Technical Report

On

Big Sandy 2 Fuel Flexibility Evaluation

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1: Purpose

At the request of AEP senior management, Engineering Services (ES) was requested to review all of the available mines for use at Big Sandy Unit 2 assuming that the Central Appalachian coal supply was unavailable. Because this review is part of the Big Sandy Unit 2 FGD design criteria the SO2 limit was set at 4.9 lb/mmBTU.

2: Background

ES Steam Generation Equipment Engineering section (SGEE) sets the fuel specifications for the coal fired fleet. The fuel specifications are established to:

1. Match the quality of the fuel to the design requirements of the units.
2. Allow the units to operate at full load on a continuous basis.
3. Meet all environmental regulations.
4. Provide an acceptable range of coal that will a meet a unit's need without a detailed engineering analysis.

SGEE’s involvement with fuel procurement began in 1979 when AEP’s leadership realized that unit-effective availability within the AEP System was less than desired and that the greatest cause of unit unavailability is often the quality of the fuel being burned. In an effort to improve unit availability, a program was initiated to determine what could be done to improve coal quality and the cost associated with those improvements. Prior to SGEE’s involvement in fuel procurement, the Effective Forced Outage Rate (EFOR) for AEP averaged over 19%. Ten years after the implementation of fuel specifications developed by SGEE, the EFOR rate dropped to nearly 6%. Specifically, Mitchell Unit 2’s EFOR declined from 30% to 5% as shown in the GADS data graphed in Attachment 1.

AEP’s 800MW units (Amos 1&2, Big Sandy 2 and Mitchell 1&2,) are sister units designed by Foster-Wheeler. Since Big Sandy Unit 2 and the Mitchell Plant share a common design, it is appropriate to review some of the lessons learned from the Mitchell fuel switch.

The cleanliness of a coal fired steam generator and operating tendencies, are a function of the coal ash constituents. Oxides of iron, potassium, sodium, calcium, magnesium, and combinations thereof have a direct impact on the cleanliness of the furnace and convective surfaces. Two terms that are generally used when speaking of unit cleanliness: slagging and fouling. *Slagging* refers to the build-up of molten ash particles and generally occurs in the furnace and at the entrance to the convective surfaces when flue gas temperatures are higher than the ash fusion temperature. *Fouling* is the build-up of condensed solid ash particles (from a vaporized state) and generally occurs on convective surfaces. Relative levels of the chemical constituents noted above, along with ash fusion temperatures are used as indicators as to whether a particular fuel will be a “slagger”, a “fouler”, both, or neither.

