LP AMINA | Energy and Environmental

13850 Ballantyne Corporate Place, Suite 125
Charlotte, North Carolina 28277

October 1, 2015

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
State Capitol
600 East Boulevard Ave Dept. 405
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: Lignite Vision 21 Grant Application entitled "LP Amina BenePlus: Commercial Demonstration Project Feasibility Study"

LP Amina, LLC. is pleased to submit this application for funding to conduct a feasibility study to commercialize a novel beneficiation technology that will co-produce upgraded lignite coal from North Dakota feedstocks and hydrocarbon fuels and chemicals. Please find the subject application enclosed.

This letter signifies our binding commitment to complete the project as described in the application if the Industrial Commission makes the grant requested.

If you have any questions, please contact me by phone at 704-944-5425 ext. 104 or by email at bill.williams@lpamina.com.

Sincerely,

William Williams
VP Business Development

PROJECT TITLE

LP AMINA BENEPLUS COMMERCIAL DEMONSTRATION PROJECT FEASIBILITY STUDY

PROJECT SUBMISSION

APPLICANT

LP AMINA | Energy and Environmental

13850 Ballantyne Corporate Place, Suite 125
Charlotte, NC 28277

PRINCIPAL INVESTIGATOR

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704-944-5425 x104
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DATE OF APPLICATION

October 1, 2015

AMOUNT OF REQUEST

$209,000

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ABSTRACT

LP Amina has developed a technology, termed BenePlus, that upgrades coal while producing highly valuable chemicals and fuels. Preliminary techno-economic analysis based on pilot data, current feedstock, and product pricing shows that the process can be deployed at substantially lower costs than traditional coal-to-chemicals, gasification-based processes and generate more profit through chemical sales than traditional coal beneficiation technologies. Additionally, significant compliance and fuel savings are expected for a power plant that uses the upgraded coal in place of raw lignite.

The technology has been proven on a small pilot scale, and LP Amina is proposing to build a commercial facility at Basin Electric's Dakota Gasification (DGC) and Antelope Valley Station (AVS) site in Beulah, ND. This project will be done in three phases:

- Phase 1 is the subject of this grant request; it will last 3-6 months and include: (a) a techno-economic study of the full plant economics co-developed by all parties, (b) validation and qualification of the catalyst, process reliability, and product slate, and (c) an engineering study on the costs and benefits of switching from raw lignite to syncoal at AVS.
- Upon successful completion of Phase 1, Phase 2 will consist of the construction and operation of a small scale Product Marketing Unit (PMU).
- Upon successful completion of Phase 2, Phase 3 will consist of the construction and start-up of a full commercial facility.

LP Amina, Basin Electric, and North American Coal (NACC) have agreed to jointly study this technology and are seeking co-funding from the LRC to conduct the Phase 1 efforts outlined above. We anticipate that Phase 1 will cost around $700,000 including in-kind contributions, with cash outlays expected to be $418,000k of the $700,000 project costs. We are seeking North Dakota matching funds for the cash portion in the amount of $209,000.

PROJECT SUMMARY

BenePlus is a proprietary coal upgrading process that carries out pyrolysis in the presence of a catalyst to yield both higher value lignite as well as a profitable hydrocarbon product slate including benzene, toluene, and heavier fuels for the production of #2 diesel fuel. The technology optimizes North Dakota lignite into a highly profitable resource that would add considerable value to the state's power industry. The ultimate goal of this project is a ca. 500 ton/hr coal upgrading facility using the BenePlus process. The commercial process would be located minemouth and produce liquid fuels, upgraded coal, fuel gas, and carbon dioxide as depicted in Figure 1:

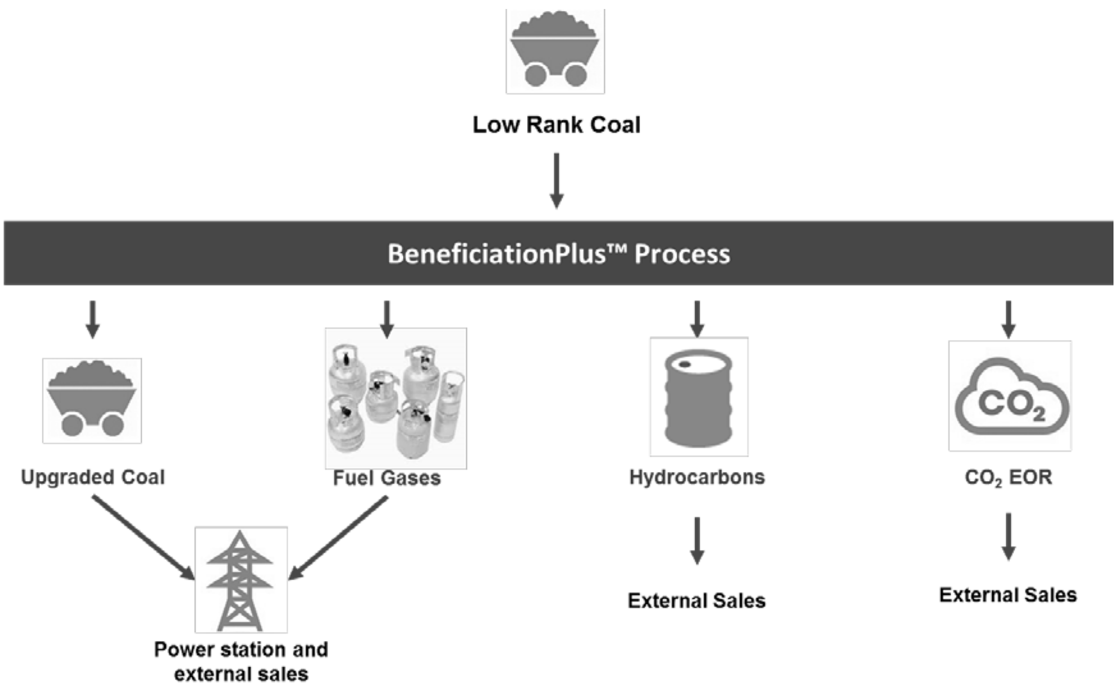

Figure 1: BenePlus process products depicting integration with a mine mouth power plant.

In this grant application, we are requesting matching funds to carry out the feasibility assessment for the commercial process (Phase 1 of the development plan).

The BenePlus process takes a more efficient and economic approach to traditional coal-to-chemical methods and stands to generate significant benefits for North Dakota. For power plants, the process requires lower capital expenditures while the production of both syncoal and liquid hydrocarbons diversifies their revenue streams. Fuel and investment cost savings will be passed down to rate payers and hundreds of direct and indirect jobs will be created to support the construction and operation of the facilities. Further, a demand for in-state sourcing, increased lignite mining activity, and tax revenue will boost the state's GDP. From a compliance perspective, the syncoal from the BenePlus process has 70% lower sulfur content and 50% lower Hg than raw lignite and power plants will see an overall 15% reduction in CO_2 emissions.

As proof of concept has been successfully demonstrated in small testing environments, the objective of Phase 1 is to assess the feasibility of scaling BenePlus technology with North Dakota lignite feed. Phase 1 consists of the following deliverables:

1. Commercial process techno-economic assessment, development plan, and timeline verified by an independent engineer
2. Catalyst qualification through 500-1000 hours of continuous pilot operation at SwRI
3. Fuel switch study to determine any necessary site changes to accommodate beneficiated syncoal

Findings from these feasibility studies will be used to for the subsequent construction of Phase 2's product marketing unit (PMU) and Phase 3's commercial-sized facility. Our staged approach will mitigate risk and ensure that funding requests are carefully considered and justified.

LP Amina and its partner companies are uniquely qualified to carry out the verification and commercialization of this technology, and we are confident in the benefits that it would bring to the state of North Dakota.

PROJECT DESCRIPTION

Objective

Our objective is to assess the feasibility of a commercial facility employing LP Amina's BenePlus technology, which will generate quality jobs and higher GDP for the state of North Dakota. Such a facility would profitably reduce the carbon footprint and sulfur emissions of North Dakota lignite, while producing a profitable hydrocarbon offtake co-product resulting in the reduced cost of electricity to rate payers.

Methodology

We propose a phased commercialization plan. Project Phase 1 is subject of this application.

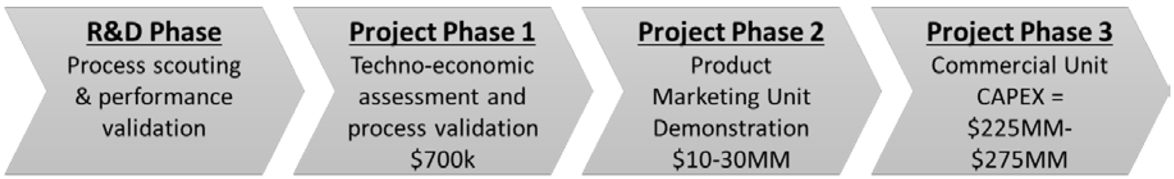

Figure 2: Phased development of BenePlus technology with budgetary estimates.

R&D Phase (complete)

This phase included studies initially conducted at Bayer Technology Services (BTS) under contract with LP Amina as well as pilot studies carried out in a continuous reactor built at Southwest Research Institute (SwRI) in San Antonio, Texas. Results are summarized below in the confidential information section.

Project Phase 1: Feasibility study to determine next steps towards a commercial facility.

In this phase, we will carry out the following tasks:

a) Techno-economic assessment of the commercial process validated by an independent engineer. In scope will be the economic assessment of the full commercial scale process as well as the validation of the overall development plan and timeline.

b) Qualification of catalyst and validation of product reliability and reproducibility. This will be conducted in the pilot reactor during an extended steady-state run (500-1000 hours of continuous operation). Tesoro has agreed to an in-kind contribution of its expertise to evaluate the value of the fuel products in their refinery network including the Mandan, ND refinery.

c) Fuel switch study to determine the nature and scope of modifications required at AVS to handle the syncoal from the BenePlus process.

We anticipate that this phase will take 3 to 6 months to complete. We estimate the cost of this phase (cash and in-kind contributions) to be around $700k, of which $418k will be cash. We are seeking $209k in funding from the NDIC with this application.

