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What is the Pellet Fuel Storage Solution when a Power Station using Pellet Fuel only Operates During Part of the Year?

A short paper and a dashboard

By William Strauss, PhD, President, FutureMetrics, June 17, 2024

This short paper and the accompanying dashboard show the consequences of a mismatch between white pellet consumption at a power station with a low capacity factor and white pellet production by pellet factories with offtake agreements for that station. The dashboard illustrates the significant capital cost savings of avoiding the dry storage requirements of white pellets by using waterproof steam treated pellets[1].

The problem is best described with an example. The default input settings in the dashboard as shown on page 3 illustrate the inventory management challenge. The reader can open the dashboard in your browser by clicking HERE.

At the default settings of the dashboard, the hypothetical power station has a 450 megawatt (MW) pulverized coal (PC) unit that will be modified to replace coal with pellet fuel[2]. But the unit will only run at a 40% capacity factor (4.8 months per year). That is, it will only be needed during peak demand months.

Given the assumed efficiency of the unit and the assumed energy and bulk density of white pellets, the station will need about 811,000 metric tonnes per year of white pellet fuel.

811,000 tonnes of pellets will be consumed over just under 5 months. But the pellet mills that produce the pellets operate almost every day of the year. The forest products industries that supply feedstock to the pellet mills, such as sawmills, do not stop making pellet production feedstock; and the business and operations models for pellet production require near continuous production.

Thus, using the dashboard's default setting with 20% of that annual demand not in storage at the power station (i.e., at the pellet mill, on vessels, or in other storage), the minimum storage needed at the power station is about 389,000 tonnes. That is the equivalent of 5.2 "Drax" domes[3]. Using an assumed cost of $270 per cubic meter of effective storage space in a dome[4], this hypothetical 450 MW unit would have to spend nearly $162 million just for domes (or silos) to manage the inventory buildup of the white pellets.

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[1] The reason that FutureMetrics focuses on steam treated (also known as steam exploded) pellets for power generation is explained in detail in a recently published FutureMetrics study. The abstract and the table of contents can be viewed HERE.
[2] Pellet fuel is used in PC power stations to replace coal in many locations around the world. FutureMetrics has a Global Pellet Markets Overview report. Table of contents is HERE.
[3] See HERE for more about the Drax power station. The station is a baseload asset in the UK grid that produces about 10% of the UK electricity from 100% pellet fuel. The Drax 2000 MW station has four domes and produces in the neighborhoods of 12.4 million megawatt-hours (MWh's). The hypothetical 450 MW unit running at 40% of the year would produce about 1.6 million MWh's but would need more dome storage than the Drax station.
[4] This is a very high-level estimate that includes the domes, the engineering, the site work, and other costs. A specific project will have costs that may be significantly higher or lower then this default setting of the dashboard.

But what if the power station can use its existing coal yard?

Given the typical size and stacking height of PC power station coal yards, in most cases there is enough room.

But the pellet fuel must withstand exposure to rain, snow, and ice without the loss of its mechanical characteristics and without absorbing much water (for details, refer to the link in footnote 1). Another FutureMetrics white paper and its accompanying dashboard[5] discusses the decision-making algorithm for deciding when higher cost water resistant pellets are favored over hydrophilic white pellets. That paper and dashboard do not consider the inventory management issues discussed in this paper and illustrated in the dashboard.

At the 40% capacity factor of the generating unit shown on the next page, given expected costs for white and steam treated pellets, that station would choose steam treated.

The primary reason is to avoid the significant capital costs associated with white pellet dry storage. The storage volume needed, and the cost, are significantly amplified when considering how to manage the mismatch between consumption over just a few months of a product that is produced all year long.

Waterproof pellet fuel that can go in the coal yard takes the capital cost (CAPEX) for storage from nearly $160 million to zero if the existing coal yard's size is sufficient and its coal stacking and reclaiming infrastructure can be used for the advanced pellet fuel (which in most cases it can).

Because the steam treated pellets have a higher bulk density and higher energy density, under the assumptions in the dashboard, they carry 1.33 times more energy in a cubic meter than white pellets. That means significantly fewer cubic meters of space are needed versus white pellets.

The bottom left corner of the dashboard has dimensions for the coal yard. The height and width inputs can be changed and the length is calculated for the storage volume needed.

The default dashboard settings allow storage inventory to go well below one week supply of onsite fuel! This is likely undesirable for most power stations. The slider control with the red handle allows the addition of a buffer to increase the low point in the chart. Note that this increases the baseline storage requirement and the estimated CAPEX for white pellet storage domes.

Lower capacity use of existing PC power stations is a likely trend over the next few decades. Wind and solar generation coupled with increasingly robust energy storage will gradually decrease the need for on-demand generation. But for a few decades at least, especially during those months of high demand due to heat or cold, an easy and already pioneered pathway to making that peaking demand with renewable highly carbon beneficial generation is with PC power stations using fuel that is compatible with existing coal storage systems.

