AmeriCarbon

April 1, 2023

State of North Dakota
The Industrial Commission
State Capitol
Bismarck, ND 58505
ATTN: Lignite Research Program

**RE: Transmittal Letter**

This transmittal letter is to set forth a binding commitment on behalf of AmeriCarbon Products, LLC to complete the project as described in the accompanying application if the North Dakota Industrial Commission makes the grant requested therein.

Sincerely,

Greg Henthorn
Vice President of Corporate Development
AmeriCarbon Products, LLC

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AmeriCarbon

**Submitted To:** State of North Dakota
The Industrial Commission
State Capitol
Bismarck, ND 58505
ATTN: Lignite Research Program

**Project Title:** Engineering Design and Feasibility Analysis for Commercial Graphite and Asphalt Manufacturing from Lignite-Derived Carbon Pitch

**Applicant:** AmeriCarbon Products, LLC

**Principal Investigator:** David A. Berry

**Date of Application:** April 3, 2023

**Amount of Request:** $700,000

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# 1. Abstract

In January 2022, AmeriCarbon began work under the project titled *North Dakota Lignite Coal-Based Pitch for Production of High Value Carbon Products via AmeriCarbon Liquid Carbon Pitch (LCP) Process*, which is funded by the NDIC, AmeriCarbon, and NACoal. The fundamental purpose of that project is to demonstrate the technical and financial feasibility of converting lignite into carbon pitch, an intermediate feedstock used in the manufacture of many carbon products. Currently, industry uses bituminous coal exclusively for such material as a by-product of the coking process in steel production; in contrast, AmeriCarbon's patented and proprietary Liquid Carbon Pitch (LCP) process focuses on carbon pitch production and has flexibility in terms of feedstock and can be tailored to produce different pitch properties for various applications.

Having demonstrated successful production of commercial grade lignite-derived carbon pitch, the primary objective of the current proposal is to build on the work completed in the first project by developing the engineering design for a commercial scale facility in North Dakota that converts coal to carbon pitch, asphalt, and battery grade graphite. By-products will also include a concentrated ash that contains rare earth elements (REEs) and certain hydrocarbon liquids, converting nearly all of the lignite feedstock into saleable products.

Combined with the engineering design contributed to the project by AmeriCarbon as cost share, the expected results of the proposed project will be to have a set of preliminary engineering design documents and drawings that cover the following processes: (i) conversion of lignite to carbon pitch, (ii) conversion of carbon pitch to asphalt, and (iii) conversion of carbon pitch to battery-grade graphite. The proposed $1.4 million project (including $700,000 requested from NDIC) will span 18 months upon initiation and involves the following primary participants: AmeriCarbon Products, LLC (applicant), the Institute for Energy Studies at the University of North Dakota, Barr Engineering, and The North American Coal Corporation. Each of the participating parties have committed cost share to the project.

# 2. Project Summary

AmeriCarbon and its North Dakota collaborators have initiated efforts to design, construct, and operate a commercial scale carbon products manufacturing facility in McLean County, North Dakota ("McLean Plant").[1] The McLean Plant will use North Dakota lignite in AmeriCarbon's patented and proprietary Liquid Carbon Pitch (LCP) process to manufacture *Eco-Pitch™*, a 100% domestic sourced alternative to coal tar pitch, a critical supply material for the production of synthetic graphite and other carbon materials.

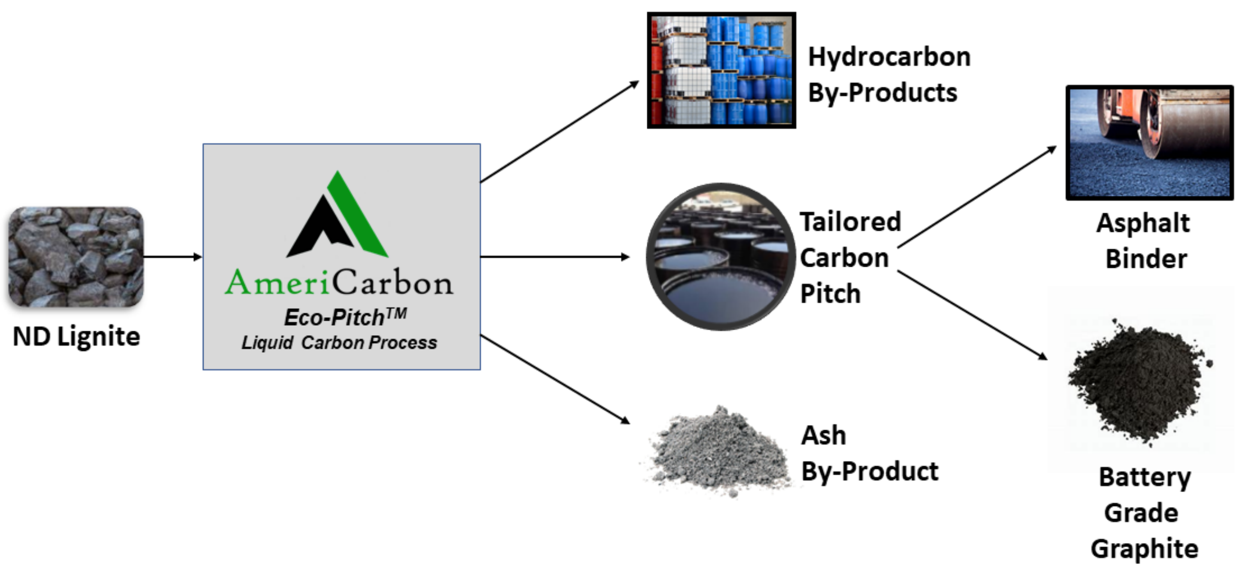


***Figure 1.*** *McLean Plant simplified product summary.*

The currently proposed project would leverage work that already has been completed to validate the commercial feasibility of manufacturing carbon products from lignite (the technical and economic feasibility assessment initially funded in part by NDIC) as well as ongoing work on the engineering design of a base module of AmeriCarbon's LCP process. Figure 2 depicts these items along with the currently proposed project and the detailed engineering and construction of the McLean Plant on an overall timeline of commercialization.

[1] AmeriCarbon has also referred to the facility as the "Battery Materials Center".

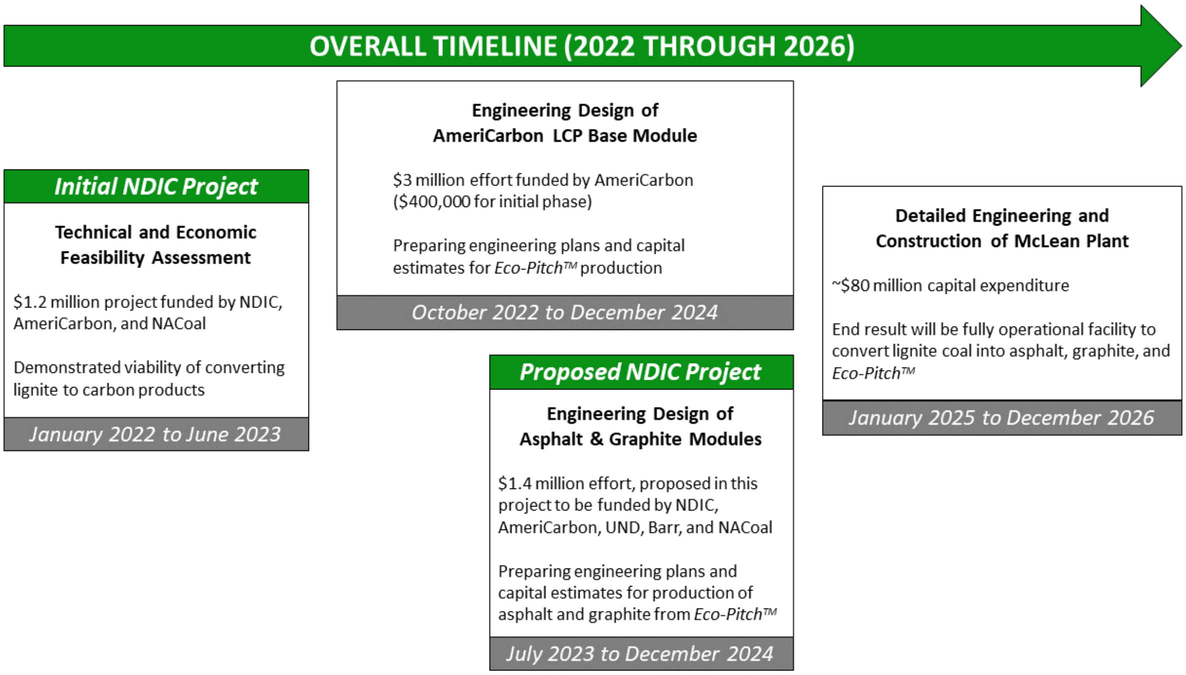


***Figure 2.*** *Overall commercialization timeline.*

In March 2023, AmeriCarbon submitted a concept paper under the Bipartisan Infrastructure Law that seeks a $27.5 million subsidy for the AmeriCarbon LCP Base Module at the McLean Plant. The federal government has a number of additional programs in the works to subsidize the construction of facilities, and AmeriCarbon is working diligently to identify and position the McClean Plant for those awards. Having engineering and feasibility studies completed and in process improve the competitive position of DOE proposals, and the currently proposed project, if awarded by the Lignite Research Council, would provide a major step forward in such competitiveness.

## The Planned McLean Plant and Its Products

The AmeriCarbon LCP process is highly efficient and produces minimum waste; the following products and by-products, referenced in Figure 1 above, will be produced at the McLean Plant after it is designed, financed, constructed, and commissioned:

1. ***Eco-Pitch™***. A coal tar pitch substitute that can be tailored for specific desired properties in the AmeriCarbon LCP process, *Eco-Pitch™* will be both an intermediate product and an end product of the McLean Plant. As an intermediate, it will be further processed into asphalt binder and battery-grade graphite. As an end product, it will be sold as binder pitch and impregnating pitch, with applicability in the electric vehicle (EV) battery market and other immediate markets where there is a shortage of supply due in part to reliance on foreign supply (principally China). Industry currently relies on coal tar pitch to be produced from coal tar, a ~5% by-product of coking ovens in legacy steel manufacturing processes. Displacement of current coal tar pitch supply with lignite-derived *Eco-Pitch™* will reduce greenhouse gas emissions content by more than 99% compared to current sources.[2]
2. **Asphalt binder**. Current demand for asphalt is met with a blend of aggregate with petroleum derived binder; coal-derived asphalt binder has been demonstrated to have certain superior qualities to petroleum-derived asphalt binder, such as with respect to adhesion, hardness, and anti-aging properties. AmeriCarbon is developing an asphalt binder based on lignite that can be blended with petroleum-based binder to improve quality and durability while integrating with existing supply infrastructure.
3. **Graphite**. The demand for graphite is increasing rapidly, and the United States government has designated graphite as a critical supply material. Meanwhile, there is currently not any domestic industrial supply of battery-grade graphite. The Inflation Reduction Act created significant tax incentives for EV battery manufacturers that can demonstrate certain levels of domestic material supply, and AmeriCarbon's ability to directly convert coal into provides a viable and scalable pathway to meeting the demand growth with a fully domestic source with abundant supply.

[2] *Technical Summary: Estimated Greenhouse Gas Emissions for AmeriCarbon's Coal Tar Pitch Versus Coal Tar Pitch Produced in China*, Downstream Strategies, September 27, 2021, submitted to NDIC on 10/01/2021 as Appendix 2-I in AmeriCarbon's proposal titled *North Dakota Lignite Coal-Based Pitch for Production of High Value Carbon Products via AmeriCarbon Liquid Carbon Pitch (LCP) Process*.

4. **Hydrocarbon by-products**. The AmeriCarbon LCP process produces a fraction of light hydrocarbons that can be separated and sold into existing markets, adding to the financial viability and material efficiency of the process.
5. **Ash by-product**. The AmeriCarbon LCP process separates solid material into a concentrated ash that contains rare earth elements (REEs) and other minerals. This ash can be sold for various applications, including REE extraction and can be used as filler in certain material applications such as cement production.