Upon successful completion of Phase 1, we will move into the later project phases as outlined in Figure 2.

Anticipated Results

Building upon the performance thus far of SwRI's small-scale testing, we anticipate that projections from our techno-economic assessment will affirm and substantiate our expectations for the commercial scale process. Results from the lignite validation should be favorable due to the fact that we are currently testing the actual coal used at AVS. Results from the catalyst qualification should be favorable because we have already demonstrated acceptable attrition and efficient solid/solid separation in our pilot mock reactor.

Facilities, Resources, Techniques Availability and Capability

Each Phase 1 deliverable will be completed by a qualified service provider.

- Southwest Research Institute (SwRI) will be responsible for catalyst qualification and lignite product validation at their facilities in San Antonio, Texas. SwRI has conducted the pilot studies on this process for the past year and is best positioned to perform testing with North Dakota lignite.
- An engineering firm will be selected to support this feasibility effort. The firm will have a proven track record of working at the DGS and AVS facilities.
- LP Amina along with our partners will complete the techno-economic analysis of the commercial-scale process, development plan, and timeline.
- A preliminary third party fuel switch study will be conducted by a qualified firm.
- Tesoro will evaluate the liquid products made in the product qualification run to determine the value of the materials and how best to use within the Tesoro system.

Environmental and economic impact

Project Phase 1 environmental and economic impact

We do not expect there to be any environmental concerns during Phase 1 of this project as the majority of the tasks consist of desktop analyses and modeling. We will be performing continuous testing of North Dakota lignite in our prototype reactor at Southwest Research Institute, but the process does not emit any harmful byproducts. While this phase of the process has little environmental and economic impact in itself, this phase is essential for determining the next steps towards commercialization.

Environmental and economic impact of the commercial facility

The commercial facility will provide significant benefits for the host site, the BenePlus operator, and the lignite mine owner. These benefits will be covered in more detail in the following section, but here we will focus on the societal impact for North Dakota, including contributions to the state-wide economy and the environment. Below, our evaluation is based on a commercial facility of an approximate size of 500 tons/hr coal as received (AR). In a later section, we will consider the impact of deploying the BenePlus process state-wide.

Economic impact

Job creation during commercial construction and operation: We expect the construction of this facility to take about 18 months, providing around 250 jobs during construction, and about 30 permanent jobs at the commercial facility.

In-state fuel/utility purchases for construction: Much of the pilot construction will need to be field mounted, particularly the tie-ins to the host site utilities. These materials will need to be sourced locally. Further, much of the start-up and shut-down in this facility will require external fuels and electricity, so utility consumption will increase during the operation of the commercial facility.

Increased revenue from lignite production and tax: As pointed out above, about 6% of the lignite's energy value into the BenePlus process goes to non-power needs (fuels and chemicals production, waste heat, and yield losses), leading to a 6% increase in lignite consumption per ton of lignite processed. Assuming the facility has an 85% uptime, this would mean about 220,000 additional tons of lignite mined at the local mine per year.

Environmental impact

Our syncoal has approximately 70% lower sulfur content and 50% lower mercury than the raw lignite. Therefore with the BenePlus process, gross and net emissions of both Hg and SO_2 will be greatly reduced.

CO_2 emissions, as shown in Figure 3, are substantially reduced. The net reduction is attributable to a number of effects. First, there is a heat rate improvement. Our syncoal is dry, so there is less efficiency loss due to water content. We estimate that the heat rate from the syncoal will be about 6% lower. The lower heat rate leads to fuel savings that will be discussed below, but it also reduces the carbon intensity of the power plant. Further, the process makes a sweet fuel gas that can be burned in a high efficiency Jenbacher engine to generate power with much lower heat rates. The result of using a 50/50 lignite/syncoal blend (energy basis) coupled with the power generation from the fuel gas, would result in a 14% reduction in carbon intensity of the power plant.

Second, the reduction in demand of limestone to the FGD scrubber reduces the production of CO_2 associated with the scrubbing reaction*. This reduces the CO_2 emissions by an additional 1% resulting in a 15% reduction in carbon intensity for the power plant.

Third, we must account for the additional emissions from the Beneplus process. The process produces CO_2 at two points: in the pyrolyzer where the coal is upgraded and in the regenerator where coke is burned off of the catalyst. This effect negates most, but not all of the CO_2 reduction in the power plant.

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* Most scrubbers use either limestone ($CaCO_3$) or lime (CaO) which is produced by calcining limestone liberating CO_2. The scrubbing reactions are as follows:
For limestone: $CaCO_3 + \frac{1}{2} O_2 + SO_2 \rightarrow CaSO_4 + CO_2$, or
For lime: $CaO + \frac{1}{2} O_2 + SO_2 \rightarrow CaSO_4$.
In either case, CO_2 is either produced directly (limestone) or indirectly (lime production) as a result of SO_2 scrubbing.

Fourth, we can earn credit for co-products. The liquid fuels produced displace fuels produced in a refinery and thus indirectly avoid CO_2 emissions. Using the Argonne GREET model[1] we estimate a 2% credit due to the liquid fuels sold from the facility.

Our plan is to sequester at least the CO_2 coming from the pyrolyzer. As will be shown in the detailed technology description, this CO_2 is easily captured because it is removed along with the H_2S in the acid gas removal system. Figure 3 considers this scenario, resulting in a net 8% reduction in CO_2 emissions.

If need be, the CO_2 from the regenerator can also be sequestered, resulting in an additional 8% reduction of CO_2 emissions relative to lignite-based power production. However, the CO_2 from the regenerator is in a dilute form in a flue gas. Recovering this would be more expensive and also incur a large parasitic load on the plant. Therefore, we recommend only sequestering the CO_2 in the pyrolysis gas.

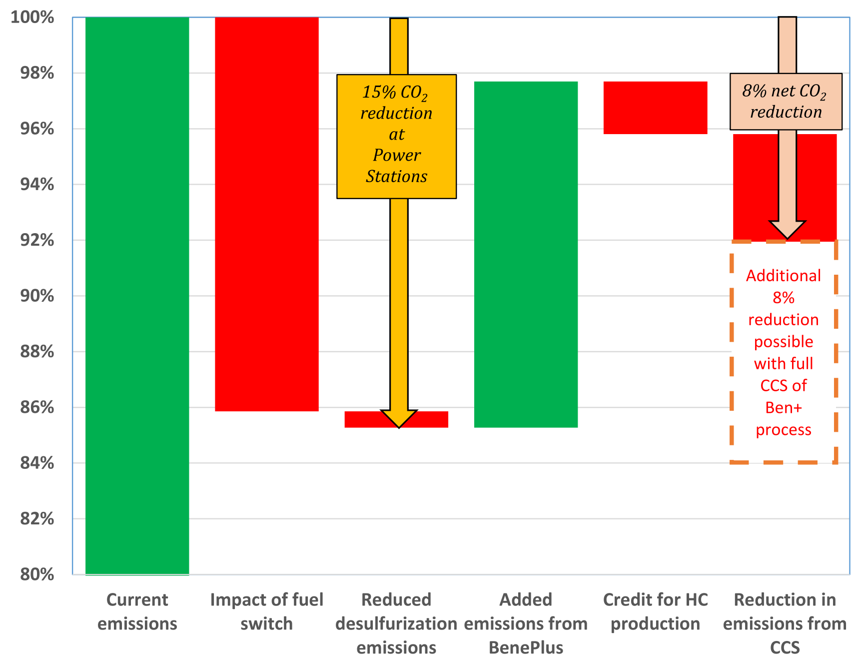

Figure 3: Impact of BenePlus technology on state-wide CO_2 emissions. Power plants will see an overall 15% reduction in CO_2 emissions. This is partially offset by emissions from the BenePlus process for a net 8% reduction in CO_2 emissions assuming CCS only on the pyrolysis gas. Flue gas CO_2 capture can be employed at an additional cost to provide up to 16% CO_2 emissions reduction.

Technological and economic impact

Traditional beneficiation techniques, such as the Encoal process demonstrated in Gillett, WY,[2] involves the drying and partial devolatilization of coal, which results in dry, higher BTU-containing coal along with several coal distillate products such as tars, anthracene oils, and other higher hydrocarbons. These coal distillate products have low value as a residual fuel. Coupled with the current low value of coal and low cost of alternate fuels such as natural gas, process economics of traditional beneficiation are generally unfavorable.

Our process differs from traditional beneficiation processes because the pyrolysis is carried out in the presence of a catalyst. The presence of the catalyst changes the product slate of the liquid distillates to more valuable components. Instead of making low value coal distillates, the BenePlus process produces a light fuels/petrochemicals stream containing predominantly benzene and toluene and a heavier fuels cut that can be hydrotreated to make a #2 diesel fuel. Many of these products trade at a significant multiple of WTI crude index. Further, the lighter cut can be used as an octane booster, which is needed to make premium gasoline in refineries that use Bakken crude due to the low octane rating of distilled Bakken crude.

As such, our product slate is of similar value to traditional coal-to-chemicals via a gasification-route followed by either Fischer-Tropsch (F-T) or methanol-to-gasoline (MTG). However, the BenePlus process requires fewer steps and does not need to be operated at elevated pressure. These advantages greatly reduce capital costs and simplify solids handling.

Finally and perhaps most importantly, because our process retains more than 90% of the coal's energy as syncoal and fuel gas, a power plant using raw lignite can simply replace or mix the syncoal with their current fuel and utilize some of the waste heat and fuel gas from the process. In fact, the upgraded syncoal and fuel gas can be burned more efficiently and reduce the fuel cost of power generation. Thus, a depreciated asset can continue to be used more efficiently for power generation, greatly reducing the cost of the project and cost to the local rate payers.

Economic value

Our preliminary estimates show that this technology has the potential to produce significant revenues with a good payback on investment and substantial value to the lignite industry and the state of North Dakota. The focus of the proposed project will be to refine these estimates, but some highlights are as follows:

Lower capital investment than traditional coal to chemicals technologies

At the core of this technology is a low-pressure mild pyrolysis reaction that directly generates a valuable liquid fuels mixture and a syncoal. Other than optional refining of the liquid fuels, there are no further processing or reaction steps required. This process is much more direct and simple than gasification routes and produces a higher-value fuels stream than traditional beneficiation. As a result, our initial estimates place the capital costs for such a process significantly lower than alternative processes.