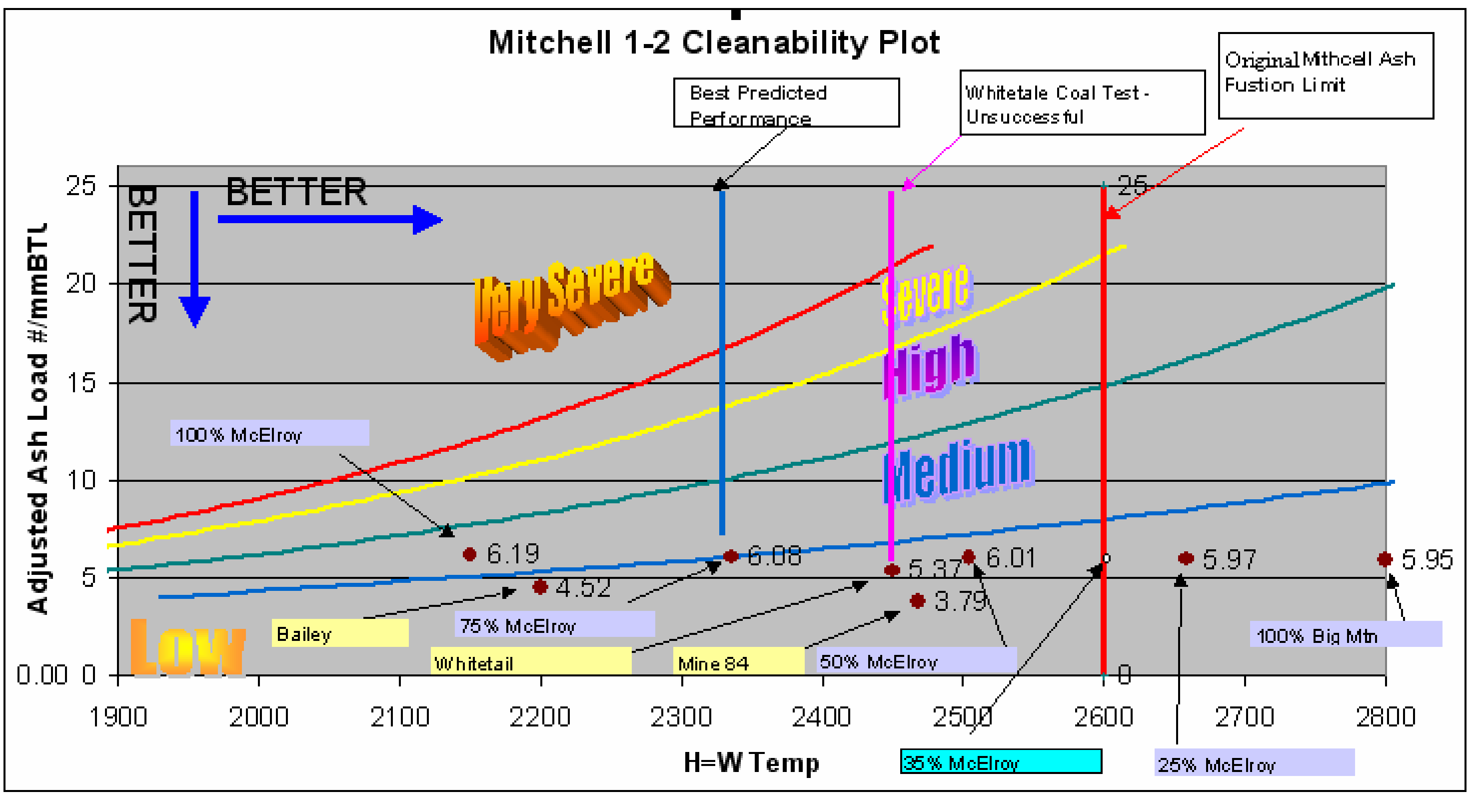
By today’s standards for furnace design with regard to fuel slagging tendencies, the furnace of the 800 MW units are marginally sized for the fuels currently being fired. A common tool for comparing furnace sizes is the ratio of heat input to furnace volume. For the 800’s this ratio is considered to be moderately high for firing the low slagging low sulfur coal.

Consider for Big Sandy 2's heat input to furnace volume ratio is 14,838 BTU/ft3-hr and for Gavin (one of our most flexible units) the heat release to furnace volume is 13,169 BTU/ft3-hr. The "hot" furnaces of the 800's do not readily lend itself to burning coals with higher slagging tendencies.

From the onset of the FGD retrofit program, the problem of using high sulfur, slagging coals were being evaluated against the design of the 800's. Test burns were conducted in 2003 at Mitchell utilizing coals from the Monongahela Valley. The coals from this valley have medium sulfur and medium ash fusion temperatures (an indicator of the ash melting temperature). From a slagging perspective, this coal would be more successful than any of the Pittsburgh #8 coals.

However, the test was unsuccessful due to running slag in the furnace. It was noted during the test burn that the slag in the furnace began running almost immediately. This is a indicator of just how small the furnaces are with respect to heat input and it clearly does not take much slag to jeopardize the reliability of the unit.

As a result of the unsuccessful test burn, a fuel switch study was implemented with Foster-Wheeler at the end of 2003. The result of the study showed the benefit of the nose addition for lowering the furnace exit gas temperatures. The addition of the furnace nose was predicted by the study to allow the use of coals with an ash fusion temperature of 2350°F from the original 2600°F. The change in allowable coal properties are shown in the table below.



The addition of the nose provided an improvement towards greater fuel flexibility. However, the improvements were not great enough to allow a fuel switch to 100% Pittsburgh 8 coals. The ash fusions on these coals typically run about 200°F lower than the new limit. As a result, the design basis for the switch included blending option to make a fuel which the unit could successfully use and maintain full load without the need for derates. This arrangement has been successfully operated on Mitchell 1&2 as well as Amos 1&2. Operating without the blend, and solely on low ash fusion temperature coals from the Northern Appalachian or Illinois Basins, would reduce the unit load to approximately 575MWn (~70%MCR).

Besides the ash limitations, the 800's share a limit on heat input. These units are equipped with six FW-MBF pulverizers. These pulverizers were modified with B&W MPS-89 type grinding elements. Each of the six mills has six outlets with each feeding a 230mmBTU/hr burner. To achieve full load, all six pulverizers must be available. Because these units do not have spare pulverizer capacity, the fuel specifications for these units has a minimum heat content of 11,800 BTU/lb. For comparison, units with spare milling capacity have the minimum heating values set around 10,800 BTU/lb.