The McLean Plant will be an important commercial scale demonstration of the production of critical materials while creating sustainable employment in high tech manufacturing. The McLean Plant will provide full manufacturing capability with a capacity to produce 15,000 tons of primary products (*Eco-Pitch*™, asphalt binder and graphite) annually and an additional 13,500 tons of by-products, while demonstrating AmeriCarbon's proprietary and commercially viable technology for future expansion and replication in additional coal impacted communities.

## Existing AmeriCarbon Facility and Background

The roots of AmeriCarbon's proprietary and patented LCP process date back to 2009, when a predecessor organization built a pilot-scale unit for broad coal liquefaction applications. AmeriCarbon has re-engineered the facility to create the LCP process for intentional production of tailored isophase and mesophase coal pitch intermediates and needle cokes. AmeriCarbon has produced pitch from lignite, bituminous and sub-bituminous coals and has also produced needle coke in the facility.

AmeriCarbon has the only known ***continuous*** pilot-scale, coal liquefaction-based, pitch production facility in the world. The facility, detailed later in this proposal, is a 12,000 sq-ft facility that contains infrastructure for laboratory through pilot-scale R&D. This allows for immediate and directly scalable engineering data from applied research generated to be confidently translated to a commercial scale plant. In our discussions with future customers, nearly all have expressed concerns about a lack of supply availability and desire to secure a domestic source of economical coal-derived pitch/chemical intermediate. Collaborative agreements are being formulated to pursue those opportunities.

## The Initial NDIC Project: Technical and Economic Feasibility Assessment

Since January 2022, AmeriCarbon has been executing on a project titled *North Dakota Lignite Coal-Based Pitch for Production of High Value Carbon Products via AmeriCarbon Liquid Carbon Pitch (LCP) Process*, which was funded in part by NDIC. At the onset of that project, AmeriCarbon and its collaborators had technical theories and reason to believe that it would be technically feasible to convert North Dakota lignite coal into a coal tar pitch product. Implementation of the project has yielded the following results:

- ✓ Identified and quantified specific market applications
- ✓ Gained an understanding of desired product specifications
- ✓ Conducted chemical formulation and process evaluation studies
- ✓ Produced carbon products from lignite coal that have been tested and confirmed to meet market and customer specifications
- ✓ Evaluated by-products that contribute to the commercial viability of the liquid carbon process
- ✓ Developed a technoeconomic model that meets investor return thresholds

Under the initial project, AmeriCarbon and its project collaborators have demonstrated that the production of carbon pitch from North Dakota lignite coal is technically feasible for multiple applications.

## Engineering Design of AmeriCarbon LCP Base Module

In October 2022, AmeriCarbon engaged an engineering design contractor to develop an engineering design for the AmeriCarbon LCP process, focused on the production of *Eco-Pitch™*, hydrocarbon by-products, and ash by-product. **<u>The scope of that engagement does NOT include the further processing of *Eco-Pitch™* into asphalt binder and graphite products</u>**.

Under that ongoing project, which has been funded to date exclusively by AmeriCarbon, preliminary engineering designs have been developed and are being refined; the effort includes cost estimates for equipment and other capital expenses required for construction and operation of the base module to produce *Eco-Pitch™* and its referenced by-products. The work product from this effort will achieve one of the key critical requisites for developing a commercial scale facility such as the McLean Plant.

## Currently Proposed Project: Engineering Design of Asphalt and Graphite Modules

The primary objective of this proposed project is to initiate engineering design and validate economic viability for the asphalt and battery modules of the McLean Plant. This builds on the prior effort funded by the NDIC in January 2022, which identified and demonstrated the technical potential of asphalt and battery grade graphite derived from lignite coal utilizing AmeriCarbon's patented/proprietary LCP process.

Unlike the current engineering design of the LCP base module, which is not coal type specific, the work product of the proposed project will be specially designed for processing *Eco-Pitch*™ produced from North Dakota lignite. The physical and chemical properties of lignite result in an *Eco-Pitch*™ that is unique and specific, and therefore the engineering design of the asphalt and graphite modules will have aspects that are specific to lignite coal and a North Dakota facility.

The following are expected project results and deliverables:

- Front End Loading Engineering (FEL 1) to provide opportunity assessment and design basis for a commercial plant in North Dakota;

- Experimental process development studies to provide basis for the engineering design/study, technology readiness and the supply of product samples for customer assessment; and

- Technoeconomic evaluation study to verify business case for commercial plant.

The ultimate end goal of the project is to position the commercialization efforts of AmeriCarbon and its collaborators to secure funding from public and private sources to complete the design and construction of the McLean Plant, with the intention of beginning commercial operation of the facility in approximately three years.

# 3. Project Description

The project involves two primary areas where attention will be focused:

(a) **Asphalt binder production**. This will involve optimizing the parameters of the AmeriCarbon LCP base module for manufacturing ideal commercial compositions of lignite-derived asphalt binder, as well as designing the material handling operations required for commercial production. UND will lead this aspect of the project with close input and interaction with AmeriCarbon.

(b) **Graphite production**. This involves the design of unit operations to convert three separate *Eco-Pitch*$^{TM}$ compositions into battery grade graphite to be sold to EV battery assemblers. Barr Engineering will lead this effort with input from UND and AmeriCarbon.

Additional background regarding these two aspects of the project, followed by project details, are provided below.

## Asphalt Binder Market and Considerations

Construction and maintenance costs for U.S. roadway infrastructure are about $100 billion annually, and asphalt paving is the largest component thereof, representing about 20%. Traditionally, asphalt binders are produced mainly by petroleum refiners, and is viewed as a simple, convenient, and profitable way to use the residual material from the refinery operation.

Although being a convenient solution, petroleum binders are plagued with different performance issues like poor adhesion, aging, elastic deformation, and also material issues like rigid physical parameters (e.g., softening point). Moreover, the demand for asphalt binders is increasing exponentially to meet new infrastructure requirements both in the U.S. and globally. But at the same time, the refinery operations are not increasing their capacities owing to environmental concerns and government regulations. Figure 3 illustrates an estimate of the deficit in the supply-demand chain for the asphalt industry.

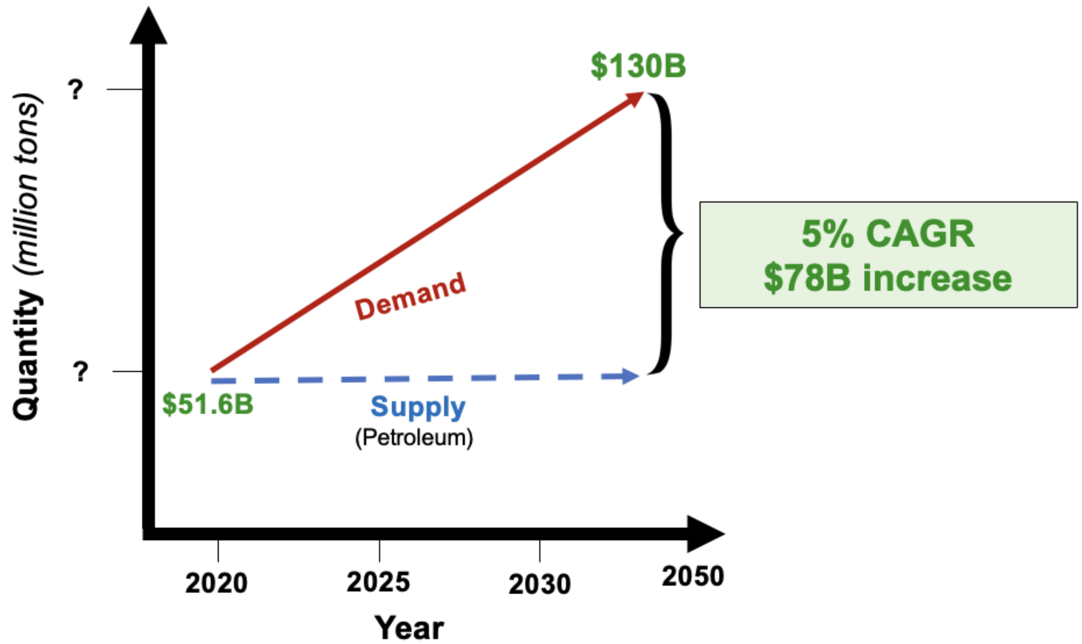


***Figure 3:*** *Indicative supply-demand curve for asphalt binder products.*

Petroleum binders are devoid of necessary resin and asphaltene structure, which is inherent based on the origin of the material. This shortcoming of the physical properties is addressed by modifications using polymer additives mixed with petroleum binders to provides more resinous structure, but that approach is not a sustainable solution.

Asphalt binder derived from carbon pitch provides a robust solution to address the issues of physical drawbacks and declining availability. Carbon pitch based binder material has several advantages including wetting and adhesion to stone and mineral aggregates, corrosion resistance, a higher coefficient of friction for safety, lower elastic deformation, less susceptibility to aging, less expensive compared to petroleum asphalt, and can be more environmentally friendly *(Andreikov et al. 2010, Chambrion et al. 1995).*[3]

Another important aspect to consider is the source of coal (coal rank) used for manufacturing coal-based asphalt binder. Lignite, owing to its structural composition, is an ideal coal for asphalt applications.

[3] Chambrion, P., Bertau, R., and Ehrburger, P. (1995). *Effect of polar components on the physico-chemical properties of coal tar*, Fuel, 74 (9): 1284–1290.

Lignite has loosely bound heterogeneous bonds in the structure, which requires less energy to break down in the liquefaction process, and thus becomes economically attractive.

In our initial project funding in part by NDIC, AmeriCarbon is recommending pursuit of this market opportunity and accelerating towards manufacturing lignite coal derived asphalt binder grade pitch at commercial scale using its unique and environmentally friendly tailored LCP process. This process will allow the manufacture of *Eco-Pitch*™ with targeted physical properties that can be used in different grades of asphalt binders and is adaptable to future needs.

Researchers have explored the blending of coal-based and petroleum-based binders and found that adding a coal-based pitch helps in fulfilling performance gaps by improving adhesion to the filler material (from the asphalt mix), reduces elastic deformation (improves crack resistance) and also improves working life (anti-aging) of the asphalt (*Xue et al. 2017*).[4] Complete replacement of petroleum asphalt with coal-based binders has not yet been extensively explored but is a possible future optimization of the opportunity.

AmeriCarbon has developed relationships with asphalt industry participants and university researchers to accelerate the efforts to position lignite-derived carbon pitch in the asphalt binder supply chain. In late 2022, AmeriCarbon was brought into a proposal submitted by a defense contractor under the U.S. Department of Transportation Federal Highway Administration Exploratory Advanced Research (EAR) Program 2022. Under the proposal, AmeriCarbon has provided lignite-derived asphalt binder pitch produced in our pilot facility for an advanced research project involving next generation roadway materials. AmeriCarbon's inclusion in the proposal followed evaluation of our carbon pitch by the defense contractor's university partner and is a form of validation of our approach and concept.

AmeriCarbon also has a collaborative relationship with Dr. James Bryce at West Virginia University. Based on the requirements of the asphalt binder industry as we have learned through our discussions, AmeriCarbon has generated a series of lignite-derived asphalt pitches which are being evaluated for performance and key indicators.

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[4] Xue, Y., Ge, Z., Li, F., Su, S., & Li, B. (2017). *Modified asphalt properties by blending petroleum asphalt and coal tar pitch*, Fuel, 207: 64-70.

## Battery Grade Graphite Market and Considerations

Graphite is a critical material for the production of lithium-ion batteries (LIBs) and electric vehicles (EVs). *Eco-Pitch*™ will be tailored into three different forms, each of which will be graphitized into a new product derived from lignite and 100% domestically sourced.

The LIB market size has dramatically increased, promoted by rapidly increasing demands for EVs, electronics, grid-level energy storage, and other industrial applications. In recent years, the global LIB electrode material demand and production capacity has exceeded its forecasted CAGR, and this trend is expected to persist as the EV market continues to rapidly expand. The global EV battery market, estimated at ~$28 billion in 2021, projected to grow to $155 billion by 2028 at a CAGR of 28% (Fortune Business Insights, 2021).[5] According to the University of North Dakota, if all the graphitic carbon in the anode is 100% carbon-ore derived, 100 million tons of coal and coal waste would be consumed.