A highly valuable product slate drives high net revenue and fast payback on capital

On the revenue side, our process benefits from two key drivers: low net conversion of coal which keeps net raw material costs low, and high selectivity to high-value fuels, most of which trade at a multiple of WTI and other crude oil indices.

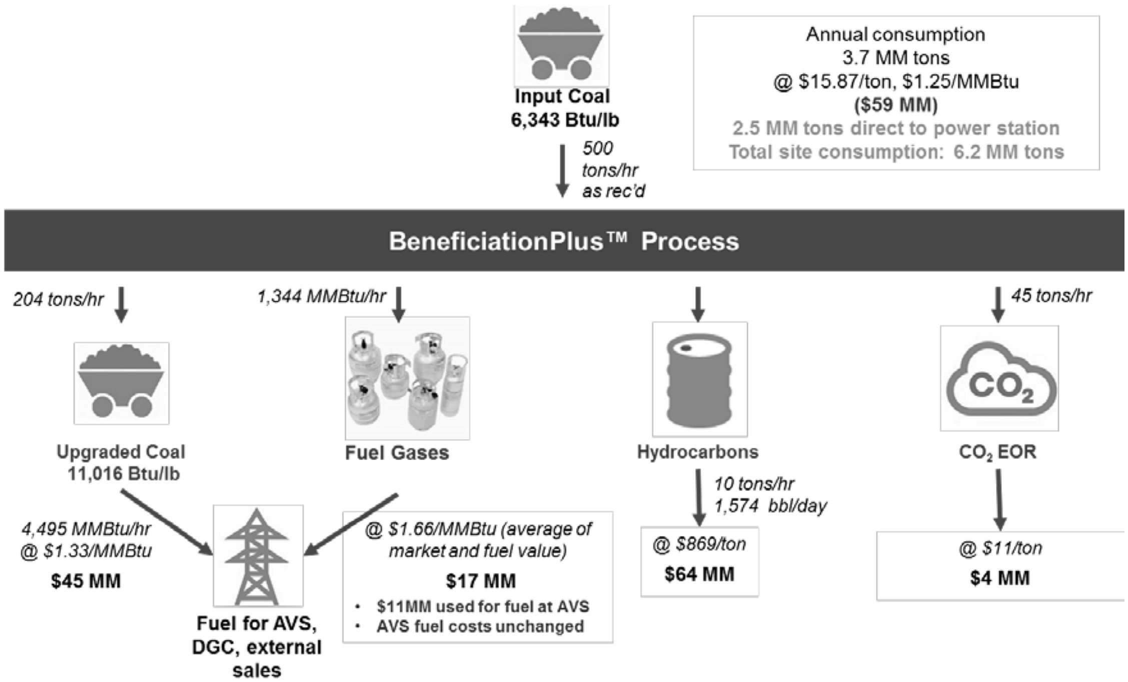

Figure 4: Raw material costs and revenue from BenePlus process. Projected annual net raw material profit of the process is $70MM.

Figure 4 summarizes the raw material costs and revenue. This figure does not include the sales of Phenol (an additional $6MM), which DGC can uniquely utilized due its already existing phenol processing train. Key points are as follows:

Low net conversion of coal conserves energy and reduces net coal conversion costs: The proposed commercial plant consuming ~500 ton/hr of lignite corresponds to a heating value of 6,343 MMBtu/hr. However, the process will return 4,495 MMBtu/hr to AVS in the form of syncoal, plus an optional additional 1,344 MMBtu/hr in fuel gases that can be burned at AVS or sold. The fuel gas and the syncoal represents 92% of the energy value of the input coal. Because of this high energy efficiency, the recovered fuel value offsets the cost of the input coal.

Liquid hydrocarbons: The presence of the catalyst leads to high selectivity of valuable hydrocarbons. Predominantly benzene, toluene, and higher aromatics, these hydrocarbons are all valuable as petrochemical feedstocks, high octane gasoline additives, and diesel fuels. There is a strong market for these components on the Gulf Coast, and even with transportation and processing costs, they can be sold at a net price substantially higher than crude value. There is also a demand for these toluene and xylene in the local fuels market as octane blend boosters.

Based on these assumptions, the detailed economics are compelling. Table 1 outlines the variable raw material costs and values:

Table 1: Raw material costs and value for 500 tph BenePlus at AVS

Stream	Flow	Units	Unit cost/value	Units	Revenue or cost per year, $MM
Raw coal, as recd.	1,000,000	lb/hr	($15.87)	per ton	($59.12)
Syncoal, as recd.	408,120	lb/hr	$29.32	per ton	$44.58
Fuel gas	1,205	MMBtu/hr	$1.25	per MMBtu	$11.23
LPG	139	MMBtu/hr	$5.25	per MMBtu	$5.43
Benzene	5,023	lb/hr	$575.99	per mT	$9.80
Toluene, Xylenes	5,475	lb/hr	$974.23	per mT	$18.06
Diesel #2	7,511	lb/hr	$3.68	per gallon	$30.32
Phenol	1,903	lb/hr	$975.86	per mT	$6.29
CO2	89,358	lb/hr	$11.00	per ton	$3.66
Net total RM Profit					***$70.25***

Uptime (hrs/yr)	7451

The capital costs for the proposed commercial facility and the remainder of the operating and variable costs are to be estimated as part of the proposed study outlined in this grant.

WHY THE PROJECT IS NEEDED

This proposed feasibility assessment is necessary to verify that the desired outcomes are achievable at larger scales and that the economics of the project are favorable. Once commercialized, the BenePlus process will offer North Dakota a highly profitable co-production process to produce syncoal and liquids, chemicals, power, and CO_2. Considering North Dakota's abundant lignite supply, employing BenePlus is a promising way to extract the most value out of this resource and generate high returns for the state.

STANDARDS OF SUCCESS

As we have reasonable grounds to believe the BenePlus process will scale successfully, our measures of success for Phase 1 involve substantiating this proposition with sound evidence.

1. Affirm with independent parties the technological and economic feasibility of building and running a commercial scale BenePlus facility
2. Validation and quantification of catalyst, process reliability, and product slate currently observed at SwRI, under continuous operation for several hundred hours up to 1000 hours.
3. Determine the impact and cost of switching the fuel diet to part syncoal at the host power station.
4. Navigate and resolve unforeseen constraints, and generally de-risk the subsequent project phases.
5. Complete all deliverables on time and within budget.

The results of these studies will position us to realize the long term-potential of this proposal:

- Develop a phase approached for a commercial-sized facility that successfully upgrades North Dakota lignite and co-produces hydrocarbons
- Strengthen North Dakota lignite industry as a significant revenue stream for the state
- Lower emissions in North Dakota produced from coal-related activity
- Create and sustain high quality jobs for the state

To responsibly gauge the proposal's progress and likelihood of success, we have taken into account the following scenarios that would warrant the termination of the project:

1. Catalyst Life: Studies demonstrate that excessive catalyst attrition will result in unmanageable catalyst costs.
2. Boiler Studies: Boiler modifications required at AVS to handle the syncoal are so expensive such that there is an unfavorable payback to Basin Electric.
3. Techno-economic assessment: A fatal flaw is uncovered that cannot be mitigated or that will increase costs such that the project finances become unacceptable for the partners.

BACKGROUND

Literature Review

Given the uneven global distribution and finite nature of crude oil reserves, there has been an ever-increasing demand to develop production technologies based on alternative feedstocks (e.g., coal, biomass, etc.). In the past decades, coal to liquid (CTL) technologies have achieved some progress.

Coal to Liquid (CTL) Technologies

Figure 5 provides an overview of the most relevant coal-to-liquid processes that have been proven to varying degrees in the past 160 years. The most technically established route for producing hydrocarbon liquids involves *gasification*, which uses relatively high temperature steam and oxygen co-feeds to produce syngas. Significant cleaning of the resulting syngas is required prior to further conversion to a methanol intermediate or for direct synthesis. Thus, the process usually requires an integrated, multistep approach, gasification-based facility, which is costly to build and operate. Another route for producing hydrocarbon liquids from coal is *hydrogenation* or the so-called *direct coal liquefaction* (DCL) route, which involves direct liquefaction via high pressure treatment of coal solids with pure hydrogen. Even though the DCL process typically utilizes catalysts, the desired hydrocarbon product selectivity of the catalytic reactor is low and further processing is required. In other words, the DCL process cannot be tailored to produce specific hydrocarbon products, and in particular, lower molecular weight hydrocarbons. Therefore, the DCL product stream requires significant additional chemical upgrading steps by facilities that are also cost intensive to build and operate.