3: Available coals for a modified Big Sandy 2 and a 4.5 lb SO2 Scrubber

SGEE was requested to determine what mines would be available for use at Big Sandy Unit 2 without the aid of blending Central Appalachian coals. To conduct this study, the following assumptions were made:

- Full Load is maintained at 800MWn
- The scrubber is designed for a 4.5 lb SO2 coal.
    - For this study, the cut off value was 4.9 lb SO2 (4.5+10%)
- The unit received the Nose addition as well as new burners
    - These items are mandatory to lowering the ash fusion temps below the current 2600°F.
- Chlorine levels are limited to 0.2%
- Only domestic coals were evaluated

To begin the study, a complete list of coals was developed that would meet the fuel specification of the unit without the nose and burners. The specification was less than 4.5 lb SO2 and having an ash fusion temp greater than 2600°F. The list developed into 145 potential mines. In that list, 113 mines are from the Central Appalachian Basin. However, for coals to have high ash fusion temps that typically comes with a low SO2 value. So it was not surprising that on that list of 145, only one coal had an SO2 value which would not be considered low sulfur coal.

Adding the nose and burners allowed the ash fusion temperatures to be lowered to 2350°F. This change allowed for the addition of 20 additional mines (total 165). As was seen in the Base case, the majority of these coals are considered low sulfur.

Big Sandy 2 Fuel Flexibility

Since this evaluation is attempting to remove the Central Appalachian Coals, all coals from that region must also be eliminated. The expectation is that the Central Appalachian coal supply will become limited and the costs will escalate. Once these low sulfur sources are removed, all other competing low sulfur coal sources with similar properties will have their cost increase accordingly. Assuming that it is desirable to limit exposure from price escalation from these low sulfur coals, all low sulfur, high heat coals were eliminated from the list of 165. The remaining non-low sulfur coals totaled 8 mines. These are shown in the table below:

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FGD, Nose and Burners

Region	Sample ID #	Coal Company	Mine	BTU/lb	% ash	% moist	SO2, lb/mmBTU	H=W Red F	%CL	HGI
Central APP	APM133	Massey Coal Sales	Black Castle	12711	9.05%	8.48%	3.6	2458	0.00%	76
	APM138	Lightning, Inc	0	12678	10.93%	7.00%	3.7	2580	0.05%	55
Northern Appalachian	APN002	Consolidation Coal Company	Dilworth Mine	13078	7.27%	6.50%	2.2	2519	0.12%	56
	APN010	Consolidated Energy	Mine 84	12999	7.10%	6.60%	2.4	2480	0.09%	53
	APN019	Mon View Mining Company	Mathies	13176	6.95%	6.45%	2.8	2540	0.01%	53
	APN028	International Coal Group - ICG, LLC	Kingwood Operations;Whitetail	12965	8.73%	8.26%	2.4	2460	0.15%	90
	OVC024	Buckeye Industrial Mining Company	West Point Mine	12500	8.24%	6.10%	2.4	2560	0.00%	53
	OVC043	Resource Fuels, LLC	Mulligan-Duran	12059	12.90%	5.50%	3.1	2450	0.07%	58

[redacted]

4: Potential Mill Improvements - Effect to coal supply

Big Sandy Unit 2, like the other 800's, are limited in mill capacity. In order to maintain full load, the heating requirement is higher than a lot of the coals in the nearby Illinois Basin. Because of this, the minimum heating value may be keeping the Illinois Basin coals from entering the model. For a relative comparison of the generic coal properties of each basin, see Attachment 2.

A possible mill modification which would increase capacity is the addition of variable mill loading. This hydraulic device applies more down force to the tires, which improves grinding efficiency. Currently, the down force in a static system is set to a compromise between top end capacity and mill turn down. Having too high of a down force will cause the mill to "rumble" early in the turndown because of an insufficient coal bed. This leads to premature failure of the mill internals. This option has been reported to provide an additional 15 to 20% capacity.

Generally speaking, coals from the Illinois basin have a heating value around 11,500 BTU/lb. To determine if the model was excluding the Illinois Basin because of the heat value, the heating value required was reduced to 10900 BTU/lb, a 7.5% decrease. This change to the model added only mines from the Utica Basin (Colorado) and not the Illinois basin. Coals from the Utica Basin are low sulfur coals with a high transportation cost to Big Sandy. These coals are all in competition with low sulfur Central Appalachian coals. If Central Appalachian coal cost increase, so will coals from the Utica Basin.