Graphite is among the U.S. government's targeted critical materials. Currently, there is no material domestic production of synthetic graphite for EV batteries. The supply of binder pitch and impregnating pitch is reliant on the supply of coal tar from Asia, principally China, as a by-product of the coking process in steelmaking. With current supplies of coal tar pitch consumed by existing traditional applications, it is unclear where the rising demand due to EV batteries is going to be fulfilled, placing the United States at a significant geopolitical disadvantage. AmeriCarbon's approach in general – and this project specifically, addresses this concern directly by providing a complete domestic supply chain for carbon.

In the past, the United States had significant coking ovens for steel making that also produced coal tar pitch as a by-product. This was sufficient at the time, but two things have since changed that has caused a shortage in U.S. coal-tar pitch supply: (i) U.S.-based coke ovens have largely closed due to loss of the U.S. steel industry and environment challenges with the coke ovens; and (ii) rapid and projected exponential growth of the carbon-based materials industry. China has significant coke oven operations and currently supplies the

[5] *Electric Vehicle (EV) Battery Market Size, Shar & COVID-19 Impact Analysis, by Battery Type (Lithium-ion, Lead Acid, Nickel Metal Hydride, and Others), by Vehicle Type (Battery Electric Vehicles, Plug-In Hybrid Electric Vehicles, and Hybrid Electric Vehicles), and Regional Forecasts, 2022-2029*, Fortune Business Insights, 2021.

majority of the world's pitch supply. AmeriCarbon has recognized this opportunity and is applying its liquefaction background in coal-to-chemicals to demonstrate its innovative pilot-scale coal-to-pitch process.

Working closely with the University of North Dakota, AmeriCarbon has developed a viable approach for commercial production of battery grade graphite from lignite coal. Among various coal types, lignite has demonstrated that it is reactive and adaptive to structural change upon chemical processing, which is a critical step in graphite production. The AmeriCarbon/UND approach for graphite anode production provides a much better fast-charging capability, which has been identified as a major roadblock to wide scale EV deployment. The AmeriCarbon/UND approach will also result in a higher packing density and thereby higher energy density.

UND and AmeriCarbon have presented a portion of their joint approach to manufacturing battery-grade graphite from lignite in a recent paper titled Coal Derived High-Performance Anode Materials for Lithium-Ion Batteries, which is attached as Appendix 3-I.

## Statement of Work and Project Objectives

The primary objective of this proposed project is to initiate engineering design and validate economic viability for the asphalt and battery modules of the McLean Plant. The following are expected project results and deliverables:

- Front End Loading Engineering (FEL 1) to provide opportunity assessment and design basis for a commercial plant in North Dakota;

- Experimental process development studies to provide basis for the engineering design/study, technology readiness and the supply of product samples for customer assessment; and

- Technoeconomic evaluation study to verify business case for commercial plant.

The project will address two primary design areas: (i) asphalt production and (ii) graphite production. Simplified schematic diagrams of each are shown in Figures 4 and 5 below.

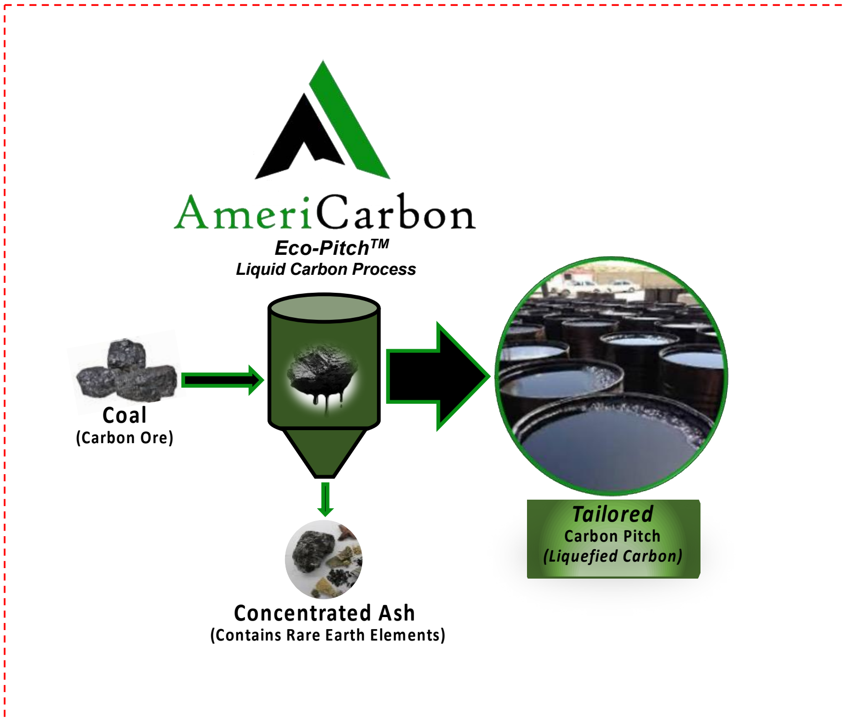


***Figure 4:*** *High level schematic diagram of the AmeriCarbon LCP process, which will be optimized for asphalt binder production.*

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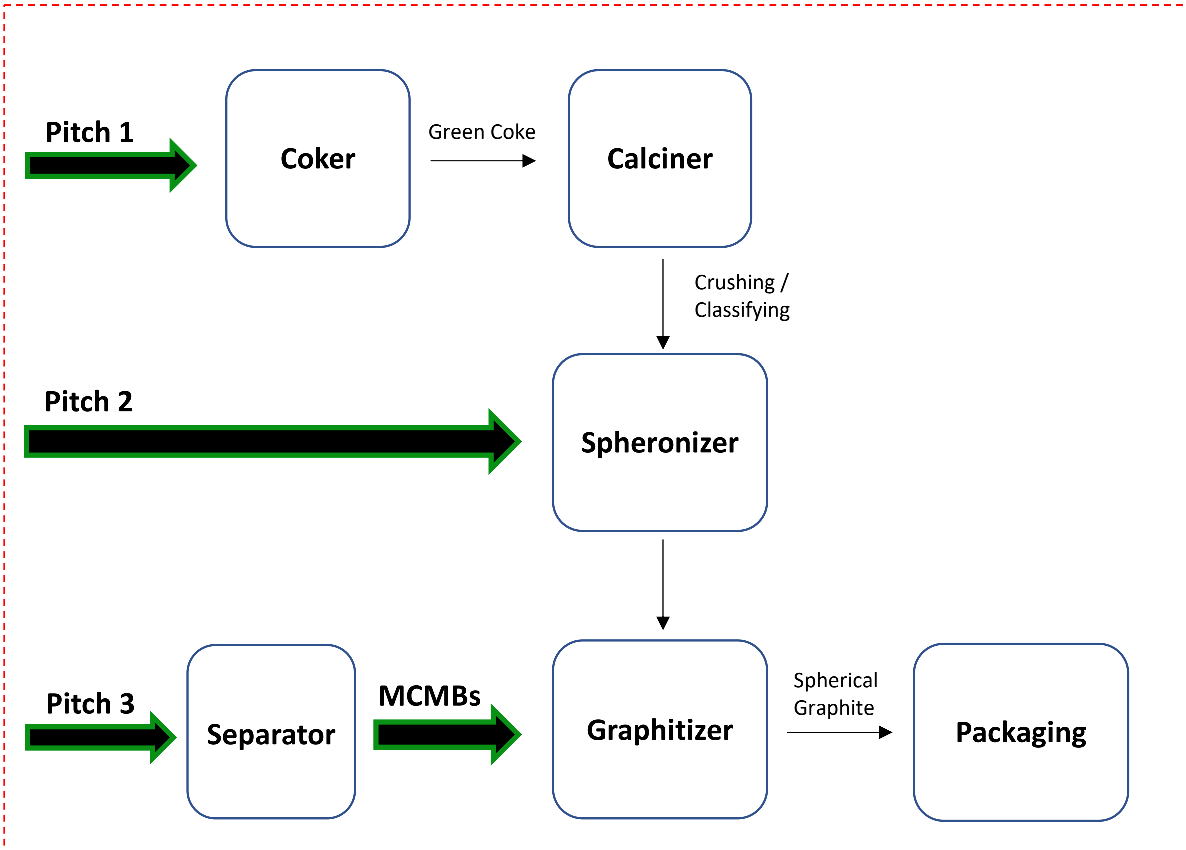



***Figure 5:*** *High level schematic diagram of the planned graphite production module.*

The project will be led by AmeriCarbon, with participation from additional performers including the University of North Dakota (UND), Barr Engineering, and The North American Coal Corporation (NACoal). The following are task statements for the project:

**Task 1: *Engineering Feasibility Study*** – An FEL-1 engineering design/study will be conducted on a commercial scale lignite coal fed facility to be located in North Dakota based on AmeriCarbon's LCP *Eco-Pitch*$^{TM}$ process. The plant will consist of a base pitch production module producing asphalt and pitch which feeds an integrated graphite conversion module for the production of battery grade graphite. Based on output of the engineering design, a Class 5 level capital cost estimate as defined by AACE International will be generated. Barr Engineering and AmeriCarbon will be the principal performers with input from experimental Task 3 and Task 4.

Primary unit operations considered may include but not be limited to:

- Coal Material Handling
- Eco-Pitch Liquefaction and Storage
- Concentrated Carbon Handling (Byproduct)
- Pitch Transport
- Coker
- Calciner
- Separator
- Spheronizer
- Graphitizer
- Super Sack Packaging
- Air Emissions Cleanup
- Waste Disposal
- Wastewater treatment and discharge

**Task 2: *Coal Feedstock Supply and Characterization*** – NACoal will supply North Dakota lignite coal to AmeriCarbon for processing into pitch at their Morgantown, WV facility. These coals will be exclusively used in the experimental development and generation of asphalt and graphite products generated in Task 3 and Task 4. Shipped coal shall be dried to lower moisture levels to practical extent possible prior to shipping. Potential inerting with nitrogen will be considered to minimize degradation of the lignite over timeframe of the project. Ultimate and proximate analysis will be conducted and supplied with the coal.

**Task 3: *Asphalt - Experimental Product Development, Evaluation and Process Design Studies*** – The objectives of this project are (1) to manufacture Lignite Pitches with targeted specifications (based on the federal and state DOT regulations), (2) assess its use to replace petroleum asphalt partially and fully with or without using modifiers, and (3) to test the lignite binder-based asphalt mix for performance evaluation. An iterative approach will be used between physical and mechanical properties assessment and Lignite pitch development, to optimize the *Eco-Pitch*TM specifications that will be produced by AmeriCarbon. Lignite pitch binders and petroleum asphalt are 100% compatible with each other, and existing literature will be used as a guidance for formulating blends. Superpave grade is the commonly used pavement grade used in the state of North Dakota as well as rest of the US and will be used for benchmarking. Specific activities can include but not be limited to:

- Lignite Pitch Development
- Binder Evaluation and Process optimization
- Performance Evaluation (Bench Scale)
- Correlating Binder and Mix Properties

This task will be performed by the University of North Dakota and AmeriCarbon. Samples as appropriate will be shared with potential customers and governing agencies to promote the use of lignite coal-based binders into the commercial marketplace.

**Task 4: *Graphite - Experimental Product Development, Evaluation and Process Design Studies*** – AmeriCarbon and the University of North Dakota will build on its success in 2022 in converting lignite coal into graphite. The primary objective of this task is to support the engineering design activity in Task 1 and additionally demonstrate the viability of a domestic supply chain for battery grade graphite. Various forms of graphite and/or carbon materials (pitch, needle coke, MCMBs) are needed to specifically make spherical "battery grade graphite". Success in Task 4 would represent the only demonstrated domestic graphite produced exclusively from lignite-coal and enable the United States in reducing its dependence on off-shore foreign suppliers for this critical strategic material.