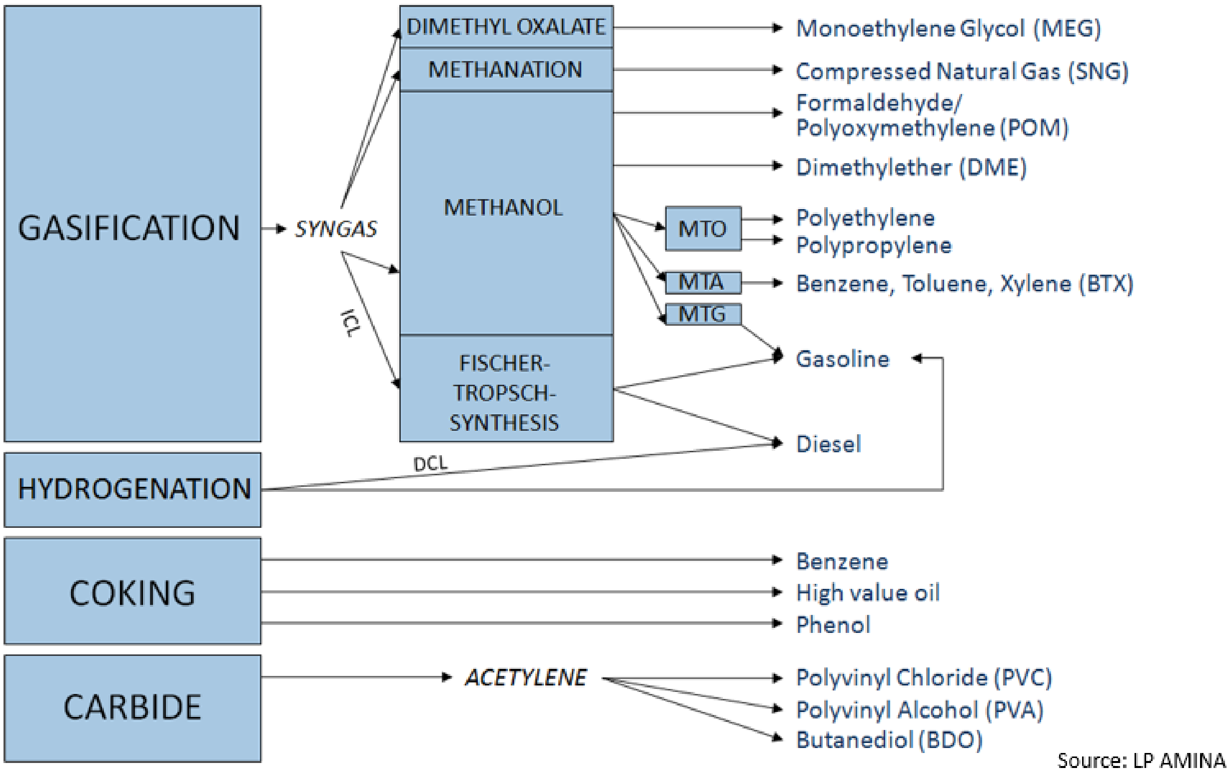

Figure 5: Coal to liquid processes

The oldest of these routes is the *coking* or p*yrolysis* process dating back to the mid-1850s when coal was used to produce kerosene liquid fuels for lanterns. The resulting liquid product streams from today's conventional pyrolysis process technologies still contain relatively high concentrations of high molecular weight tars that require considerable upgrading, typically via catalytic hydrogenation. The overall product selectivity for conventional pyrolysis processes, e.g. ENCOAL®, C_2O and others, is relatively low. The following section takes ENCOAL® mild coal gasification process as an example of typical conventional pyrolysis process to illustrate its process characteristics and benefits.

ENCOAL® Mild Coal Gasification Project

The ENCOAL® mild coal gasification project, owned by ENCOAL® Corporation, which is a subsidiary of Ziegler Coal Holding Company, was selected as a part of the U.S. Department of Energy (DOE) Clean Coal Technology (CCT) Demonstration Program and funded by the DOE from 1992 to1997 to operate a 1,000-ton-per-day mild gasification demonstration plant at Triton Coal Company's Buckskin Mine near Gillette, Wyoming.

Process Description

The core technology of the ENCOAL® project is mild coal pyrolysis or mild coal gasification based on LFC™ (Liquids from Coal, originally developed by SGI International) Technology, which involves heating the coal under carefully controlled conditions thus causing chemical changes in the feed coal, meanwhile converting the volatile matter in the coal to fuel gas or valuable hydrocarbons. The ENCOAL® process produced two new fuels, Process-Derived Fuel (PDF™) and Coal-Derived Liquids (CDL™), as alternative fuel sources, demonstrating its environmental benefits when serving industrial and utility boiler sites throughout the nation.

Figure 6 shows the ENCOAL® process diagram. In the demonstration plant, Buckskin mine coal was first crushed and screened and then fed into a rotary-grate dryer. The solids leaving the dryer were then fed directly to the pyrolyzer rotary grate. A hot recycle gas stream raised the temperature to 1,000 °F. Pyrolysis reactions occurred during which volatile gaseous materials were released. After leaving the pyrolyzer, the solids were quickly cooled in a quench table to stop the pyrolysis reactions. The PDF™ deactivation loop included a vibrating fluidized bed where oxidative deactivation occurred at active sites in the particles in order to reduce the tendency of the product to spontaneously ignite. After treatment in the VFB system, the solids were cooled in an indirect rotary cooler where a controlled amount of water was added to rehydrate the PDF™. A final step occurred in a finisher where air was added to oxidize the PDF™. The purposes of moisture and oxygen treatments were both to stabilize the PDF™. The product PDF™ was transferred to a surge bin for storage. The pyrolysis gas stream was sent through a cyclone to remove entrained particles and then cooled in a quench tower to condense the final oil product and to stop any secondary reactions. Electrostatic precipitators (ESPs) recovered any remaining liquid droplets and mist from the gas leaving the condensation unit. About half of the residual gas from the condensation unit was recycled directly to the pyrolyzer, while some was burned in the pyrolyzer combustor before being blended with the recycled gas to provide heat for the pyrolyzer. The remaining gas was burned in the dryer combustor. The hot flue gas from the dryer combustor was mixed with the recycled gas from the dryer to provide the heat and gas flow necessary for drying. The exhaust gas from the dryer loop was treated in a wet scrubber followed by a horizontal scrubber, both using a water-based sodium carbonate (Na_2CO_3) solution in order to recover fine particulates that escape the dryer cyclone, and to remove most of SO_x from the flue gas.

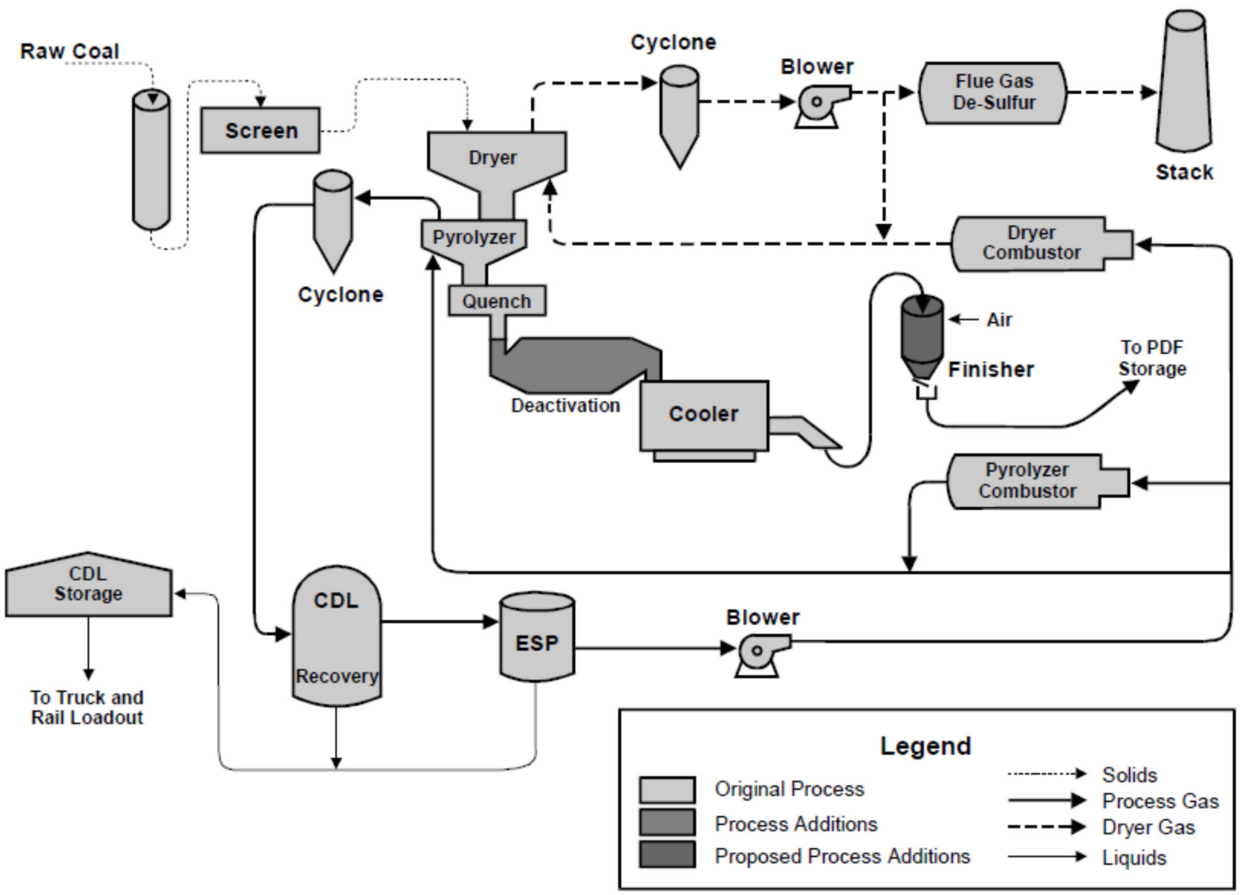

Figure 6: ENCOAL® mild gasification system

Benefits of ENCOAL® Process

The benefits of ENCOAL® process are as follows:

1. Low-rank coals are upgraded to PDF™. The removal of coal moisture increases the specific heating value. A portion of the volatile matter is also removed to stabilize the PDF™, resulting in a solid fuel product that handles, ships, and burns very much like bituminous coal.
2. There is a reduction of the sulfur content of the low-rank feed coal during its conversion to PDF™. In addition, evidence showed a significant reduction in nitrogen oxides (NOx) in power plants

displacing low-rank coals with PDF™ because of a more stable flame than usual with normal fuel.

3. The co-produced hydrocarbon liquid CDL™ is an acceptable substitute for heavy industrial fuel (e.g., Number 6 fuel oil) as is. CDL™ can also be fractionated into its major constituents, several of which are valuable chemicals.
4. As high costs and environmental noncompliance problems continue to add pressure on the declining U.S. coke industry, the steel industry is replacing coke in blast furnaces with pulverized coal injection. PDF™ may become a viable injected fuel/reactant for these blast furnaces.