[5] See the January 2, 2024 paper, "Sometimes Black Pellets are the Optimal Choice for Power Stations Replacing Coal" at the FutureMetrics website.

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This dashboard shows the consequences of a mismatch between white pellet consumption at a power station with a low capacity factor and white pellet production for that station. It also shows the significant capital cost savings of avoiding the dry storage requirements of white pellets by using waterproof pellets.

At the current dashboard settings, the station will use pellets for 4.8 month per year but the pellet suppliers operate all year long. Building dry storage for white pellets over the 7.2 months that the power station is not consuming fuel is not financialy feasible.

Produced by FutureMetrics

Size of Power Station Unit = 450 MWs

Capacity Factor = 40%

40% Power Station Efficiency = 40% which is a heat rate of 8,530

Annual MWh Output = 1,576,800

Percent Upstream Pellet Fuel in the Supply Chain, not in Storage: 20%

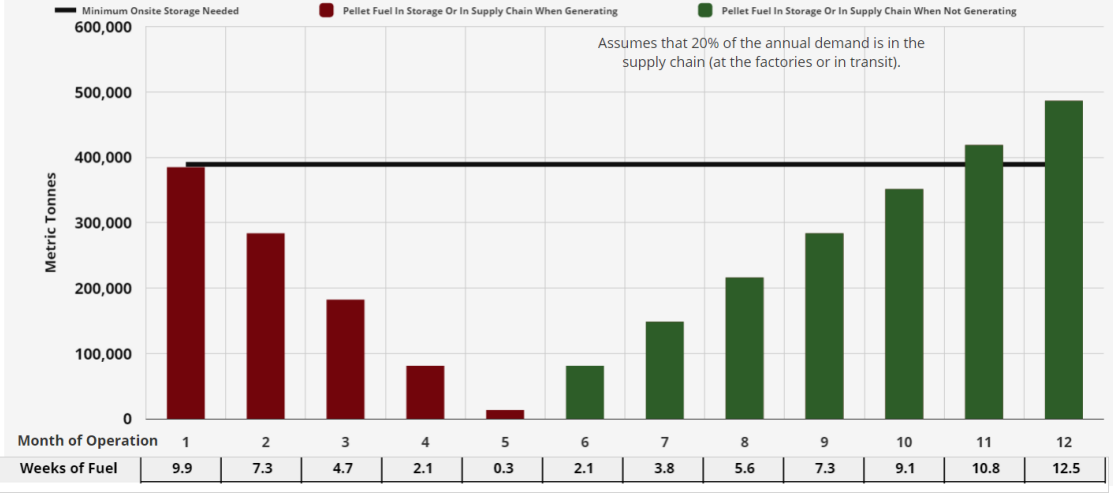
Option for Additional Production in the 5.0 months when generating to increase minumum fuel supply: 0

Minumum Fuel Supply in Weeks = 0.3

White Pellet Storage Needed For A 450 Megawatt Power Station Operating At A 40% Capacity Factor

Red Bars Are When The Station Is Consuming White Pellets

Station Generates 4.80 Months per Year



White Pellets

17.5 Energy Density of White Pellet Fuel = 17.5 GJ/tonne which equals 4.86 MWh/tonne

650 White Pellet Bulk Density = 650 kg/cubic meter

→ White Pellet Energy Density per Cubic Meter = 11.38

810,925

Expected White Pellet Fuel Need over 4.80 months = 810,925 tonnes

Min Pellet Storage Needed for 7.20 Months when no Fuel is being Consumed is 389,244 tonnes or 598,837 cubic meters

Volume needed is equivilent to 5.19 'Drax' domes

The Drax power station domes are 50 meters high and 63 meters in diameter. They each hold about 115,000 cubic meters of white pellets. The Drax power station in the UK generates about 2,000 MWs at a high capacity factor.

Drax Power Station

Dome cost per Cubic Meter $270 ?

Estimated CAPEX for Dome Storage = $161,685,982

Steam Treated ("exploded") Waterproof Pellets

Click here to see why we look at steam treated pellets.

19.5 Energy Density of Steam Treated Pellet Fuel = 20 GJ/tonne which equals 5.42 MWh/tonne

775 Steam Treated Pellets Bulk Density = 775 kg/cubic meter

Steam Treated Pellet Energy Density per Cubic Meter = 15.11

Increase in Total Energy per Cubic Meter for Steam Treated Pellets = 1.33

Using Existing Coal Yard to Store Steam Treated Pellet Fuel

Or ZERO CAPEX

Dimensions of coal yard in meters to store 450,738 cubic meters of steam treated pellets

150 Width 10 Heigth

300 Length (calculated)

+ Add scenario | View all scenarios