This task is highly integrated through iterative feedback optimization between the coal conversion and graphite product quality. It leverages AmeriCarbon's unique ability to produce tailored pitches exhibiting distinct physical and chemical properties that are necessary to produce at least three distinct pitch types leading to the primary intermediate carbons to make the battery grade graphite including needle coke and meso carbon micro beads (MCMB's). Task activity includes but is not limited to:

- Identification of optimal pitch formulations and manufacturer of required pitch quantities.
- Optimization of AmeriCarbon's needle coke procedure for battery-grade graphite production.
- Development of UND's MCMB extraction/separation process
- Fabrication of spherical battery-grade graphite
- Fabrication of UND designed coin-cell batteries for graphite performance testing and comparison to commercial graded graphite

The University of North Dakota and AmeriCarbon combined have the facilities to execute this task but may engage third party services as required. Samples as appropriate will be shared with potential customers and governing agencies to promote the use of lignite coal-based binders into the commercial marketplace.

***Task 5: Technoeconomic Study*** – A study will be conducted to evaluate the commercial potential of the subject North Dakota Lignite Coal-Based Asphalt/Graphite commercial plant. Input will be based on existing AmeriCarbon information, prior studies and results from Tasks 1-4.

**Deliverables:**

- Pitch Samples: Identified in Task 3 and Task 4 as necessary throughout the project
- Quarterly Interim Reports
- Task 5: Technoeconomic Report
- Final Report

## Environmental and Economic Impacts of the Project

With respect to the conduct of the proposed project, environmental impact will be minimal. Existing facilities will be used, with the exception of the purchase of a graphitization furnace. The facilities used in the project will operate within reasonable parameters of waste and energy consumption that are consistent with their current usage levels.

In terms of economic impact, the project budget of [$1.4 million] will include $551,000 to UND for work to be performed in North Dakota, and $200,000 to Barr Engineering for work performed primarily in Minnesota and North Dakota.

Future potential impacts are significant. *Eco-Pitch™* is a quantum leap forward in terms of improved environmental impact compared to current supplies. Due to AmeriCarbon's efficient and low temperature process, greenhouse gas emissions are reduced by more than 99% compared to coal tar pitch produced as a by-product of coking ovens in the steelmaking process (Downstream Strategies, 2021). Further, because AmeriCarbon's process operates at lower temperatures, certain carcinogenic compounds and other harmful chemicals are not generated in the process.

# 4. Facilities & Equipment

The project will be conducted at existing facilities that are operated by the project's performers. The facilities are outlined below.

### AmeriCarbon Research and Pilot Demonstration Facility

***Figure 6:*** *AmeriCarbon's Research and Pilot Demonstration Facility in Morgantown, West Virginia.*

AmeriCarbon operates a state-of-the-art 12,000 sq-ft facility in the Morgantown Industrial Park (Morgantown, West Virginia) that contains infrastructure for laboratory through pilot-scale R&D. The facility contains six commercial flame suppression laboratory hoods and a wet chemistry area along with multiple high-bay areas for pilot-level research and demonstration.

***Figure 7:*** *AmeriCarbon's pilot scale unit operations that underpin the LCP process.*

## AmeriCarbon Equipment

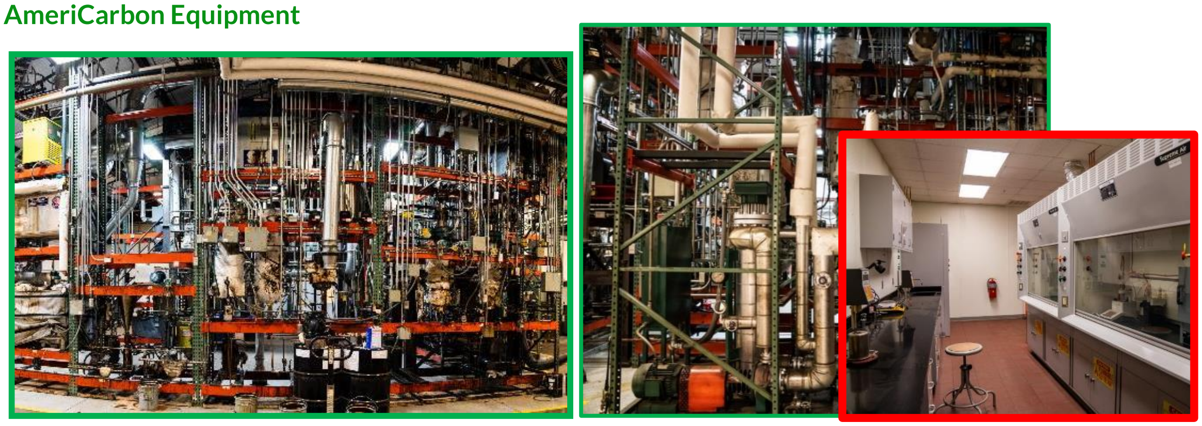


***Figure 8:*** *AmeriCarbon's pilot scale and research equipment.*

AmeriCarbon's equipment includes: coal liquefaction & coker train capable of processing 10 tons per day; capable of producing custom coal pitch, needle coke, and advanced carbon products; product separation and collection train; both trains are fully automated and managed by an industry standard computer / software system; six commercial hood laboratory with flame suppression and exhaust system; fully equipped for benchtop lab research and development. The facility is heavily instrumented and managed by a PLC control system with continuous monitoring.

## Barr Engineering

Barr Engineering is headquartered in Minneapolis, and has offices in several locations in the United States and Canada. Barr Engineering's Bismarck, North Dakota office opened in 2008, serving clients in North and South Dakota, Wyoming, Montana, and Saskatchewan. Barr Engineering's well-rounded team of engineers and scientists represent a variety of disciplines such as mechanical, mining, structural, civil, and environmental engineering. With a deep local perspective, Barr Engineering helps clients navigate challenges, like a cold-weather climate, unique to the upper Midwest.

Barr Engineering's Bismarck staff are members of professional societies such as the North Dakota Petroleum Council, North Dakota Water User Association, Bismarck Mandan Chamber of Commerce, North Dakota Geological Society, Lignite Energy Council, and American Council of Engineering Companies of North

Dakota. Barr Engineering cares about community and participates in service activities with organizations like Gateway to Science and Toys for Tots North Dakota.


***Figure 9:*** *Barr Engineering's Bismarck office.*

## University of North Dakota

Founded in 1883, six years before the state itself was established, UND gave North Dakota its name when the former Dakota territories separated into two distinct states. Today, UND is a busy 521-acre campus, the state's largest. UND has emerged as a leader in engineering, medicine, aviation, space, and unmanned aircraft systems.

The following facilities at UND will have applicability to the proposed project:

*Battery Assembly and Test Center (UND-IES)*. The center can fabricate and test various batteries, from small-size CR2032 coin-type cells to full-size pouch cells and up to 48V battery packs. The cylindric cell fabrication facility consists of a set of machines for electrode coating, rolling press, vacuum drying, slitting, ultrasonic spot welding, winding, grooving, and sealing. The center houses a Neware CT-4008 Battery Analyzer for coin-type cells, CT-3008n and BTS4000-5V30A Battery analyzers for pouch cells, an HYNN-BP600A battery testing system for battery packs, and high/low temperature chambers (Espec) and electrochemical workstations (Gamry) with capabilities including charge/discharge characteristic tests, capacity tests, cycle life tests, Cyclic Voltammetry (CV), Electrochemical Impedance Spectroscopy (EIS) analysis, and battery standard dynamic tests.

*Materials Characterization Lab (UND-IES).* The MCL was established to support UND research and educational activities, support industry research and sample analysis needs, and serve as a regional satellite lab. The laboratory is supported by experienced technicians and analytical chemists and has a vast array of analytical equipment and capabilities, including a field-emission scanning microscope (FE-SEM) FEG 650 (FEI, USA), x-ray powder diffraction (XRD) Smartlab (Rigaku, Japan), Thermo Scientifics' Nicolet NXR 9650 FT-Raman spectrometer, x-ray fluorescence spectrometer Supermini 200 (Rigaku, Japan), Thermogravimetric analyzer SDT-Q600 (TA, USA), and a computer-controlled scanning electron microscope S3400 (Hitachi, Japan) with EDS (IXRF, USA). The MCL will be used to examine the crystal purity, chemical composition, morphology, and particle-size distribution of the anode materials, as well as the MPP feedstock.

*UND-IES Lab.* This lab is equipped to perform chemical synthesis and processing steps and has a small autoclave (Parr) for MCMB synthesis, an atmosphere-controlled TFM2 2-Zone tube furnace (Across International, USA), and a bench-scale muffle furnace (KJ-a1200-27L, China) for carbonization steps, and an atmosphere-controlled glove box (MBraun LABstar MB) for battery construction.

*Environmental Analytical Research Laboratory (UND-IES)*. The equipment available for the proposed project includes a lab muffle furnace with atmosphere control, a carbon analyzer TOC SSM 5000A analyzer (Shimadzu, Japan), Ion Chromatography (Dionex 100), and an inductively coupled plasma optical emission spectroscope ICP-OES 5510 (Agilent, USA).

*Sample Preparation Laboratory (UND-IES)*. UND has a fully equipped sample preparation lab that will be used to take advantage of the above equipment, with all of the necessary capabilities for the project's required sample preparation. Available equipment includes a Mixer/Mill 8000 M (SPEX, USA), a LaboPol-21 polisher (Sturers Inc.), an X-press sample presser (SPEX, USA), a K-1 flux (SPEX, USA), a shatter box (SPEX, USA), and a Micronizing mill (McCrone).

### Additional Equipment

The team proposes to acquire a graphitization furnace for this project which would be housed at the University of North Dakota. The project team has identified multiple toll graphitization service providers but due to the low availability and long waiting time, having a graphitization furnace at UND enables the project team to more efficiently conduct the necessary research for the proposed project in a timely manner.

# 5. Standards of Success

The project will support the onshoring of the manufacture of advanced carbon products, an emerging industry in the United States which has the potential to grow to 480,000 jobs over the next three decades, according to April 2021 testimony in the U.S. Senate Energy and Natural Resources Committee. By using lignite coal as a raw material for manufacturing and connecting the dots in the supply chain all the way to valuable finished products, AmeriCarbon and our collaborators have the potential to significantly reduce the amount of embedded carbon in a wide array of finished products with double digit compound annual growth rates.

This project will serve a foundational role in laying the groundwork for the development of commercial scale manufacturing facilities in North Dakota to capture the state's rightful share of the economic opportunity brought about by the onshoring of advanced carbon product manufacturing. The production of carbon pitch from lignite coal is a linchpin that will lead to additional manufacturing opportunities where lignite-derived carbon pitch is the feedstock for further value-added refinement into valuable carbon materials and products. Long term, this can lead to several million dollars of capital investment, the creation of thousands of new jobs with sustainable employment, and reduced greenhouse gas emissions from the U.S. manufacturing sector.

The long-term success of this project, therefore, will be measured by the following:

1. *Commercial pitch production facilities*. How many commercial scale pitch production facilities will be located in North Dakota and in what time frame? Our hope, pending successful technical results, would be to enable at least one commercial facility located in North Dakota within three years with an installed capacity of 28,500 tons of production annually (including all products and by-products).

2. *Downstream manufacturing facilities*. How many additional advanced carbon products manufacturing facilities will be located in North Dakota that use carbon pitch as a feedstock, and what will be their economic impact? Our hope is that within five years, there could be a network of manufacturers locating in North Dakota, leading to hundreds of jobs during construction and facility operations.

In order to achieve the desired economic impacts, the project must produce certain tangible technical results. Specifically, these can be summarized as follows:

a. *Technical results*. The desired technical results are to develop a series of engineering plans for the McLean Plant with respect to the asphalt and graphite modules described herein.

b. *Techno-economics*. Capital expenses will be estimated and evaluated in the context of techno-economics to be able to project the commercial viability of the different carbon manufacturing applications.

The standards success for the technical results will be whether the project has resulted in a series of drawings, technical formulations, and capital expense budget for commercial construction and operation of the McLean Plant. We believe that financial projections for such a facility would target an internal rate of return (IRR) sufficient to attract private sector financing of a first-of-its-kind facility; in the alternative, a lower projected IRR could also be considered successful if certain federal incentives and subsidy could be leveraged.

