply increasing the number of trains to site alone wouldn't be able to deliver the volume of pellets required, the team then decided to redesign the traditional freight trains to maximise the volume of biomass they can carry.

"The brief was, NASA wouldn't make a better one," says Greensmith.

The team started from the wheels up. By changing to a more box like wagon shape, lowering the body so it sits closer to the track, reprofiling the top to efficiently fit in the Victorian tunnels and bridges and changing the position of the unloading doors, the new wagons are now able to carry in excess of 70t of biomass, compared to the 50t, which previously designed wagons were able to carry.

"We have doors outside of the wheels, which is completely new," says Drax Group head of supply chain and logistics Graham Backhouse. "No one had done anything like that before. We designed it to maximise the cubic capacity to run within our Victorian railway system."

They also completely redesigned the track layout on site to increase the efficiency of the deliveries.

"We used to run round our site at 5mph (8km/h) now we've changed that to 15mph (25km/h) and change the signals as the trains are longer," says Greensmith. "We turn around a train in 90 minutes now."

The new redesigned, longer trains and just-in-time delivery meant that the entire 2.8km long rail network around the site also had to be redesigned.

One of the 1.3km of 5m wide conveyors which rise to heights of around 75m above ground

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The trains now deliver the biomass to site, moving slowly, but continuously through the purpose- built, twin-track unloading shed dropping the pellets to the hoppers below. But, if the plant is to run smoothly and safely, the dust created by the movement of these near dry pellets has to be rigorously controlled.

This dust was one of the biggest challenges for the team. If particles of the combustible material are allowed to build up in the air, they can cause an explosion.

“Basically we told the men: ’assume you’re handling gunpowder’,” says Shipstone.

To control the dust, teams of people with industrial vacuum cleaners clean each of the rooms daily and there are pointed cones of foam on top of all flat ledges to prevent a build-up. State of the art fire detection systems have also installed inside the buildings, conveyors and tubes which carry the pellets and crushed material.

Inside the domes, the wood pellets also presented another problem. To store the required volume of biomass on site, it had to be piled 50m high within the domes. However, left to its own devices, this organic material will try to compost itself, giving off heat in the process. Small stock piles pose no particular threat, but as the size of the pile increases there comes a point where the heat being generated is more than the heat being lost to atmosphere through convection from the pile’s surface and through conduction to the floor. At this point spontaneous combustion can occur, with disastrous consequences.

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To control this and prevent the biomass from catching fire, the team had to limit the supply of air. So the team decided to replace the surrounding air with inert nitrogen. With no real precedent for this, the team had to model the flow of the nitrogen around the domes to ensure that this atmosphere would be sufficient to stop the composting effect.

At present, three of the generating units have been converted to biomass and with the right government support, Drax could convert the remaining three. With all of the infrastructure needed to process the pellets already built at the site, including the domes which have enough capacity to feed all six boilers, the team is confident that converting the remaining units can be done quickly and far more cheaply than for the original project.

Delivering the biomass pellets

From the managed forests to the processing plants, Drax has set some high standards around the sustainability of its biomass supply.

The wood itself is sourced from all over the world; Portugal, the Baltics and Eastern Canada, but most of it comes from two Drax-owned sites, one in Gloster, Mississippi and the other in Morehouse Parish, Louisiana. The thinnings and the unwanted wood chips, which are sourced from nearby forests, are then transported to the two plants by a sub-contractor before the moisture they contain is removed. These new pellets are much lighter than the original wood chip, making transport to the ports far more energy efficient.

As part of the conditions set by Drax, the companies transporting the material to the production plants must always use the most up to date vehicles, coinforming to the highest low carbon emissions standards.

From the Louisiana plant, the pellets are transported by heavy duty trains to the port at Baton Rouge, Louisiana ready to be shipped to the UK.

“In the US we can carry 8,000t by train, as a guide, we can carry 1,700t as a maximum in the UK. The trains are 3.2km long, so we run one train a week in the US to Baton Rouge,” says Drax head of supply chain and logistics Graham Backhouse.

Once at port, the pellets are shipped to the UK. Even this process has been optimised to ensure that the amount of material arriving at the ports is the right amount to then be shipped in the most efficient freighter possible. Huge new storage and handling facilities were built at the ports in the US and in the UK.

Four UK ports, Hull, Tyne, Immingham on the east coast and Liverpool on the west coast were chosen to take in the pellet shipments. Liverpool was chosen for its proximity to the West Coast Main Line, so that supplies could be maintained if there were problems on the east coast main line.