The following table shows the additional mines added as a result of the mill improvements:

FGD, Nose, Burners and Mill Improvements									
Region	Sample ID #	Coal Company	Mine	BTU/lb	% ash	% moist	SO2, lb/mmBTU	H=W Red F	%CL
Colorado	CUT006	Peabody COALSALES Company	Foidel Creek;Twenty Mile	11089	8.07%	12.88%	0.9	2580	0.01%
	CUT008	Clermont Energy	Deer Creak Mine	11250	7.81%	13.19%	1.0	2400	0.10%
	CUT017	Arch Coal Sales Company, Inc.	West Elk B Seam Non-Compliar	11542	8.01%	10.99%	1.5	2400	0.01%

5: Stainless Steel Superheater - Effect to coal supply

As noted earlier, the oxides of iron tend to lower the ash fusion temperatures coal ash. Generally speaking, the higher the sulfur in the coal the more iron will be found in the ash. Because so few mines have been found acceptable for use at Big Sandy on 100% consumption, another option to lower ash fusion temperatures was added.

It is well known that stainless steel sheds slag. Stainless steel also has better heat transfer properties than a chroly heat transfer section. For Big Sandy 2, the possibility of replacing the Platen and the Finishing sections of the superheater was added as a means of reducing FEGT.

Rockport Unit 1 has a stainless steel superheater while Rockport Unit 2 uses a chroly superheater. This configuration allows for a comparison of the benefits of the material change to Furnace Exit Gas. Data trended between these two units show the unit with the stainless steel superheater operates, on average, with an FEGT 75 degrees cooler than the unit without.

Based upon this knowledge, the minimum ash fusion was lowered to represent the change in superheater sections. As a result, only one extra Colorado mine was found acceptable for use on Big Sandy 2.

6: Option for Future Study

The addition of furnace wing walls is a potential mechanism for reducing furnace exit gas temperature (FEGT). The addition of wing walls would serve to re-balance the absorption characteristics between the superheat circuit, high pressure reheat circuit, and low pressure reheat circuit. While wing wall would lower FEGT there are a great many unknowns about the feasibility of installing wing walls.

No detailed design of furnace wing walls has been undertaken, including the physical feasibility of their installation, a cursory review indicates that approximately 15,000 square foot of surface (on a flat projected basis) would serve to reduce the FEGT to a value necessary for the use of the coals in either the Illinois Basin or Northern Appalachian Basin.

The addition of wing walls requires a careful study of the downstream effects to the unit. The added temperatures to the fluid might jeopardize the suitability of the metals in the circuits immediately downstream of the wing walls. The addition of wing wall surface would could be detrimental due to the reduction in "heat head" available to the convection pass surfaces. The wing walls will add a substantial amount of weight to the support structure. The weight of the wing walls will require changed to the building and furnace support steel. The costs of which could be very substantial.

It should also be noted that the installation of wing walls could also reduce fuel flexibility. If wing walls were to be installed to facilitate the firing of high slagging coals, there could be potential problems when firing low sulfur coals.

7: Conclusion/Recommendation

The blending of Central Appalachian coals is essential to provide Big Sandy options for sources of High Sulfur coals. While there are a handful of small mines which could be used on a scrubbed and modified Big Sandy Unit 2, their use as a sole supplier for the units needs does not improve fuel flexibility for the unit. Without the blend, the unaltered ash fusion temperatures of the Northern Appalachian and Illinois Basins are 200^{o}F below the design of modified unit. In order to lower the FEGT to values which would not create running slag in the furnace, the unit load would be limited to approximately 575 MWn.

In order to eliminate the need for blending with Central Appalachian coal on Big Sandy, further reduction in Furnace Exit Gas Temperatures is required. This may be accomplished with the addition of wing walls. However there are many unknowns and a full study should be implemented. The addition of wing walls adds a significant amount of weight which will require modification to the build and furnace support structures. The fluid temperature increase from the wing walls may require pressure part changes in the down stream circuits due to reducing the allowable stresses. The expected cost of this very detailed study is around $75,000 and would take nearly 6 months.