# 6. Background

The basis for AmeriCarbon's LCP process is derived from long-standing coal liquefaction technology. Coal liquefaction was first successful developed and implemented in Germany around the time of the World War because of abundance of coal reserves and the need to find alternative resources to petroleum-based transportation fuel for military vehicles like tanks, airplanes and warships. Friedrich Bergius, a German chemist, was the first to invent direct coal liquefaction to convert lignite to fuel in 1913 [22]. Bergius developed a process that required high pressure (70 MPa) and temperature (> 500$^0$C) using iron-based catalyst. The indirect coal liquefaction process was later developed in 1923, famously known as Fischer-Tropsch process. In this process, the coal is first converted into "synthesis gas" (syngas) which is mainly a mixture of $H_2$ and CO, which is then converted into light hydrocarbon liquid fuel through a series of steps. Both these methods, direct and indirect coal liquefactions, were developed primarily to covert different types of coal into a fuel source[23, 24]. The third way of coal is pyrolysis in which coal is converted partly into liquid hydrocarbon and remining into gaseous hydrocarbon and coke. This liquid hydrocarbon is commonly known as "coal tar", which served as a starting material for lot of chemical and material development[25, 26]. After Germany, United States and Japan also embarked on all three different ways of coal liquefaction; direct, indirect and pyrolysis simultaneously. Unfortunately, the research exploration is this field started to cease as an enormous supply of petroleum was identified in Middle East in 1950. Currently, the only major liquefaction plants worldwide are operated by Sasol (syngas, indirect liquefaction) in South Africa and by Shenhua (direct liquefaction) in China[27].

To date, there has not been a critical demand to pursue coal-liquefaction technology in the United States. However, recent efforts both in the United States and globally to exploit the superior properties of advanced carbon materials have prompted AmeriCarbon to leverage prior liquefaction efforts with its own innovations to produce the key intermediate chemical linking carbon-rich coal to manufactured carbon products…coal tar pitch. In the past, the United States had significant coking ovens for steel making that also produced coal tar pitch as a by-product. This was sufficient at the time, but two things have since changed that has caused a shortage in US coal-tar pitch supply:

- US-based coke ovens have largely closed due to loss of the US steel industry and environment challenges with the coke ovens;
- Rapid and projected exponential growth of the carbon-based materials industry

China has significant coke oven operations and currently supplies over 72% of the worlds pitch supply. AmeriCarbon has recognized this opportunity and is applying its 10-yr liquefaction background in coal-to-chemicals to demonstrate its innovative pilot-scale coal-to-pitch process…liquid coal pitch (LCP).

AmeriCarbon is on an aggressive path to commercialize this technology and is currently focused on completing research/development and optimizing the process to allow intentional pitch plants to be scaled for specific coals.

Please refer to the Project Summary section for additional background regarding the project and the associated technologies.

# 7. Qualifications

## AmeriCarbon Team Members

AmeriCarbon has assembled a credentialed project team and has developed a portfolio of strategic alliances with innovative developers, research institutions, and industry partners. Its executives bring expertise in the technical subject matter of hydrocarbon conversion, advanced coal products, technology scaleup and commercialization, and business and project finance.

Our team contributes the following to the proposed project:

- Technical Expertise. The AmeriCarbon team is led by David Berry, who is serving as principal investigator for the project. Dave has numerous patents and patents pending through more than three decades of institutional research experience with the U.S. Department of Energy and U.S. Department of Defense that are focused on hydrocarbon conversion technologies. Dave has extensive experience from the laboratory through the pilot-scale and has surrounded himself with world class researchers and innovative thinkers which have contributed to AmeriCarbon's unique technology. Dr. Chetan Tambe will serve as a senior researcher during the project. Dr. Tambe has a decade of experience in process design and development with a focus on hydrocarbon liquid processing. Mark Scafella will serve as senior chemical technician. Mr. Scafella constructed the AmeriCarbon LCP pilot facility and has 10 years operating experience in the facility conducting coal liquefaction to various fuels, chemicals and pitch.

- Scale Up Capability. AmeriCarbon's business executives have spent the majority of their decades-long careers working in the realm between laboratory scale research and industrial development. The skills required to commercialize technology through the pilot demonstration phase are invaluable and contribute to AmeriCarbon's special capabilities in technical innovation and application.
- Commercial Track Record. Implementing innovation at pilot and industrial scale requires experience in large commercial transactions and the ability to manage capital with discipline. These qualities are the hallmark of AmeriCarbon's financial and commercial team members, who have raised and managed several hundred million dollars in the energy and materials sectors. Greg Henthorn formally serves as AmeriCarbon's vice president of business development and will continue to lead these activities in addition to providing project management and business operations support for the project. Chad Green is the company's CFO and has been involved in several billion dollars in commercial finance, including private equity and public markets.

## University of North Dakota Team Members

Project members from UND include the following:

- **Dr. Daba Gedafa** is the Chair and Michael & Sitney Lodoen Endowed Professor of Civil Engineering at the University of North Dakota. He has an extensive research experience with coal byproducts including bottom ash, slag, and fly ash for sustainable asphalt and concrete infrastructure. He determined the amount of fly ash that can be used to replace asphalt binder and mineral fillers for sustainable asphalt pavements. He has also determined the optimum content of bottom ash and ground bottom ash with and without nano clay as a fine aggregate and cement replacement, respectively by comparing it to the compressive strength of cement-based concrete. Fresh properties, mechanical properties, and durability of optimum bottom ash and ground bottom ash-based concrete were determined. He also determined the maximum amount of cement that can be replaced by fly ash with and without nanomaterials while providing the equivalent or higher performance of concrete as compared to the control (cement-based concrete). He has published more than 70 peer-reviewed articles. He is a registered professional engineer, Envision Sustainability Professional, and a fellow of the American Society of Civil Engineers.

- **Dr. Xiaodong Hou,** Research Assistant Professor, is a material chemist at UND-IES with over 15 years of experience synthesizing and characterizing advanced functional materials. He has over 40 peer-reviewed publications in the field of chemistry materials and holds five patents. Dr. Hou has been directing multiple projects directly related to developing advanced electrode materials for LIBs. One of the technologies aimed at developing coal-derived carbon materials for composite electrode materials for LIBs has finished its pilot-scale test and is in the process of licensing.
- **Dr. Daniel Laudal**, Director of UND-IES, has 16 years of R&D leadership related to energy systems. Dr. Laudal is an expert in lignite organic/inorganic chemistry and utilization processes and has been working on projects related to lignite and carbon-based projects for most of his career. He was previously the project manager for Minnkota Power Cooperative's Project Tundra, a $ 1.5 billion world-scale $CO_2$ capture and storage project in ND. Dr. Laudal also served as the Environmental Manager for Minnkota and coordinated the project's complex legal, environmental, technical, and financial development. The proposed project will benefit from Dr. Laudal's extensive project management and development experience.

## Barr Engineering

Barr Engineering is an industry-leading provider of engineering and environmental consulting services. Employee owned since 1966, Barr Engineering traces its origins to the early 1900s. Its engineers, scientists, and technical specialists help clients across North America and around the world benefit their communities by responsibly developing, managing, processing, and restoring natural resources. Key team members for this project include the following:

- **Ryan Rayda** has more than 15 years of experience providing structural engineering services for industrial, municipal, commercial, and public clients. He manages projects and designs structures related to power plants, mining and minerals processing facilities, pipelines, water treatment facilities, pumping stations, schools, hospitals, and commercial developments. Ryan also provides lifting and rigging design.
- **Dan Palo** has 25 years of experience with process design, plant improvement, project management, and research and development for processes that involve minerals, chemicals, fuels, and manufactured products. From research and development through scoping and prefeasibility studies to basic and detailed design, Dan's work spans the mining life cycle. He routinely helps clients to develop both greenfield and brownfield projects from full plant evaluations to the assessment and improvement of existing circuits.
- **Nicole Nguyen** has more than a decade of process engineering experience working with energy, fuels, and power clients. She has served as a lead process-design engineer, startup and commissioning field engineer, project manager, and instrumentation and controls engineer. Nicole has experience as project manager and task lead in detailed design for power projects as well as developing detailed cost estimates and performing budgetary feasibility studies for power, mining, and fuels projects. She has been involved with equipment procurement and selection, contract management, process and controls design, and commissioning.

*Note: Detailed resumes from AmeriCarbon, UND, and Barr Engineering are included in Appendix 7-I.*

# 8. Value to North Dakota

The proposed project will contribute to onshoring the supply chain of advanced carbon products – with current feedstock demand being largely met by China – and connect the dots all the way from raw materials (in the form of lignite coal) all the way to a finished product, reducing our nation's reliance on foreign suppliers to fuel growth in this strategic area. This economic activity can leverage North Dakota's rich and abundant supply of lignite by using it as a highly valuable raw material feedstock for value-added manufacturing.

The proposed project plays a necessary and critical role in the development of the McLean Plant. Upon breaking ground, the McLean Plant will have immediate, near term, and long-term impacts with respect to the creation of high wage employment for McLean County, North Dakota and the surrounding region. The facility is projected to create 40 high wage full time jobs when the facility opens, with growth to 70 jobs at full capacity. The created jobs will be manufacturing and engineering jobs with high wages and located in and near economically distressed regions. The company has entered into a Memorandum of Understanding regarding a Project Labor Agreement regarding the McLean Plant. AmeriCarbon is committed to workforce development as a major pillar of the company's activities in North Dakota.

The proposed project will enhance the use of North Dakota lignite coal by providing an alternative commercial use other than electricity. In the event that coal-fired electricity generation remains steady over time, this project could also lead to an opportunity to grow the coal industry and provide funds for increased research, jobs, and economic growth and development.

Products of the McLean Plant can be used to create electric vehicles parts and electrodes as well as to keep up with the growing demand for charging stations around the state. It can also lead to additional asphalt production that could extend beyond the state's borders. The McLean Plant will help to preserve existing coal jobs by ensuring demand for the product in case of an economic downturn in the coal industry. The proposed project will also lead to job growth in the coal sector due to the additional demand for lignite coal to be used for carbon pitch. Demand for advanced carbon products is growing annually and when combined with the AmeriCarbon LCP process, the underlying opportunity is to convert a $50-150/ton resource into a $5,000-$25,000/ton product. Job growth can also come from the resurgence of domestic production of carbon pitch in the United States.

# 9. Management

From an organization/company point of view, AmeriCarbon will serve as the point organization and will manage the project, including all vendors and personnel who are performers under the project. From an individual perspective, David Berry will be the Principal Investigator and lead the project team.

The project will have a flat organizational structure reporting to a single authority, the Principal Investigator. This is intended to streamline project communication and decision making, facilitating the performance of the tasks and achievement of the objectives described in the proposal, including in the Statement of Project Objectives section in a timely and efficient manner, and in the timeframe outlined in the proposal.

The project team's flat organizational structure will allow for efficient and rapid response to questions and challenges that may arise in the performance of the project. Communication will occur largely via videoconferences and telephonic conferences on regularly scheduled and ad hoc bases throughout the project as needed. The principal investigator has considerable experience in managing teams in different locations, managing project scope, and ensuring technical direction without veering off track. This will provide a disciplined approach to project timelines and budgeting while avoiding scope creep challenges. The principal investigator will be responsive to incoming requests from NDIC and is prepared to schedule videoconferences, telephonic meetings, or in-person meetings as desired.

As noted in the attached resumes, which may be found in Appendix 7-1, the principal investigator has more than three decades of research experience, including the management of cross functional teams with diverse skills and competencies. All members of the team have considerable experience managing and performing in similar teams spanning multiple decades.

