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Sometimes Black Pellets are the Optimal Choice for Power Stations Replacing Coal

Introducing a new *FutureMetrics* dashboard that helps determine which pellet fuel is the optimal choice.

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Key considerations are pellet fuel cost and energy density, capital cost for the modification from coal to pellet fuel, and coal pulverizer capacity[1].

This short document describes the decision-making model that every power boiler operator that is considering conversion from coal to pellet fuel should use. The decision-making model is built into an interactive dashboard that allows the user to experiment with a variety of inputs and see how, under some input combinations, black pellets, not white pellets, are the optimum choice for fuel. An outline of the what the dashboard does, and a screenshot of the dashboard are below. The dashboard is HERE.

Despite more than a decade in which so-called black pellets produced using either torrefaction or steam treatment (ST)[2] have been touted as a better solution, the industrial pellet fuel sector is dominated by white pellets. There are two primary reasons for this:

(1) The thermal treatment of wood fiber results in both mass and energy losses. Thus, not every gigajoule (GJ) of energy in the feedstock ends up in the pellet fuel. Therefore, the feedstock cost per GJ in black pellet fuel is higher than the cost per GJ for white pellets. In short, black pellets will always be more costly to produce per unit of energy in the fuel than white pellets if the mass losses are not monetized well.

(2) The technological processes for producing torrefied or ST pellets have often not been reliable and/or safe. There have been many projects and technologies that have failed to make it into profitable commercial operation for producing black fuel pellets to replace coal in power generation. As a consequence, potential end users are rightly skeptical of black pellet projects.

Some of the cost of production differential has been reduced for ST pellet production. The production of biochemicals (primarily furfural) from the mass losses has created significant net positive additional cash flow per

[1] See HERE for description of power station coal pulverizers.
[2] This technology has been known as "steam explosion". However recently the terminology has evolved to use descriptions that do not use the word explosion.

unit of input feedstock. The mass loss is converted into a net value add. Therefore, the price per GJ for ST pellets can be much closer to the cost per GJ of white pellets.

There is R&D work on creating a value-add from the syn-gasses created in the torrefaction process. Currently, that gas is simply used as fuel in the reactor and as gaseous fuel for co-located industries that need 24x7x365 heat. The mass losses that are embodied in the syn-gas are not (yet) upgraded to higher value chemicals. Thus the price per GJ for torrefied pellets has to be higher than for white pellets. If there is biochemical production at the ST pellet factory and no additional value from the torrefaction mass losses, torrefied pellets will be more costly per GJ than ST pellets.

There are now a few examples of ST and torrefied pellet factories successfully operating at commercial scale. For proven commercially operating processes, technology risk has been assuaged for both the thermal treatment of the wood and the production of furfural. Skepticism should remain in place. But after due diligence, some technologies will pass muster in terms of reliability, safety, and the consistency of expected cash flows.

The security of fuel supply is essential for the end user. The white pellet sector is large with many dozens of production facilities. The delayed start for reliable black pellet production means that the black pellet sector is small with limited production facilities.

This analysis focuses on the economics of choice. However, when considering the use of torrefied or ST pellets, the buyer should engage in due diligence and include a focus on supply chain robustness.

This is not an insurmountable hurdle. Just like the typical project development model in the white pellet space, if the end user can commit to a known demand at a fair price, then multiple producers can make investment decisions for the new supply demands. Furthermore, there is an efficient pathway to "bolting on" the thermal treatment equipment to existing white pellet plants[3]. This would leverage the already robust white pellet supply chain.

The Key Decision Metrics

The decision, white or black, ultimately depends on which yields the lower total cost per megawatt-hour (MWh) generated. The total cost per MWh is based on several inputs.

The fuel cost per MWh generated will be higher for torrefied and ST fuels[4]. But that is offset by other factors that contribute to a lower total cost per MWh.

The capital cost for conversion from coal to pellet fuel will be lower for black pellets than for white pellets.

[3] Please contact William Strauss at FutureMetrics to learn more. WilliamStrauss@FutureMetrics.com
[4] At least with the ST process, if the net cash flows from a furfural production offtake agreement are high enough, it is possible that ST pellets can be price competitive with white pellets on a $/GJ basis.

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The primary reason is that with most black pellets the power station does not have to build large and costly dry storage domes or silos to keep the pellet fuel from being exposed to rain and snow. ST pellets and some torrefied pellets do not lose their mechanical characteristics when they get wet and thus can be stored in the open in existing coal yards and handled by existing reclaim systems. Based on data from completed bioconversions[5], the domes or silos needed to store white pellets and keep them dry are about 50% of the total capital cost for converting a power boiler from coal to pellet fuel.

The modification costs have to be recovered from the megawatt-hours generated. The cost of conversion and the total number of MWhs that these costs are spread over (number of years) will determine the CAPEX per MWh. The screenshot of the dashboard on the next page has a default setting of $700,000 per MW of design capacity for a full modification from coal to white pellets with the financial investment return term equaling 15 years. The dashboard setting has black pellets avoiding 60% of that cost. The power station bioconversion for black pellets will result in a lower capital cost per MWh.

If dry storage is 50% of capital costs, why are the avoided costs 60% on the dashboard? The characteristics of black pellets versus white pellet and the higher energy density per tonne of black pellets are the reasons. The modification costs will likely be lower due to better compatibility with the existing fuel feeding pipes and the burners. The pulverizers may require fewer or no modification for optimal size reduction and fuel flow. New conveyance from the fuel storage to the pulverizers is not needed. And downtime for implementing the modifications will likely be significantly lower.

The higher energy density has another even more important impact. It will lower the likelihood of there being a constraint based on puliverizer capacity.

Power stations can easily modify burners but adding new pulverizing capacity is complex, expensive, and would cause increased downtime. It is typically not part of the conversion model.

The dashboard (at its default settings as shown on page 5) yields a capacity constraint with white pellets that causes an unavoidable derating of the system from the design capacity of 350 MWs to 251 MWs. At the dashboard's default settings, the number of pulverizers are more than sufficient for coal and are just enough for the higher energy density ST pellets. Note the dashboard can be switched to torrefied pellets which are typically higher energy density than both white and ST pellets.

The lower energy density of the white pellets results in a 23.2% derate because not enough tonnes per hour can be pulverized to get enough energy into the boiler with white pellets. Note that the dashboard has the maximum average pulverizing mill availability a bit less than the total number of mills. The assumption is that planned and unexpected maintenance will take the pulverizing mills offline from time to time.

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[5] From several FutureMetrics projects and other sources. For an example of the magnitude of the needed dry storage, see HERE.

The screenshot shows that given the lower number of MWhs generated from white pellets due to derating combined with the higher conversion cost yields a net capital cost benefit per MWh with ST pellets.

Combining the higher fuel cost per MWh with lower CAPEX per MWh, given the settings shown on page 5, yields a net result that favors ST pellets.

Note that the capacity factor is a critical input. The assumption shown is 50%. The lower the capacity factor, and thus fewer MWhs to absorb costs, the more that black pellets will be favored over white pellets.

After setting the inputs to approximate a given project, the prices per GJ (and thus per tonne at the assumed energy densities) for white and black pellets can be moved to see where the indifference point is.

- **Low capacity factors will often result in black pellets being favored.**

- **Constraints on pulverizer capacity that result in significant derating with white pellets will often result in black pellets being favored.**

Each power station unit is unique. But the objective of minimizing the total cost per generated MWh is not.

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