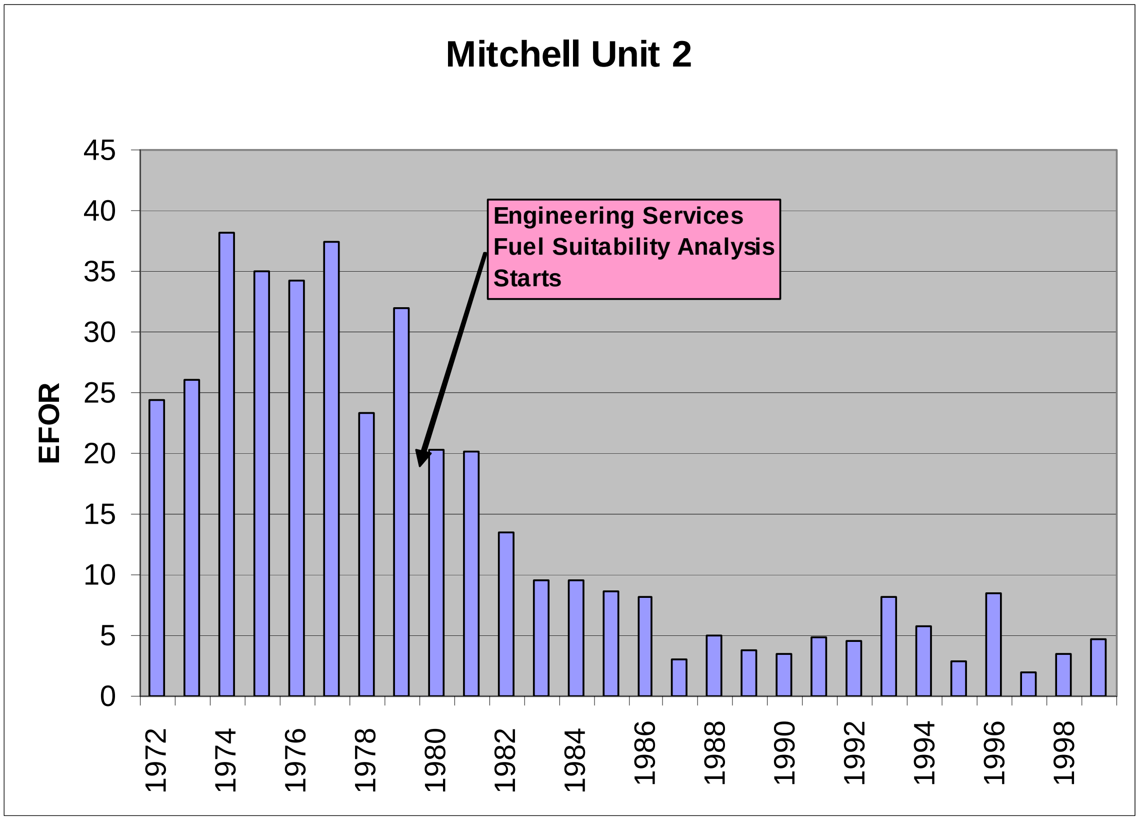
The following table has been assembled to show the equipment changes necessary on Big Sandy 2 to handle coals from the different basins. The blends of high and low sulfur coals shown are the maximum theoretical to achieve the limitations of the installed modifications. (low sulfur coals are from the CAPP and CUT regions). As mentioned before, the wing walls need to be studied and could eliminate the return back to low sulfur coal.

Big Sandy 2 Fuel Flexibility

Coal Basin(s) Used	Boiler Improvements Required	Confidence of success	Improvement Costs	Comments
100% CAPP	None	High	---	Current Operation
100% CUT	None	High	---	Transportation costs
100% NAPP	Burners, Nose and Wing Walls	Medium	High	Needs studied for feasibility, could restrict fuel options
100% ILB	Burners, Nose and Wing Walls, Mill Mods	Medium	High	Needs studied for feasibility, could restrict fuel options
40% CAPP / 60% NAPP	Burners and Nose	High	~$50 million	In operation at Mitchell and Amos
40% CUT / 60% NAPP	Burners and Nose	High	~$50 million	Transportation costs
35% CAPP / 65% ILB	Burners and Nose	High	~$50 million	SO2 will approx 3.5
35% CUT / 65% ILB	Burners and Nose	High	~$50 million	SO2 will approx 3.5
25% CAPP / 70% ILB	Burners, Nose and Mill Mods	High	~$85 million	SO2 will approx 4.0
25% CUT / 65% ILB	Burners, Nose and Mill Mods	High	~$85 million	Transportation costs, SO2 will approx 4.0

CAPP - Central Appalchian and includes Southern Appalchian coals
NAPP - Northern Appalchian
ILB - Illinois Basin
CUT - Colorado Utica Basin

Attachment 1: Mitchell 2 Historical EFOR Data.
Example of the affect of imposing fuel specifications lowering a unit's EFOR.



Big Sandy 2 Fuel Flexibility

Attachment 2: Generic Coal Properties of the United States