## Risk Management Plan

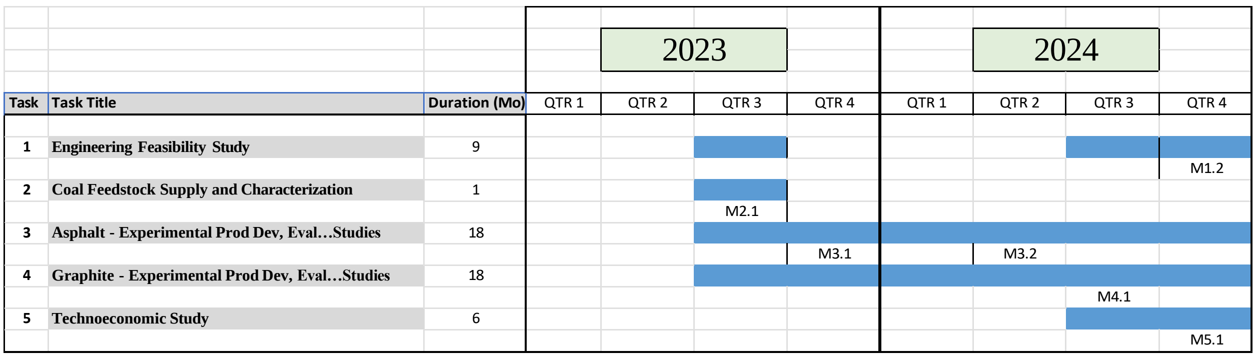
AmeriCarbon continually identifies risks and challenges to the project, including financial, technical, performance, schedule, and regulatory compliance. Strategies for mitigating and managing these risks include developing contingency plans, conducting risk assessments, and implementing quality assurance and quality control measures. Regular communication and collaboration with stakeholders and team members is essential to keep everyone informed of progress and address any issues or concerns.

**Table 1**. Perceived Risks and Mitigation Strategies

| **Perceived Risk** | **Risk Rating** | | | **Mitigation/Response Strategy** |
|---|---|---|---|---|
| | **Probability** | **Impact** | **Overall** | |
| | **(Low, Med, High)** | | | |
| **Financial Risks:** | | | | |
| Vendors or supplies | Low | Med | Med | *Alternate suppliers.* Although the technology and research is at cutting edge, alternative vendors/suppliers have been identified for most equipment utilized and carbon processing companies. |
| | | | | |
| **Cost/Schedule Risks:** | | | | |
| Major equipment failure | Low | High | Med | *Alternate funding sources.* Pilot-scale facilities can be costly to repair. The majority of project equipment utilized on this project is comprised of multiple smaller components and often can be repaired or replaced in reasonable fashion. AmeriCarbon is sufficiently capitalized to have near-term ability to mitigate most facility failures of this nature. |

# 10. Timetable

The proposed project is anticipated to take 18 months from project initiation. The following is a timeline Gantt chart with milestones, milestone table and suggested deliverables (higher resolution versions are found in Appendix 10-I):




The following are the deliverables and timeline:

| Task | Milestone Title & Description | Planned Completion Date | Verification Method |
|---|---|---|---|
| 1 | M1.1 - Engineering Design Study | Project Completion | Topical Report |
| 2 | M2.1 - Coal Supply & Characterization | 60 d after award | Shipped/Delivered |
| 3 | M3.1 - Initial Pitch Samples for Test | 3 mo after award | Shipped/Delivered |
| 3 | M3.2 - Optimized Pitch Samples for Test | 12 mo after award | Shipped/Delivered |
| 4 | M4.1 - Optimized Battery Grade Graphite Testing | 14 mo after award | Final Report |
| 5 | M5.1 - Technoeconomic Results | Project Completion | Final Report |

# 11. Budget

The project budget totals $1,400,000, with $700,000 being requested from NDIC, $20,000 in in-kind services provided by NACoal, $100,000 cost share provided by University of North Dakota, $14,000 in-kind services provided by Barr Engineering and $566,000 provided as in-kind services from AmeriCarbon. A detailed budget was prepared using the standard U.S. Department of Energy budgeting model. Key tables from the budget are included in Appendix 11-1.

# 12. Matching Funds

Support letters for matching funds are included in Appendix 12-1, including a cost share commitment of $20,000 from NACoal, $100,000 from University of North Dakota, $14,000 from Barr Engineering and $566,000 from AmeriCarbon, for a total cost share resulting in a combined cost share of $700,000, representing 50% of the budget.

# 13. Tax Liability

The applicant does not have any past due tax liability with the State of North Dakota. An affidavit is attached in Appendix 13-1.

# 14. Confidential Information

Not applicable.

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# 16. Appendices

Attached.

Appendix 3-I

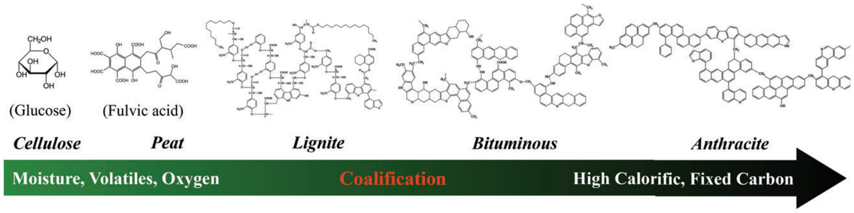
# Coal Derived High-Performance Anode Materials for Lithium-Ion Batteries

*Shuai Xu[1], Xiaodong Hou[1], Dave Berry[2], Chetan Tambe[2]*

[1] University of North Dakota, Grand Forks, 58202, United States
[2] AmeriCarbon Products, LLC, Morgantown, WV 26501, United States

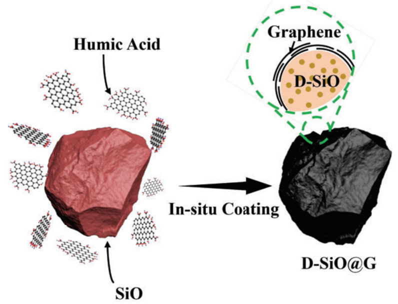
UND Institute for Energy Studies, University of North Dakota | AmeriCarbon | NETL National Energy Technology Laboratory

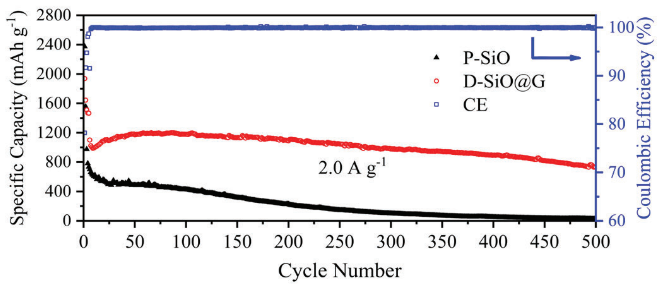
## BACKGROUND

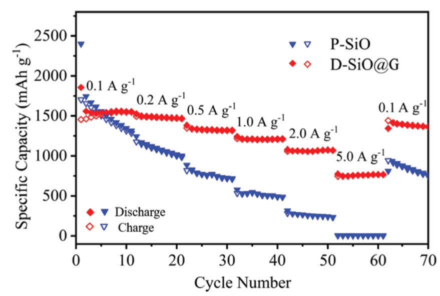



Coal is formed from buried plant matter by coalification, during which buried plant matter changes from cellulose, through peat, lignite, and bituminous coal to anthracite. In this evolution, high temperature and pressure facilitate the removal of functional groups (mostly H and O) and fuse carbon into benzene rings. Under extreme conditions, anthracite can evolve into graphite. The intermediates, like lignite, possesses loose intermolecular bonding, showing great potential in anode materials for LIBs (lithium-ion batteries).

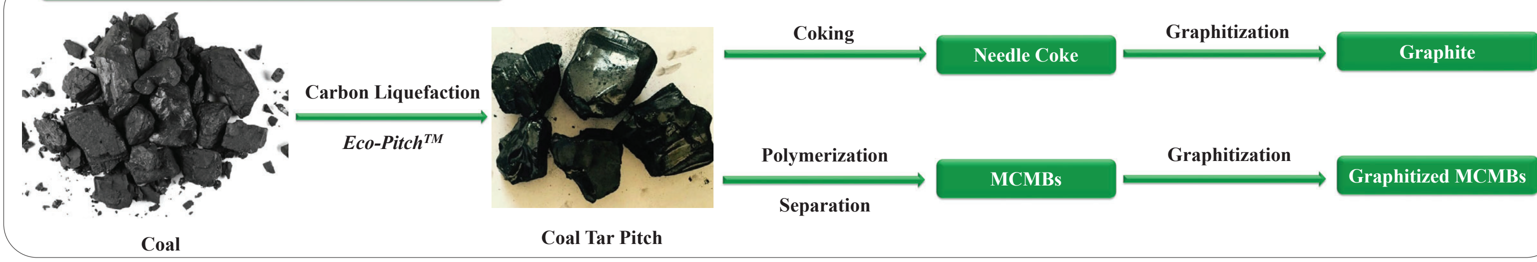
## COAL DERIVED HUMIC ACID FOR GRAPHENE COATING



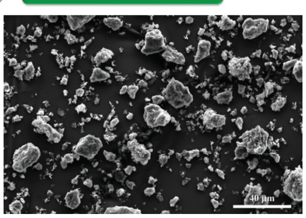



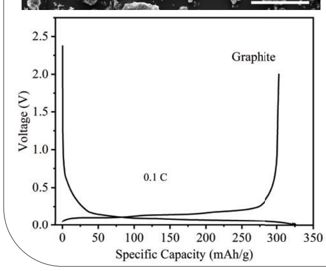



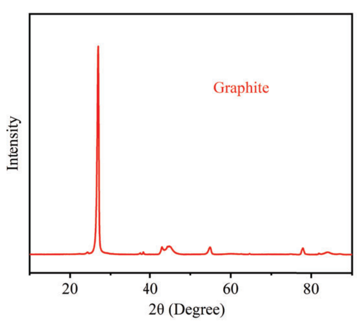

## COAL DERIVED GRAPHITE AND MCMBS




## GRAPHITE



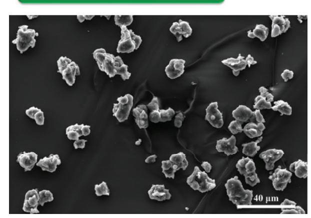



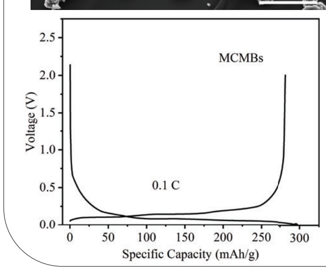

High ICE of 93.0 %.

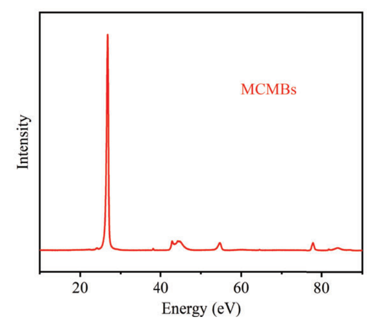
High crystallization.

Lithiation plateau: 0.1 V.

## MCMBS




High ICE of 94.7 %.

High Crystallization.

Lithiation plateau: 0.1 V.

## CONCLUSIONS

Humic acid extracted from lignite was converted to graphene coating on SiO, which shows superior electrochemical performance.

Lignite was converted to coal tar pitch, followed by further processing to produce synthetic graphite and MCMBs for the anodes of LIBs.

This work provides promising approaches for large-scale production of anode materials in LIBs from low-cost coal ore.

## REFERENCES

1. Xu, S.; Zhou, J.; Wang, J.; Pathiranage, S.; Oncel, N.; Robert Ilango, P.; Zhang, X.; Mann, M.; Hou, X. Adv. Funct. Mater. 2021, 31 (32), 2101645.
2. http://www.americarbon.com/blank/#s-e0347b0a-ec32-4c52-a308-3eb48664078c

## ACKNOWLEDGEMENTS

The work was supported by National Energy Technology Laboratory (UCFER, contract number DE-FE0026825/S000045) and (DE-FE0032139), Office of Fossil Energy (DE-FE0031984), Department of Energy, AmeriCarbon Products, LLC, and Canadian Light Source Inc.