Cracking and Reforming Concept

Modern trends in petroleum refining are advancing a number of new catalytic processes for converting heavier feedstocks into useable lighter hydrocarbon products. Many of these processes already have a long commercial history. Due to their large heteroatom concentrations and metal concentrations, heavy residual feedstocks present similar engineering challenges as do coal feedstocks, such as high aromaticity and high molecular weight. As such, lignite feedstock is chemically similar to residual oils being upgraded in the refining sector. Figure 7 highlights similar features of the two feedstocks. In a typical lignite structure, the hexagons (and occasional pentagons) represent six (or five) carbon atoms arrange in the so-called aromatic structure.

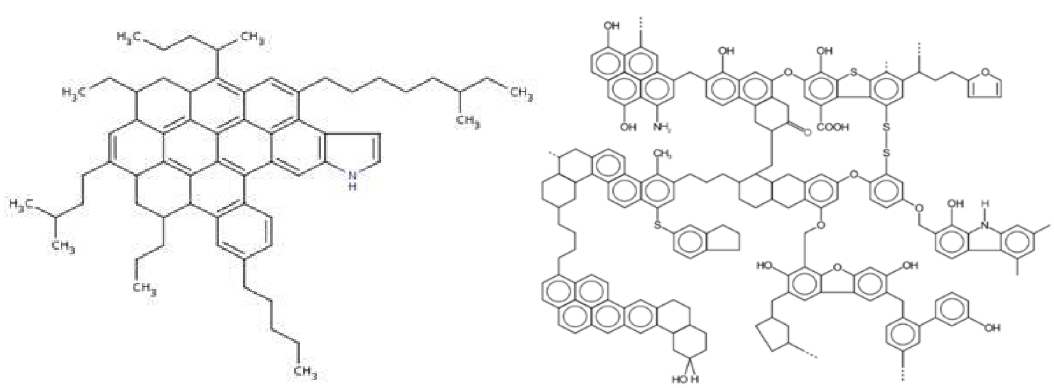

Figure 7: Molecular structure similarity of asphaltene (left) and lignite (right)

Table 2 compares the elemental compositions of lignite (North Dakota Lignite and San Miguel Lignite DAF coal analysis data listed herein) and whole 650-930 °F distillate/resid of Maya crude feedstock. Maya is a common export crude blend from Mexico. The C, H, N, S contents are similar in lignite and Maya crude. However, lignite has a much higher oxygen content than residual fuel oil.

Table 2: Comparison of elemental composition of lignite and crude distillate/resid

Feedstock	Elemental Composition (wt%)					Remarks
	C	H	N	S	O	
North Dakota Lignite	73.14	5.18	1.15	1.95	18.59	DAF
San Miguel Lignite	69.75	6.04	1.29	5	17.93	
Maya Crude	83.7	10.3	0.53	4.62	0.83	MCR: 20.5 wt% Ni: 83 ppmw V: 441 ppmw

Conventional Fluidized Catalytic Cracking

Conventional fluidized catalytic cracking, shown in Figure 8 was first developed in the 1930's and 1940's as a means of upgrading low-value heavy residual oils in the crude oil refining industry to high-value liquids, mainly as high octane gasoline. Fluidized catalytic cracking continues to serve as a workhorse in the modern petroleum refining industry. In 2006, it was estimated that 400 FCC units were in operation at petroleum refineries worldwide. In the conventional FCC process, heavy oil is vaporized by heating to temperatures of 400-600°C in the presence of a catalyst powder (nominally 75 μm) in an entrained flow riser reactor for brief contact of about 0.5-3.0 seconds. The heavy oil components are selectively converted to lower MW and high-octane fuels which exit the reactor overhead for downstream condensation and further processing. The catalyst is captured via cyclone separators and must be regenerated due to the accumulation of coke which otherwise reduces the catalyst activity. The coke is typically burned off the catalyst in an air blown fluidized bed regenerator then returned to the riser reactor to complete the cycle.

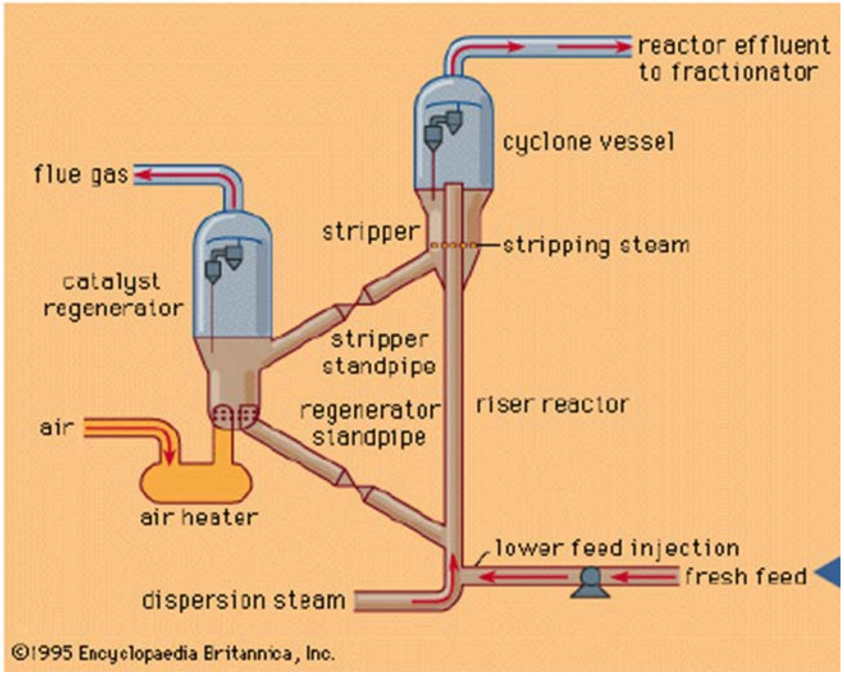

Figure 8: Conventional fluidized catalytic cracking

Biomass Fluidized Catalytic Cracking (BFCC)

Biomass Fluidized Catalytic Cracking (BFCC) is relatively new concept being developed by a handful of start-up companies in recent years. As shown in Figure 9, BFCC operates in much the same way as FCC. The biomass must first be dried and size reduced to a fine powder after which it comes in contact with a catalyst in a riser reactor, or fluidized bed. As in FCC, the catalyst must be separated and regenerated. During regeneration it is expected that a fairly large portion of non-volatile “fixed carbon” from the biomass in addition to accumulation of coke must be removed from the catalyst. In today's BFCC processes, the resulting bio-oils need to be deeply hydrotreated and de-oxygenated to serve as refinery ready liquids. Some companies working on Biomass Fluidized Catalytic Cracking are Anellotech, Envergent (UOP-Ensyn) and KiOR, etc.

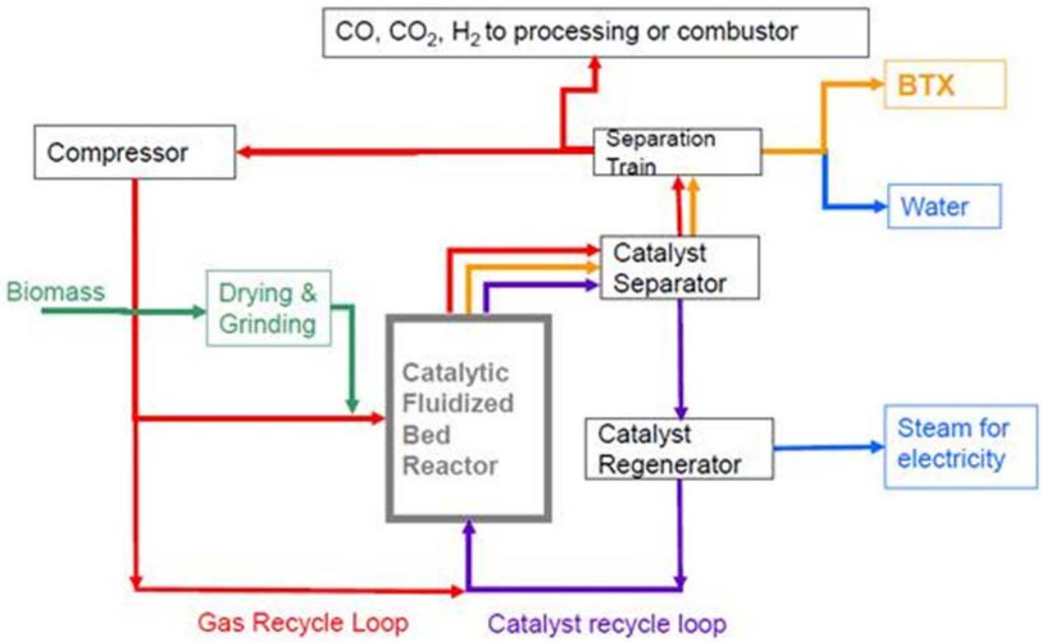

Figure 9: Biomass fluidized catalytic cracking (BFCC)

LPA BenePlus Process

The conventional CTL processes are inherently poor in yield and create tarry byproducts which are difficult to isolate and low in value. It would be advantageous to produce clean refinery-ready hydrocarbons utilizing a more efficient and more environmentally friendly method that relies on existing coal reserves and new innovative processing technology which improves yields and profitability. Especially advantageous is a process that would utilize a less expensive, relative low-quality coal, especially in locations where oil reserves are limited and coal resources are plentiful.

Table 3: Comparison of ENCOAL™ and LPA BenePlus process characteristics

<table>
<tr><th></th><th>ENCOAL™ Process</th><th>LPA BenePlus Process</th></tr>
<tr><td>Coal candidate evaluation step</td><td colspan="2">1. Technical screening criteria based on candidate coal's physical and chemical properties: (1) High moisture content adds more value by upgrading; (2) Low ash content is required because the ash remains in the solid product; (3) The lower the fuel ratio, the greater the amount of volatile mater available for recovery as valuable hydrocarbons; (4) The H/C ratio needs to be high in order to ensure volatile matter will evolve with a high percentage of recoverable hydrocarbon vapor and not oxygen based gases (i.e., CO_2 and CO); (5) Free swelling is an important consideration concerning coal handling and processing in the drying and pyrolyzing stages of the CTL process.
2. Small-sample testing of the candidate coal and upgraded coal in a thermogravimetric analyzer (TGA) subjected to mild gasification conditions.
3. Commercial-scale demonstration of the CDL process.

