

FY16-LXXIX-200

“LP Amina Beneplus Commercial Demonstration Project Feasibility Study”

CONTRACTOR: LP Amina

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PARTICIPANTS

<u>Sponsors</u>	<u>Cost Share</u>
NDIC	\$209,000
Basic Electric	\$25,000
North American Coal	\$25,000
LP Amina	\$159,000
In-Kind contributions from Basin, NA Coal, Tesoro And LP Amina	<u>\$382,000</u>
Total	\$800,000

Project Schedule –

Contract Date – 12/16/15

Start Date – 1/1/16
Completion Date –12/31/16

Project Deliverables

Status Report – Boiler study 3/31/16 (x)
Process and catalysis Reliability 4/15/16 (x)
Technical and Economic assessment 5/1/16(x)
Final Report – 5/31/16 (x)

OBJECTIVE / STATEMENT OF WORK:

This project will focus on determining the feasibility of applying the LP Amina Beneplus technology to ND Lignite coal. This technology results in a value-added liquid from coal and a beneficiated lignite coal product. The project will also consider the viability of using the beneficiated coal in an existing lignite-based boiler. The liquids produced will be evaluated by Tesoro as an input to existing refinery operations.

STATUS:

Boiler Study

The boiler study indicates that it is possible to burn a 50/50 blend in the AVS boiler. There are some favorable changes when burning this blend – fouling and slagging tendencies of the blended coal are lower; boiler efficiency increases; combined fan power drops over 1.5 MWe; the amount of SO₂ produced has a double-digit drop produced; and the net plant heat rate drops. However, there are some areas of concern which were noted by Burns & McDonnell. Main steam and reheat temperatures drop 18°F and 10 °F, respectively, leading to a loss in plant output of just over 7 MWe at the 50% blend. Additionally, there is an increase in ash and boiler waste products as well as concern with the handling of the upgraded fuel product on the existing conveying system. None of these concerns were significant enough to cause Burns & McDonnell to advise against using a 50/50 blend of syncoal and lignite at AVS, but they did suggest looking at additional modifications such as flue gas recirculation to recover some of the loss in steam temperatures and plant power output.

Process and Catalysis Reliability

Over the course of roughly 10 weeks, the SwRI pilot facility processed ~1,000 pounds of coal corresponding to nearly 500 cumulative hours of operation. Overall, these runs met with good success in terms of:

- **Avoided any issues with plugging and coal agglomeration**
- **Avoided any issues with HTM deactivation leading to tar formation, or leading to the production of non-desirable hetero-atom containing hydrocarbon products; all products were clean hydrocarbons**
- **Demonstrated recycle of light hydrocarbon-laden py-gas back to the pyrolysis reactor for further increasing BTX yield to around 2.8% BTX (lbs/lb of dry coal feed)**
- **Demonstrated impact of HTM coking on BTX yields and ability to de-coke the HTM**
- **Demonstrated HTM recoverability of 99.86% (lb HTM/100 lb of coal processed)**

These runs also helped to reveal that further process improvements would be necessary and beneficial in the following areas:

1. **Regenerator design and optimized HTM recirculation rates for improved activity and yield**
2. **Coal separation from spent HTM for reduced ash load on regenerator**
3. **Steam stripper design for improved yield opportunity (+0.4% potential)**
4. **Improved py-gas separations and recycle for improved yield (+0.7% potential)**
5. **Longer term scouting for improved HTM composition and resilience**
6. **Improved pyrolysis reactor design to achieve higher HTM recovery rates, as demonstrated in cold flow measurements.**

Proof of process testing was successful and revealed that all process technology challenges for which there was sufficient time to address were adequately resolved. Additional solutions were identified to further improve and sustain yield.

Technical and Economic Study

This document strives to avoid suggesting any intraparty business deals. Instead, the analysis herein will seek to quantify the overall value if a single party (most likely a utility) buys the coal, operates the BenePlus process, converts the coal to syncoal, fuel gas, petrochemicals, and CO₂, uses the syncoal and fuel gas in their own boiler, and sells the remaining products on the market. While this most certainly will

not be how the commercial operation is structured, it offers the simplest way to quantify the value of this technology.

Specifically, the following approximate benefits are expected:

- A 3.6% increase in total coal consumption (BenePlus process + AVS) resulting in over \$3.6 mio additional sales to NACC
- A 2% improvement in heat rate resulting in less coal consumption at AVS
- Reduction in sulfur and mercury abatement costs for AVS
- Over \$35 mio additional non-power sales from benzene, toluene, and xylene (BTX), diesel, and CO₂
- Reduction in CO₂ footprint of the facility and sales of CO₂ for EOR

We estimate that these benefits will sum to over \$27-\$28 mio net improvement in EBITDA annually from new sales and reduced operating costs of the power plant. The BenePlus facility and modifications to the boiler will cost about \$200 mio. This gives a simple payback of roughly 7 years and an IRR of 10%. Additionally, the CO₂ footprint will be reduced as shown in the accompanying process validation report. This opportunity is therefore unique as CO₂ can be reduced while turning a profit with good payback on capital.

Final Report

The process development, boiler, and economic studies furthered understanding of all criteria outlined above.

1. Syncoal can be produced with sufficient quality and reliability.
2. Projected overall emissions are reduced, namely CO₂ and SO_x.
3. Demonstrated aromatic yields of about 3 - 4 lbs per 100 lbs of dry coal fed.
4. Estimated that, with some modifications, the boiler can use up to 50% syncoal and with 50% syncoal, a projected 2.5% to 3% heat rate improvement is expected.
5. Estimated profits will pay back the capital investment within 7 years with current assumptions.
6. Estimated an additional 187,000 tons of annual coal sales if AVS switches to a 33% syncoal fuel diet.