# Appendix 7-I

**DAVID A. BERRY**

## EDUCATION AND TRAINING

West Virginia University, Chemical Engineering, B.S. (1984)
West Virginia University, Chemical Engineering, M.S. (1999)

## RESEARCH AND PROFESSIONAL EXPERIENCE

***CEO/CTO – AmeriCarbon LLC, Morgantown, WV, 2020 – current:***
Leading the commercialization of coal conversion to enabling carbon pitch intermediate for high-value carbon product manufacturing such as arc furnace carbon electrodes, advanced battery storage electrodes, carbon fibers, carbon foams, computer chips and other carbon-based products for commercial and defense sector. owns and operates a 12,000 ft2 research/production facility with full laboratory facilities (vented hoods, wet chemistry, etc.) as well a continuous PLC controlled pilot scale hydrocarbon processing train for high temperature/high-pressure chemical conversion and other PLC controlled pilot space.

***Associate Director – National Energy Technology Laboratory, Morgantown, WV, 2009 – 2020:***
Managed a multi-million-dollar research program of engineers and scientists with primary expertise in catalysis, reaction engineering, surface science, electromagnetic energy, plasma chemistry, hydrocarbon conversion (coal, oil, NG) and materials science. Major focus in the development of fossil energy conversion technologies involving fuels/chemicals production, gas cleanup, power-generation cycles (turbines, fuel cells, hybrids), syngas conversion and hydrocarbon fuel reforming (i.e. diesel, logistic fuels, natural gas, coal-derived, bio-fuel…) including coal/biomass & methane gasification. Responsible for oversight of >36 laboratories ranging from bench-scale to small pilot operations.

***Research Leader – National Energy Technology Laboratory, Morgantown, WV, 1992 – 2009:***
Managed/conducted research for a $10 Million per year, multi-disciplined research team (engineers, scientists, technicians) in the development of fuel processing technology involving projects ranging in size from $200,000 – $500,000 per year. Focus involved developing capability and technology for processing of hydrocarbon fuels (i.e. diesel, logistic fuels, natural gas, coal-derived, bio-fuel…) for integrated operation with fuel cell systems. Developed program for coal/biomass & methane gasification. Established new science capability development with plasma and electromagnetic frequency technologies. Construction & operations of multiple laboratories from laboratory through small pilot scale. Processes include test reactors (fixed, fluid, and transport), catalyst and sorbent preparation and an array of analytical characterization equipment/methods.

***Technology Manager – National Energy Technology Laboratory, Morgantown, WV, 1986 – 1992:***
Managed a $10 million per year research and development program for the development of advanced high temperature solid oxide fuel cell power generation systems. Conducted all phases of planning (vision/objectives/requirements), budgeting, patents/license and functional management of multiple development projects with values ranging from $200 k to $150 M. Interfaced with academia, government (civilian & defense), industrial, and utility groups, both foreign and domestic, to accomplish and facilitate the development. Facilitated technology development and demonstration through coordinated cost participation between industrial participants, natural gas utilities and electrical power generation utilities.

***Project Manager – Belvoir R&D Center, Fort Belvoir, VA, 1984 – 1986:***
Managed and conducted engineering for development effort between various military groups and industrial companies (Allied Signal, Goodyear, OPW…) for a turbine-based helicopter and ground vehicle refueling system for use in extreme arctic conditions from development stage through conduct of end user/military acceptance testing and eventual acceptance into official army inventory.

## PUBLICATIONS - Selected

1. Ping Wang, Bret Howard, Nicholas Means, Dushyant Shekhawat, David Berry. "Coal chemical-looping with oxygen uncoupled (CLOU) using a Cu-based oxygen carrier derived from natural minerals". Energies 2019, 12, 1453, doi:10.3390/en12081453.
2. Daniel J Haynes, Dushyant Shekhawat, David A Berry, Amitava Roy, James J. Spivey, Effect of calcination temperature on the steam reforming activity of Ni substituted pyrochlore catalysts, Jun 2018 to Applied Catalysis: A: Gen.
3. Ping Wang, Nicholas Means, Bret Howard, Dushyant Shekhawat, and David Berry, The Reactivity of CuO Oxygen Carrier and Coal in Chemical-Looping with Oxygen Uncoupled (CLOU) and In-situ Gasification Chemical-Looping Combustion (iG-CLC), Fuel 217 (2018) 642-649).
4. M.W. Smith, D.A. Berry, D. Shekhawat, D.J. Haynes, J.J. Spivey, Partial oxidation of liquid hydrocarbons in the presence of oxygen-conducting supports: Effect of catalyst layer deposition, Fuel, 89 (2010) 1193-1201.
5. D.J. Haynes, A. Campos, M.W. Smith, D.A. Berry, D. Shekhawat, J.J. Spivey, Reducing the deactivation of Ni-metal during the catalytic partial oxidation of a surrogate diesel fuel mixture, Catal Today, 154 (2010) 210-216.
6. D. Shekhawat, D. A. Berry, H. W. Pennline, E. Granite, J. J. Spivey, Special Issue: Advanced Fossil Energy Utilization, Fuel, Volume 89, Issue 6, January 1, 2010.
7. Maria D. Salazar-Villalpando, D. A. Berry and A. Cugini, Role of Lattice Oxygen in the Partial Oxidation of Methane over Rh/Supported Ceria Catalysts. Isotopic Studies, Solid State Ionics, December 2009.
8. M. Salazar, D. A. Berry and T. H. Gardner, "Partial Oxidation of Methane over Rh/Supported-Ceria Catalysts: Effect of Catalyst Reducibility and Redox Cycles", Published, International Journal of Hydrogen Energy, 33/11, (2008), 2695-2703
9. Shadle, L.J., Berry, D.A., and Syamlal, M., "Coal Gasification", Encyclopedia of Chemical Technology, Concise, 5th Edition (ISBN 978-0-470-04748-4). , John Wiley & Sons, Inc., NY, NY, May 2007.
10. Turton, R.A., Berry, D.A., Gardner, T.G., and Miltz, A., "The Evaluation of Zinc Oxide Sorbents in a Pilot-Scale Reactor: Sulfidation Kinetics and Reactor Modeling", Industrial Engineering and Chemistry, Ind. Eng. Chem. Res. 2004, 43, 1235-1243

## PATENTS - Selected

1. U.S. Patent # 9,935,318 SOFC Cathode with Oxygen Reducing Layer, (2018)
2. U.S. Patent 9,598,644 Method of CO and/or CO2 hydrogenation to higher hydrocarbons using doped mixed metal oxides, (2017).
3. U. S. Patent 9,562,203 Methane-rich syngas production from hydrocarbon fuels using multi-functional catalyst/capture agent, (2017).
4. U.S. Patent 9,126,833 Process for continuous synthesis of mixed oxide powders, (2015).
5. U.S. Patent 8,486,301 Method for designing a reforming and/or combustion catalysts system, (2013).
6. U.S. Patent # 7,442,353 "Heat Recirculating Reformer for Fluid Stream Pollutant Removal, (2008).

## SYNERGISTIC ACTIVITIES

- Editorial Board Member, "Catalysis Today", January 2006-2009.
- Distinguished Visiting Scientist, Oak Ridge National Laboratory, April 2002.
- Research Management Board Member, Army Core Technology Program (CTP) for Power Systems, June 2005 / 2006.

# GREGORY G. HENTHORN

**EDUCATION**

West Virginia University, Morgantown, WV, Executive MBA (2003);

West Virginia University, Morgantown, WV, J.D. (2000)

West Virginia University, Morgantown, WV, B.S., Chemical Engineering (1995)

**RESEARCH AND PROFESSIONAL EXPERIENCE**

**AmeriCarbon Products, LLC**; VP of Corporate Development; Morgantown, WV; 2020-present; Focuses on commercial transactions; investor relations, capital attraction and management; business development with customers and collaborators; administrative and financial oversight.

**West Virginia University**; Associate Professor (Adjunct); Morgantown, WV; 2019-present; Energy Production and Operations (ENLM 220)

**Flat Rock Energy**; EVP of Business Development; Morgantown, WV; 2010-2020; Flat Rock is a private equity funded oil and gas exploration and production company that develops, funds, and implements drilling programs in the Appalachian Basin. Founder of company, securing more than $100 million in private equity funding; Negotiated commercial transactions with investors and other oil and gas operators.

**Kinetic Clean Energy**; Managing Partner; Morgantown, WV; 2007-2010; The company coordinated the origination, development, and finance of several methane-based renewable energy projects. Financed more than $50 million in renewable electric power facility construction projects; Organized facility to convert fleet vehicles to compressed natural gas; Assisted in the formation of a team to commercialize ethane-to-plastics technology.

**Fourth Venture Group**; Vice President; Morgantown, WV; 2000-2007; Fourth Venture was an angel capital and early stage venture capital firm that served as a launching pad for technology commercialization and economic development. Served as Chief Operating Officer for a 500,000-

member online portal that integrated with hundreds of brick-and-mortar merchants; Worked with DOE laboratories and NGOs to commercialize technologies developed in former Soviet military research institutes; Explored development of a liquefaction facility to convert coal to liquid transportation fuels; Co-founded an enterprise-class business-to-business software company that was focused on the surveying and construction sectors, from establishment of the business to its divestiture; Held executive management positions in two specialized manufacturing companies.

**SELECTED PUBLICATIONS & PRESENTATIONS**

- "New Business Opportunities in TransTech Energy Technologies", West Virginia Senate Economic Development Committee Meeting, West Virginia State Capitol, January 18, 2011.
- "Opportunities for the Coal Industry to Create Revenue from Carbon Offsets", 36th Annual West Virginia Mining Symposium, West Virginia Coal Association, Civic Center, Charleston, WV, February 18, 2009.
- Bai, Xingji and Henthorn, Greg. "13 Per Day." *Capacity Magazine* Spring (2007): 77-79. Print.

**SYNERGISTIC ACTIVITIES**

1. **TechConnectWV**, Charleston, WV; Member, Board of Directors, 2004-present; Member, Executive Committee, 2010-present. TechConnectWV is a non-profit, 501(c)(3) organization dedicated to the advancement of science, technology, and the innovation economy in West Virginia.
2. **West Virginia University**, under contract with Kinetic, 2012-2016; *Feasibilities of a Coal-Biomass to Liquids Plant in Southern West Virginia* (Award DE-FE0009997).
3. National Research Center for Coal & Energy, West Virginia University, Morgantown, WV; Consultant, Energy Efficiency Division, under contract with Kinetic, 2010-2011; *Supported establishment of initial TransTech Energy Conference.*
4. **West Virginia High Technology Consortium Foundation**, Fairmont, WV; Consultant, INNOVA Commercialization Group, 2010-2011; *Identification of technology commercialization and investment opportunities at NETL and WVU*

# Xiaodong Hou Ph.D.

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**EDUCATION AND TRAINING**

2010-2013 **Postdoctoral**, Chemistry Department, University of North Dakota, Grand Forks, ND, USA.
2009 **Ph.D. Polymer Chemistry and Physics**, Shanghai Jiao Tong University, Shanghai, China.
2005 **M.S. Chemical Engineering**, Shaanxi University of Science and Technology, Shaanxi, China.
2002 **B.S. Chemical Engineering**, Shaanxi University of Science and Technology Shaanxi, China

**RESEARCH AND PROFESSIONAL EXPERIENCE**

2012-present **Research Associate Professor** Institute for Energy Studies (IES), UND. Research Interests: advanced materials for Li-ion batteries, and coal-derived high-value carbon materials.
2017-2012 **Research Assistant Professor** Institute for Energy Studies (IES), UND. Research Interests: advanced materials for Li-ion batteries, and coal-derived high-value carbon materials.
2014-2016 **Senior Chemist/Lecturer** Advanced Material Characterization laboratory, Institute for Energy Studies, UND. Main research interests and expertise: synthesis and characterization of advanced chemical materials, environmental sampling and analysis, and crystal structural analysis.

2013-2014 **Interim Lab Director** and **Analytical Chemist** Environmental Analytical and Research Laboratory, UND. Principal areas of expertise: apply various spectroscopic, chromatographic and microscopic techniques to determine the chemical components of broad environment samples.

2010-2013 **Postdoctoral Research Associate** Chemistry Department, UND. Research interests: synthesis and characterization of covalently bonded hierarchical nanomaterials.