Note: LPA has developed an Aspen model to evaluate the upgraded coal and valuable hydrocarbon products based on pilot-scale pyrolysis experimental data.</td></tr>
</table>

Pyrolysis conditions		
Temperature	~ 1000 °F	~ 1000 °F
Catalyst	No catalyst	With catalyst
VM conversion	~ 60%	55-75%
Upgraded coal		
Yield	46.54 wt% of feed coal	45-50 wt% of feed coal
Moisture	8-9 wt%	0-3 wt%
HHV (Btu/lb)	11,100 – 11,300	10,000 – 12,000
Hydrocarbon products		
Yield	19.7 gallons from 1 ton of feed coal (AR)	51 lbs of liquid fuels or 7 gallons from 1 ton coal feed (AR) + 7 lbs of fuel gas from 1 ton coal feed (AR)
Quality	Low value tars were reported to have limited markets, and sold at or below fuel value.	Liquid fuels are high value mix of… 67% Aromatics (benzene, toluene, xylene) 25% Natural gas liquids 8% Low sulfur diesel fuel
Unit Operations		
Acid gas removal unit for hydrocarbon products cleanup	No	Yes
Post-pyrolysis	Moisture and oxygen are added to the coal char after pyrolyzer	No

Laboratory studies to date

[Laboratory studies to date are reported in the confidential information section]

Pilot studies to date

[Pilot studies to date are reported in the confidential information section]

BenePlus Process Description and Schematic

[BenePlus process is described below in the confidential information section]

QUALIFICATIONS

LP Amina is a multinational environmental engineering company that provides proprietary solutions for reducing emissions in coal and gas-fired power plants, as well as unique technology for producing affordable and CO2-reducing synthetic crude and hydrocarbons from coal. The company has performed over 50 clean energy projects in China and the US and is recognized as an industry leader and innovator in the clean energy space. The participants of this project comprise of experienced professionals from LP Amina who have extensive R&D, technical, and financial expertise and are fully qualified to contribute to the project.

R&D

Matthew Targett is LP Amina's VP of Research and Development and is widely regarded as a forerunner of Asia's clean energy scientific advancement. He has 20 years of technical leadership experience, previously serving as the Head of Innovation Management for Bayer Technology Services in Asia, as well as holding numerous R&D and manufacturing technology leadership positions at DuPont. Dr. Targett holds a BS degree in Chemical Engineering from the Pennsylvania State University and an MS and PhD degree in chemical engineering from the University of Pennsylvania.

William Williams is the VP of Business Development at LP Amina and the principle investigator of this project. With 20 years of experience in the chemicals industry, his professional career includes positions with Cabot Corporation, Praxair, and DuPont. Dr. Williams holds a BS degree from the Worcester Polytechnic Institute and a PhD from the University of Minnesota.

Technology

William Latta is the founder and CEO of LP Amina. Mr. Latta has 22 years of technical and managerial experience in the power industry. Prior to LP Amina, he worked for Alstom Power, ABB, and Combustion Engineering (CE) in the US and in China. He is a co-chair of the Clean Coal Working Group in the US-China Energy Cooperation Program (ECP), actively supporting the development and commercialization of clean energy technology in both countries. Mr. Latta holds a BS degree in Mechanical Engineering from the Georgia Institute of Technology and an MBA from Duke University.

Mark Forwerck is the President of LP Amina's US operations. Mr. Forwerck has 35 years of experience in the power industry and worked previously with Alstom in various management and technical positions and Babcock Power as the Direct of Field Engineering and Services. At LP Amina, Mr. Forwerck was responsible for developing the initial suite of solutions that were deployed in China and has directed the development and introduction of LP Amina's technology to the US market. Mr. Forwerck holds a BS degree in Engineering from the Ohio State University.

Matthew Zedler is the Director of Global Technology Development and Integration at LP Amina. Since joining in 2011, he has been the technical design lead for over a dozen low-NOx burner/SOFA systems. Currently, Mr. Zedler drives our cross-border initiatives, leveraging our US and China engineering resources to produce optimal pollution control solutions for our customers. Mr. Zedler holds an MS degree in Mechanical Engineering from MIT and an MS degree in the same field from the Georgia Institute of Technology.

Financial Analysis

Seth Pinegar is the Senior VP of Corporate Development. He joined LP Amina in 2014 and is responsible for global finance and corporate development, including M&A and strategic business development. Before LP Amina, Mr. Pinegar was the CFO of Bleum Incorporated and the SVP and Head of Corporate Development for iSoftStone Holdings. Prior to his operational roles, Mr. Pinegar was an investment banker for nearly a decade with J.P. Morgan and UBS Investment Bank. He holds a BA degree from the University of Washington.

Basin Electric Power Cooperative – Proposal Partner

Basin Electric Power Cooperative is an electric generation and transmission cooperative based in North Dakota. Started in 1961, it provides electricity to 2.9 million customers in nine states. The cooperative owns and operates Antelope Valley Station, one of the proposed commercialization sites for the BenePlus demonstration. Individuals specifically involved in this feasibility study include Mr. James Sheldon - Senior R&D Engineer, Mr. Gavin McCollam - Engineering Services Director, Mr. Michael Just - engineering manager of Basin's Dakota Gasification subsidiary.

North American Coal Corporation – Proposal Partner

The North American Coal Corporation mines and markets lignite, bituminous and metallurgical coal primarily as fuel for power generation and for steel production and provides selected value-added mining services for other natural resources companies. Mr. Dennis James is the Director of New Technology for NACC and will be serving as a steering team lead and technology lead.

Southwest Research Institute (SwRI) – Pilot Testing

SwRI, headquartered in San Antonio, TX, is one of the oldest and largest independent, nonprofit, applied research and development organizations in the United States. SwRI's 11 technical divisions offer a wide range of technical expertise and services in such areas as chemistry, space science, nondestructive evaluation, automation, engine design, mechanical engineering, electronics and more.

The Institute occupies more than 1,200 acres and provides more than 2 million square feet of laboratories, test facilities, workshops and offices. In 2013, SwRI® sponsored $6.7 million in internal research to develop innovative technologies that ultimately benefits clients.

Tesoro Corporation – Offtake Analysis

Tesoro Corporation is an independent refiner and marketer of petroleum products, operating six refineries with a combined capacity of over 850,000 barrels per day. Its Mandan Refinery in North Dakota has a crude oil capacity of 71,000 bpd and produces gasoline, diesel fuel, jet fuel, heavy fuel oils, and liquefied petroleum gas.

VALUE TO NORTH DAKOTA

North Dakota is home to the largest known deposit of lignite in the world, and its lignite industry has long been a critical contributor to the stability of the state’s economy. BenePlus technology fulfills each of the priorities set forth by North Dakota for lignite research, and if adopted by power plants, the added economic and environmental value would be a tremendous asset to the state.

Ultimately, we see the North Dakota market supporting multiple BenePlus process facilities, likely sited at the state’s largest mine-mouth power plants: Antelope Valley Station, Coal Creek Station, and Milton R. Young Station. Existing rail connections and unit train unloading facilities at the remaining facilities would be used to transport upgraded coal from the three BenePlus process facilities to the remaining facilities.

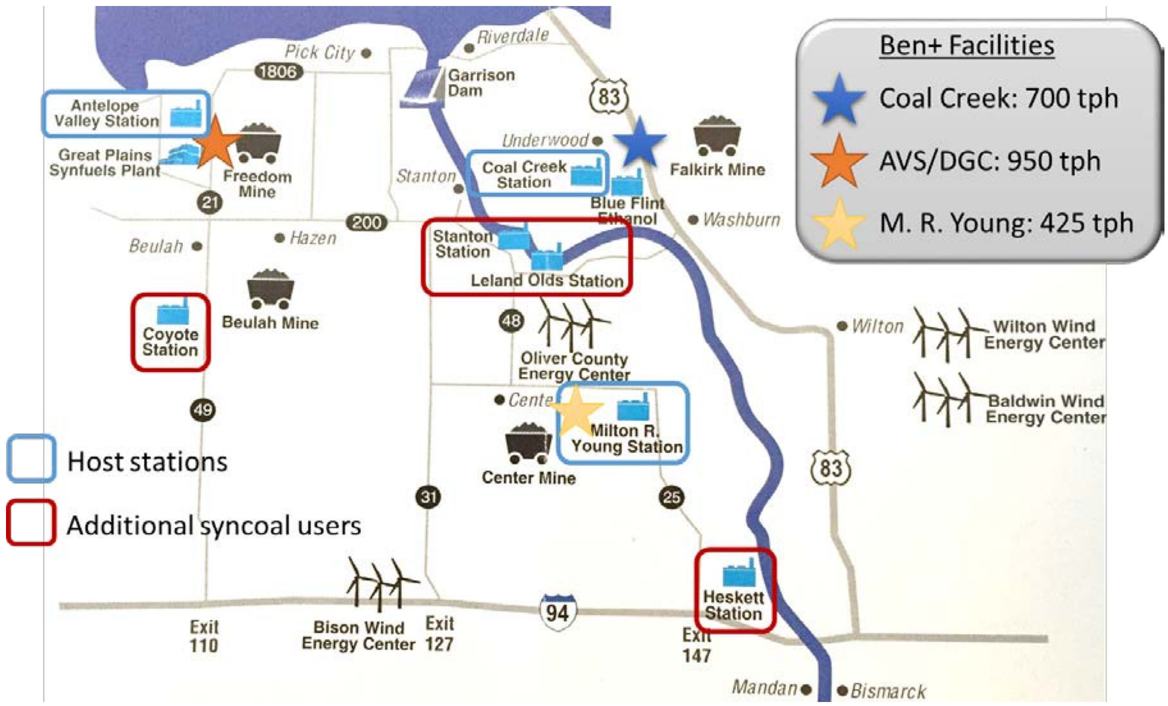

Figure 10: Depiction of ND market for BenePlus facilities at maturity. (Map modified from ND Energy Trail brochure).

Figure 10 depicts a possible scenario with three anchor plants:

- Coal Creek facility processes 700 ton/hr raw lignite for Stanton and Coal Creek stations, as well as the Spiritwood cogeneration facility in Jamestown (not shown in Figure 10).
- AVS/DGC facility processes 950 ton/hr for Antelope Valley, Coyote, and Leland Olds Stations.
- M. R. Young facility processes 425 ton/hr for Milton R. Young and Heskett Stations.

The financial and environmental impact of such a scenario is summarized in Table 4. Deployment of this technology throughout North Dakota, would provide substantial public and private benefit to North Dakota as prescribed by the goals of the NDIC charter.

1. **Private and public sector use:** BenePlus would trigger an increase in lignite production as a system-wide conversion to burning syncoal would reinforce the demand for lignite mining. The

technology would be used directly by private power plants, but its benefits would be enjoyed by both upstream and downstream sectors in the form of increased revenue to coal producers, increased lignite tax revenue for the state, and lower utility rates for the end consumers.

2. **Commercial potential:** BenePlus technology requires lower capital investment than traditional beneficiation processes and boasts a quick payback period of four to six years (based on recent oil pricing), which makes for a very compelling case for widespread implementation.
3. **Enhance the use of North Dakota lignite**: Lignite is already used to generate 80% of North Dakota's electricity and provides power for multiple neighboring states. Complemented with BenePlus, the main incentives for lignite's expanded use are threefold:
    a. The use of higher-efficiency syncoal would increase system efficiency and lower the cost to produce the same amount of power. These savings would be passed onto rate payers.
    b. The new hydrocarbon and carbon dioxide product slate would introduce raw material margins of over $289 million for businesses running BenePlus. Based on our demonstrated yields and today's prices, we expect annual sales of fuels and chemicals between $60MM and $70MM.
    c. BenePlus results in a net reduction in emissions to help power plants comply with strict environmental standards. The product coal is a dry, reduced sulfur coal that can be burned in a power facility with a lower heat rate and lower sulfur emissions. We estimate that the North Dakota power plants would save a total of $34.5MM annually in reduced fuel, sulfur remediation, and operational costs. Further, this process will reduce the carbon footprint of the power generating station; carbon capture and sequestration (CCS) at the BenePlus facility could reduce carbon emissions by up to 16% (Figure 3). Preliminary results suggest a 50% decrease in Hg, 52,000 ton/year reduction in SO2, and nearly 3MM ton/year reduction of CO_2. This process can play a key role in North Dakota's strategy to comply with the EPA clean power plant proposal.

4. **Preserve existing and create new jobs:** Deployment of BenePlus technology would not harm existing jobs in the lignite industry. In fact, implementation is expected to generate 250 jobs per plant per year during construction, and sustain 30 jobs per plant per year for plant operation. We also anticipate a 4% increase in mining jobs to support the increase in demand from plants that convert to using a lignite feedstock. For each direct job that is added, three more are needed to supply the industry with goods and services.[3] Thus, the overall impact is compounded.

Table 4: Potential financial and environmental† impact of BenePlus technology if deployed in ND state-wide‡.

1. Financial

	Change in lignite consumption, tons	Change in PRB consumption, tons	Revenue impact due to change in lignite consumption, $MM	Revenue impact due to change in PRB consumption, $MM	Revenue impact from fuel gas use, $MM	Revenue impact from upgraded coal, $MM	Total net revenue impact from fuel switch, $MM	Revenue impact from reduced FGDS RMC, $MM	Hydrocarbon and CO2 sales from Ben+	Net revenue change
ND power stations (total)	*(13,705,160)*	*(485,330)*	*$232.99*	*$19.41*	*($46.95)*	*($176.32)*	*$29.13*	*$5.38*		*$34.51*
Antelope Valley	(3,300,637)	0	$56.11	$0.00	($10.72)	($40.26)	$5.13	$1.45		$6.58
Leland Olds	(1,947,601)	0	$33.11	$0.00	($6.39)	($23.98)	$2.74	$0.47		$3.21
Coyote	(1,635,841)	0	$27.81	$0.00	($5.27)	($19.81)	$2.73	$0.65		$3.38
Milton R Young	(2,326,593)	0	$39.55	$0.00	($7.58)	($28.46)	$3.52	$0.85		$4.37
R M Heskett	(289,631)	0	$4.92	$0.00	($0.90)	($3.37)	$0.65	$0.11		$0.76
Coal Creek	(4,204,857)	0	$71.48	$0.00	($13.90)	($52.19)	$5.39	$1.85		$7.24
Stanton	0	(485,330)	$0.00	$19.41	($2.20)	($8.25)	$8.97	$0.01		$8.97
Ben+ operator	*14,637,432*	*0*	*($248.84)*	*$0.00*	*$46.95*	*$176.32*	*($25.57)*	*$0.00*	*$289.02*	*$263.45*
Lignite producers	*932,273*		*$15.85*							*$15.85*
Total/Net for ND	*932,273*	*(485,330)*	*$15.85*	*$19.41*	*$0.00*	*$0.00*	*$3.56*	*$5.38*	*$289.02*	*$313.81*

2. Environmental (negative numbers are a reduction in emissions)

	Change in SO2 emissions tons/yr	Change in CO2 emissions tons/yr	Current CO2 emission rate, lb/MWh	Projected CO2 emission rate, lb/MWh	Change CO2 emission rate, lb/MWh	Change CO2 emissions, %
ND power stations (total)	*(68,575)*	*(4,977,407)*	*2,406*	*2,056*	*(351)*	*-15%*
Antelope Valley	(8,254)	(1,178,566)	2,467	2,097	(370)	-15%
Leland Olds	(25,367)	(661,712)	2,371	2,032	(339)	-14%
Coyote	(7,615)	(594,354)	2,530	2,142	(388)	-15%
Milton R Young	(14,999)	(817,664)	2,438	2,078	(361)	-15%
R M Heskett	(1,716)	(115,336)	2,869	2,377	(492)	-17%
Coal Creek	(9,956)	(1,423,945)	2,316	1,989	(327)	-14%
Stanton	(668)	(185,830)	2,252	1,977	(275)	-12%
Ben+ operator	*0*	*2,252,809*				
Total/Net for ND	*(68,575)*	*(2,724,598)*	*2,406*	*2,214*	*(192)*	*-8%*

BenePlus technology has the powerful potential to improve the environmental performance of North Dakota's power plants and introduce a new means of enhancing the productivity and sustainability of the lignite industry. The coal producer will make a higher value coal, the coal consumer will reduce the production cost of electricity, the rate payers will see a reduction in electricity costs, and the coal

† There are two CO_2 emissions sources in the BenePlus process: 1) CO_2 generated with the pyrolysis gas, and 2) CO_2 from the regenerator. The CO_2 emissions baseline estimate assumes capturing only CO_2 from the pyrolysis gas product stream, and venting the CO_2 from the regenerator.
‡ Spiritwood station is not included in this analysis because it has less than a full operating year, so baseline data is difficult to determine at this point.

conversion facility will make revenue and profit from hydrocarbon sales. This will create tax revenue and high-paying jobs for the state of North Dakota. Investment in the demonstration and commercialization of this technology promises to transform the North Dakota power industry.

MANAGEMENT

Phase 1 of this project will be managed predominately by LP Amina and completed with the support of the project partners and a few external personnel. Individual contributions are as follows:

Principal Investigator: Dr. William R. Williams, VP of Business Development for LP Amina will work on this 2/3 of his time. He will drive the overall project and ensure the timely completion of each objective through weekly team meetings, periodic reviews with the steering team, and stage gate reviews as outlined in the timetable section below.

Steering Team Leads: There will be one steering team lead from each of the partners. At this point they are as follows: Mr. William Latta, CEO of LP Amina, Mr. Gavin McCollam, Engineering Services Director of Basin, Mr. Dennis James, Director of New Technology for North American Coal, and Mr. Rick Weyen, Vice President of Strategy and Business Development for Tesoro Corporation. Each will be expected to contribute about 1/6 of their time in this capacity.

Technology Leads: The technology leads will be responsible for evaluating the technical content of the project, operating as an internal technical review board. The technology leads will be as follows: Dr. Matthew Targett, CTO of LP Amina, Mr. Michael Just, the engineering manager of Basin's Dakota Gasification subsidiary (DGC), and Mr. Dennis James of North American Coal. Mr. James will contribute 1/6 of his time, and Dr. Targett will dedicate 1/3 of his time in their roles as technology leads. Thus, Mr. James, in his dual role as steering team lead and technology lead will be expected to contribute one third of his time on this project. Mr. Just brings practical experience at managing the safety and operations of handling chemicals at DGC, as well as a unique understanding how to qualify coal-derived fuels for the petrochemicals market. We expect Mr. Just to contribute 1/6 of his time consulting on integration, safety, and fuels qualification.

Business Development Lead: Dr. Williams will dedicate about 1/6 of his time on business development, in addition to 2/3 of his time as principal investigator. His roles will include developing and negotiating off-take letters of interest and preliminary terms as well as negotiating and coordinating external efforts around Project Phase 1 activities.

Financial Leads and Analysts: Mr. Seth Pinegar, Senior VP Corporate Development, of LP Amina, and Mr. James Sheldon, Sr. R&D Engineer for Basin will serve as financial leads. Mr. Pinegar will be primarily responsible for evaluating the economics of the proposed JV to run the first commercial unit, and Mr. Sheldon will be primarily be responsible for evaluating the economic impact and costs of the fuel switch at AVS and for coordinating all external studies on the fuel switch. About 1/6 of Mr. Pinegar's time and 1/3 of Mr. Sheldon's time will be dedicated to these efforts. To assist Mr. Pinegar and Mr. Sheldon, we expect to dedicate 1/3 of an analyst's time from LP Amina and Basin.

Process Engineer: Dr. Meng Li of LP Amina will be responsible for building a working Aspen model for the mass and energy balance for both the PMU and commercial scale facility. She is expected to spend 2/3 of her time on this project.

Engineering Lead and design engineer: LP Amina will hire or internally transfer a project engineer to coordinate all efforts around engineering and the feasibility study for the commercial unit. This person will dedicate 2/3 of his/her time to this job. In addition, a design engineer will be assigned to the project on a 1/3 time basis.

Two evaluation points will be used during the course of this project. If either of the following circumstances arise, we will discontinue the project.

1. Catalyst Life: Studies demonstrate excessive catalyst attrition making the project uneconomical.
2. Boiler Studies: Boiler modifications required at AVS to handle the syncoal resulting in unfavorable economics.

TIMETABLE

Our timeline assumes that funds will be available from the grant by December 1, 2016. The three major deliverables of this project as outlined above are the process and catalyst reliability validation, the techno-economic feasibility validation, and the boiler fuel switch study. As can be seen in the Gantt chart in Figure 11, these activities can largely be carried out in parallel. However, the process and catalyst reliability data will be essential before the techno-economic assessment can be finalized.

During the project we will conduct a number of gate reviews roughly corresponding to the off-ramps outlined in the "Standards for Success" section. At each gate review, if a fatal flaw is uncovered that cannot be mitigated, the project will be terminated. The gate reviews will correspond to the following key critical tasks outlined in Figure 11 below:

- Upon completion of the boiler study, on or about January 11, 2016. If at this point, it is apparent that major modifications are required to the boiler to handle even a small amount of syncoal, we will re-evaluate the project, and may terminate at that point;
- upon completion of the process and catalyst reliability validation on or about February 8, 2016;
- and upon completion of the techno-economic assessment on or about February 22, 2016. This final review will determine whether to proceed to Phase 2 (PMU construction).

Task Name	Duration	Start	Finish	Predecessors
Boiler fuel switch study	**30 days**	**Tue 12/01/15**	**Mon 01/11/16**	
Determination of maximum syncoal possible with minor boiler modifications	4 wks	Tue 12/01/15	Mon 12/28/15	
Estimation of ancilary equipment costs	2 wks	Tue 12/29/15	Mon 01/11/16	2
Process and catalyst reliability validation	**55 days**	**Tue 12/01/15**	**Mon 02/15/16**	
Start-up and run preparation	2 wks	Tue 12/01/15	Mon 12/14/15	
Continuous operation (24 x 5)	8 wks	Tue 12/15/15	Mon 02/08/16	6
Data analysis and report out	1 wk	Tue 02/09/16	Mon 02/15/16	7
Techno-economic feasibility validation	**60 days**	**Tue 12/01/15**	**Mon 02/22/16**	
Task 1: Intitial meeting	1 day	Tue 12/01/15	Tue 12/01/15	
Task 2: Review of Strategy and Schedule for Project Development	5 wks	Wed 12/02/15	Tue 01/05/16	11
Task 3: Review of Basic Technical Information	4 wks	Tue 01/19/16	Mon 02/15/16	11,8FF
Task 4: Review of product quality	6 wks	Tue 01/05/16	Mon 02/15/16	11,8FF
Task 5: Operating and Maintenance Cost Review	4 wks	Tue 01/19/16	Mon 02/15/16	13FF
Task 6: Capital cost review	11 wks	Tue 12/01/15	Mon 02/15/16	13FF,3FF
Task 7: Report out and documentation	1 wk	Tue 02/16/16	Mon 02/22/16	11,13,14,15,16,12

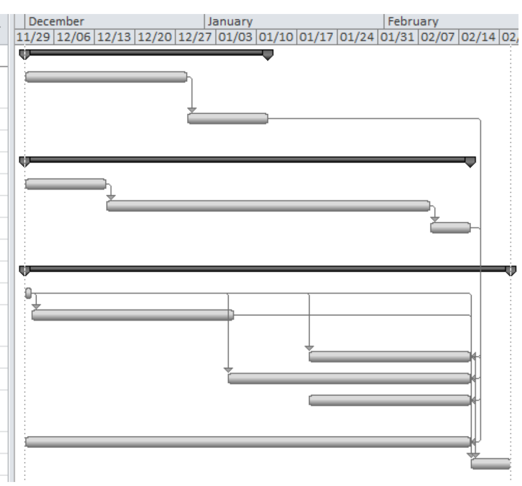

Figure 11: Gantt chart timeline for Phase 1 activity covered by scope of this application.

BUDGET

The project phase 1 budget is summarized in Table 5. To complete the Project Phase 1 objectives, we anticipate spending $700,000 with about $418,000 coming from cash expenses.

Table 5: Project Phase 1 budget summary

In Kind Spend, $K (3 months)		LPA				Basin				North American				Tesoro					
		$/month	FTE months	total	full amount	$/month	FTE months	total	full amount	$/month	FTE months	total	full amount	$/month	FTE months	total	full amount	SUB TOTAL	TOTAL
	Principal Investigator	20	2	40		20		0		20		0		20		0			
	Steering Team Lead	20	0.5	10		20	0.5	10		20	0.5	10		20	0.5	10			
	Technology Lead	20	1	20		20	0.5	10		20	0.5	10		20		0			
	Financial Lead	20	0.5	10		20	1	20		20		0		20		0			
Personnel	Biz Dev Lead	20	0.5	10	170	20		0	50	20		0	20	20		0	10	250	
(Including Fringe)	Process Engineer	10	2	20		10		0		10		0		10		0			
	Analyst	10	1	10		10	1	10		10		0		10		0			282
	Engg Lead	20	2	40		20		0		20		0		20		0			
	Design Engineer	10	1	10		10		0		10		0		10		0			
	Other	10		0		10		0		10		0		10		0			
Indirects																		0	
Travel					24				5				2				1	32	
Other																		0	

Out of Pocket Cash Spend (3 months)		
Description	Provider	Amount, $K
Process Validation	SwRI	318
Independent Engineer Assessment	Leidos	65
Fuel Switch Study	B&M	35
TOTAL		418

Spend Summary	$K
Total spend (including inkind)	700
Total cash expenditures	418
Cash from LRC	209
Total cash from Partners	209
Total spend ratio: partners/LRC	*2.35*
Cash spend ratio: partners/LRC	*1.00*

The cash expenses include the following:

- SwRI Contract Lab Studies: Southwest Research Institute (SwRI) has conducted the pilot studies on this process for the past year, and has submitted a quotation (attached in a confidential appendix) for work to qualify the catalyst, demonstrate continuous, reproducible process operation, and create samples of product off-take for partners and potential customers to evaluate. We will conduct part 1 of the quote during the application period. Therefore, it is not included in the budget. The quote is $432k, of which we expect about $318 to be directly billable to the project during the grant period.
- Independent Engineer Assessment (IE): The independent engineer will review and vet Phase 1's data, economic analysis, scale-up strategy, and timeline for Phases 2 and 3. We have received a firm quote from Leidos, a reputable IE with extensive experience in the coal to chemicals industry for $65k (attached in a confidential appendix).

- Fuel Switch Study: To simplify the logistics and scope of the first project, we wish to use all of the product coal locally, preferably on-site at AVS. We therefore need to know how much syncoal can be used practically at AVS without incurring expensive boiler modifications. Based on this study, we may modify the scale of the first commercial plant. We have solicited quotations from Alstom, Burns & McDonnell (attached in a confidential appendix), and Sargent & Lundy. Based on the quotes received to date, we have budgeted $35k for this activity.

In-kind contributions will be predominantly personnel, the majority from LP Amina. We estimate the fully loaded personnel costs (salary, fringe, and overhead) to be about $20k per month for senior staff and $10k for junior staff. Specific personnel role and time contributions are detailed under the Management section.

The remainder of the in-kind contributions consist of travel expenses. We expect LP Amina to spend around $24k in travel, NACC around $5k, and Basin around $3k. The following major activities will require travel:

- Steering team meetings: We expect at least 2 steering meetings during Phase 1 to be attended by the steering team members, technical leads, and the principal investigator. We assume that one will be in Bismarck and one may be by teleconference. Therefore, Basin will incur no travel costs. For the remaining partners, we have budgeted the following travel costs for these meetings: $14,000 for LP Amina (a higher amount due to international travel for Dr. Targett and Mr. Latta), $1,000 for NACC, and $1,000 for Tesoro.
- Technical reviews: We expect at least two additional technical reviews with the entire technology team including Dr. Targett, Dr. Williams, and Dr. Li of LP Amina, Messrs. Sheldon and Just of Basin, and Mr. James of NACC. For these meetings we are budgeting $10,000 for LP Amina, $5,000 for Basin, and $1,000 for NACC.

MATCHING FUNDS

We are seeking $209k from the state of North Dakota to pay for part of the cash expenses to be matched by the partners in cash contribution. Therefore, the proposed cash match for the grant will be $1 industrial direct costs per $1 state funds granted. Including indirect funds the industrial contribution will be $2.35 per $1 state funds granted. The direct and indirect (in-kind) contributions will be divided as follows.

Direct Costs

Basin Electric Cooperative, North American Coal, and LP Amina have agreed in principle to share a portion of the cash expenses (minus the amount given from NDIC). Therefore, of the $418k cash expenses, the grant will cover $209k and the remaining cash expenses will be divided among Basin, North American Coal, and LP Amina. We will finalize the amounts each partner contributes before the end of the application review period, and any granted monies will only be released upon finalization of the structure of the contribution from the partners.

Indirect Costs

Each company will commit to in-kind contributions and travel expenses as outlined above. There will be no intercompany transfer to cover in-kind contributions. Thus, LP Amina will contribute roughly 69% of the indirect costs, Basin will contribute roughly 19%, NACC will contribute roughly 8%, and Tesoro will contribute the remaining 4%.

TAX LIABILITY

LP Amina LLC. does not have an outstanding tax liability owed to the state of North Dakota or any of its political subdivisions.

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[1] https://**greet**.es.**anl**.gov/ . We used the GREET offset for benzene to estimate the liquid fuel credit.
[2] DOE/NETL-2002/1171,
http://www.netl.doe.gov/File%20Library/Research/Coal/major%20demonstrations/cctdp/Round3/netl1171.pdf
[3] https://www.lignite.com/about-lignite/lignite-production/economic-impact/