2005-2009 **Ph.D. Graduate Research Assistant** Shanghai Jiao Tong University, Shanghai, China. Research interests: Synthesis and characterization of advanced inorganic nanoparticles/block copolymer hybrid materials for energy application.

**PUBLICATIONS (Selected from over 40)**


1. Zhang, X.; Pushparaja, R. I.; Mann, M.; **Hou, X.**, Coal-Derived Graphene Foam and Micron-Sized Silicon Composite Anodes for Lithium-ion Batteries. *Electrochimica Acta* **2022**, *434*, 141329.
2. Ilango, P. R.; Savariraj, A. D.; Huang, H.; Li, L.; Hu, G.; Wang, H.; **Hou, X**.; Kim, B. C.; Ramakrishnah, S.; Peng, S., Electrospun flexible nanofibers for batteries: design and application. *Energy Environ. Rev* **2022**, in press.
3. Xu, S.; **Hou, X**.; Wang, D.; Zuin, L.; Zhou, J.; Hou, Y.; Mann, M., Insights into the Effect of Heat Treatment and Carbon Coating on the Electrochemical Behaviors of SiO Anodes for Li‐Ion Batteries. *Advanced Energy Materials* **2022,** *12* (18).
4. Liu, X.; Han, J.; **Hou, X**.; Altincicek, F.; Oncel, N.; Pierce, D.; Wu, X.; Zhao, J. X., One-pot synthesis of graphene quantum dots using humic acid and its application for copper (II) ion detection. *Journal of Materials Science* **2021,** *56* (8), 4991-5005.

5. Pushparaj, R. I.; Cakir, D.; Zhang, X.; Xu, S.; Mann, M.; **Hou, X**., Coal-Derived Graphene/MoS2 Heterostructure Electrodes for Li-Ion Batteries: Experiment and Simulation Study. *ACS applied materials & interfaces* **2021,** *13* (50), 59950-59961.
6. Reagen, S.; Wu, Y.; Liu, X.; Shahni, R.; Bogenschuetz, J.; Wu, X.; Chu, Q. R.; Oncel, N.; Zhang, J.; **Hou, X**.; Combs, C.; Vasquez, A.; Zhao, J. X., Synthesis of Highly Near-Infrared Fluorescent Graphene Quantum Dots Using Biomass-Derived Materials for In Vitro Cell Imaging and Metal Ion Detection. *ACS applied materials & interfaces* **2021,** *13* (37), 43952-43962.
7. Xu, S.; Zhang, X.; Sun, D.; Zhao, X. J.; **Hou, X.**, Facile Synthesis of Micrometer-sized Hierarchical Porous Si@C Anodes for High-Performance Lithium-Ion Batteries. In *The 45th International Technical Conference on Clean Energy*, Virtual, 2021.
8. Xu, S.; Zhou, J.; Wang, J.; Pathiranage, S.; Oncel, N.; Robert Ilango, P.; Zhang, X.; Mann, M.; **Hou, X.**, In Situ Synthesis of Graphene-Coated Silicon Monoxide Anodes from Coal-Derived Humic Acid for High-Performance Lithium-Ion Batteries. *Advanced Functional Materials* **2021,** *31* (32), 2101645.
9. **Hou, X.;** Hou, Y.; Mann, M., Porous Silicon/Lignite-derived Graphene Composite Anodes for Lithium ion batteries. In *36th International Battery Seminar and Exhibition*, Fort Lauderdale, FL, 2019.
10. Baker, J.; Xu, S.; Mann, J.; Dockter, A.; Hou, Y.; Mann, M.; **Hou, X**., Preparation of Lithium Ion Battery Cathode Composites Using Leonardite-Derived Humic Acid. In *2018 AIChE Annual Meeting*, Pittsburg, PA, 2018.

**PATENTS**

1. **Xiaodong Hou.** Battery Cathodes from Humic Acid. US Non-provisional Patent Application 20220123316, 17/558080.
2. **Xiaodong Hou** and Shuai Xu. Battery Anodes from Humic Acid. US Non-provisional Patent Application 20220115641, 7/558023.
3. **Xiaodong Hou** and Shuai Xu. Battery Materials and Fabrication Methods, PCT/US2021/044488, and US Provisional Application No. 63/124,487.

**SYNERGISTIC ACTIVITIES**

- Principal Investigator: the technical group lead of battery research at IES, the major active projects include “Advanced Processing of Coal and Coal Waste to Produce Graphite for Fast-Charging Lithium Ion Battery Anode” awarded $1,000,000, and “ Lignite-derived Carbon materials for Li-ion Battery Anode”, awarded $500,000 by DOE NETL ACP program, “The Preparation of a High Capacity Graphene Modified Graphite /SiOx Anode Electrode Batteries”, awarded $259,796 by a private cell manufacturer. “Porous Silicon/Lignite-Derived Graphene Composite Anodes for Li-Ion Batteries”, awarded $369,581 by DOE UCFER. “New Battery Charing Technology”, awarded $248,229 by NDIC Research ND program. “Advanced Lithium Batteries for Unmanned Aircraft Systems” $140,000 and “Lignite-Derived Graphene/Si Anode for Li-ion Battery” awarded $150,000 by UND VPR Post-Doctoral Program.
- Industrial Collaboration: Dr. Hou has been working with multiple companies on battery R&D, including as a consultant at a local battery company Clean Republic since 2014
- Invited lecture & Presentations: He presents on multiple battery- and coal-relevant conferences.
- Graduate Faculty: Dr. Hou mentors one postdoc, five Ph.D. students and two undergraduates on Coal-derived materials for Li-ion battery research.

# Daba S. Gedafa, Ph.D., P.E., ENV SP, F. ASCE

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243 Centennial Drive Stop 8115, Upson II Hall Room 260A
University of North Dakota, Grand Forks ND 58202-8115
Cell: 785-341-6827, Email: daba.gedafa@und.edu

**EDUCATION AND TRAINING**

2008-2009 **Postdoctoral**, Civil Engineering Department**,** Kansas State University, Manhattan, KS.
2009 **Ph.D. Civil Engineering,** Kansas State University, Manhattan, KS.
2005 **M.S. Civil Engineering**, IIT Bombay, Mumbai, India.
2001 **B.S. Civil Engineering**, Addis Ababa University, Addis Ababa, Ethiopia.

**RESEARCH AND PROFESSIONAL EXPERIENCE**

2022-present **Professor** Department of Civil Engineering, UND. Research Interests: Sustainable material characterization, resilient and sustainable transportation infrastructure.
2017-2022 **Associate Professor** Department of Civil Engineering, UND. Research Interests: Sustainable material characterization, resilient and sustainable transportation infrastructure.
2011-2017 **Assistant Professor** Department of Civil Engineering, UND. Research Interests: Sustainable material characterization, resilient and sustainable transportation infrastructure.
2009-2011 **Assistant Professor in Residence** Department of Civil Engineering, University of Connecticut, Storrs, CT. Research Interests: Sustainable material characterization, resilient and sustainable transportation infrastructure.
2008-2009 **Postdoctoral Research Associate,** Department of Civil Engineering, Kansas State University, Manhattan, KS. Research Interests: Sustainable material characterization, resilient and sustainable transportation infrastructure.
2005-2008 **Graduate Research Assistant,** Department of Civil Engineering, Kansas State University, Manhattan, KS. Research Interests: Sustainable material characterization, resilient and sustainable transportation infrastructure.

**PUBLICATIONS (Selected from over 60)**

1. Melaku, R., Ness, S., **Gedafa, D.S.,** and Suleiman, N. (2022). "Investigating the Use of Fly Ash for Sustainable Asphalt Binders," *Proceedings of the 11th International Conference on the Bearing Capacity of Roads, Railways, and Airfields, June 28-30, 2022,* Trondheim, Norway, Volume 3, pp. 436-444.

2. Melaku, R.S. and **Gedafa, D.S.** (2020). "Impact of Wastewater Treatment Sludge on Cracking Resistance of HMA Mixes at Lower Mixing Temperature," *ASCE Journal of Materials in Civil Engineering*.
3. Saha, R., Melaku, R.S., Karki, B., Berg, A., and **Gedafa, D.S.** (2020). "Effect of Bio-Oils on Binder and Mix Properties with High RAP Binder Content." *ASCE Journal of Materials in Civil Engineering*.
4. Tolliver, S. and **Gedafa, D.S.** (2016). "Investigating the Use of Fly Ash and Nanomaterials for Sustainable Concrete Infrastructure," *International Journal of Engineering Research & Technology*,

Vol. 5, No. 7, pp. 173-177.

5. **Gedafa, D.S.**, Hossain, M., Romanoschi, S., and Gisi, A.. (2010). "Field Verification of Superpave Dynamic Modulus," *ASCE Journal of Materials in Civil Engineering,* Vol. 22, No. 5, pp. 485-494.
6. **Gedafa, D.S**., Hossain, M., Romanoschi, S., and Gisi, A.. (2010). "Comparison of Moduli of Kansas Superpave Asphalt Mixes," *Transportation Research Record: Journal of the Transportation Research Board,* Vol. 2154, pp 114-123.
7. Abolghasem Yazdani* and Daba S. Gedafa. "Effect of Nanopolymer Modified Binder on Hot Mix Asphalt," *Proceedings of the International Conference on Transportation & Development*, May 31-June 3, 2022, Seattle, WA, pp. 190-200.
8. Liu, J., Melaku, R., **Gedafa, D.S.,** and Suleiman, N. (2022). "Comparison of Field and Laboratory Mix Performance," *Proceedings of the 11th International Conference on the Bearing Capacity of Roads, Railways, and Airfields,* June 28-30, 2022, Trondheim, Norway, Volume 3, pp. 445-453.
9. Jun Liu*, Robeam S. Melaku*, Daba S. Gedafa, and Nabil Suleiman. (2021). "Performance Comparison of HMA Mixes Used on Different Levels of North Dakota's Highway Performance Classification System," *ASCE International Airfield and Highway Pavements Conference 2021,* pp. 137-145.
10. Pariyar, R., Nabil Suleiman,N., Gedafa, D.S., and Karki, B. (2021). "Comparison of Unconventional and Conventional HMA Mixes Performance in North Dakota," *ASCE International Airfield and Highway Pavements Conference 2021,* pp. 209-218.

**SYNERGISTIC ACTIVITIES**

- Principal Investigator: He has an extensive research experience with coal byproducts including bottom ash, slag, and fly ash for sustainable asphalt and concrete infrastructure. He received three grants from the NDIC. He determined the amount of fly ash that can be used to replace asphalt binder and mineral fillers for sustainable asphalt pavements. He has also determined the optimum content of bottom ash and ground bottom ash with and without nano clay as a fine aggregate and cement replacement, respectively by comparing it to the compressive strength of cement-based concrete. Fresh properties, mechanical properties, and durability of optimum bottom ash and ground bottom ash-based concrete were determined. He also determined the maximum amount of cement that can be replaced by fly ash with and without nanomaterials while providing the equivalent or higher performance of concrete as compared to the control (cement-based concrete).
- Professional Certifications: He is a registered professional engineer, Envision Sustainability Professional, and a fellow of the American Society of Civil Engineers.
- Presentations: He has made more than 20 presentations at national and international conferences.
- Collaboration: He has collaborated with people from universities and industries
- Graduate Faculty: Dr. Gedafa mentors five Ph.D. students and eight MS students in addition to leading 12 graduate students to successful completion of their graduate studies.

**Dr. Daniel A. Laudal,** Director, Institute for Energy Studies, University of North Dakota (UND)
daniel.laudal@und.edu 701-777-5745

***Education and Training***

| | | |
|---|---|---|
| University of North Dakota | Chemical Engineering | B.S. 2006 |
| University of North Dakota | Chemical Engineering | Ph.D. 2017 |
| University of North Dakota | Master of Public Admin. | Expected 2023 |

***Research and Professional Experience***

*2021-Present Director, UND Institute for Energy Studies (IES)*
Leading the research and academic programs in Energy at the College of Engineering & Mines. Help realize the IES goal of developing UND into a premier "Energy University" that "inspires the creation of new knowledge to enable the development of revolutionary energy technologies, train the next generation of energy experts, and establish advanced industries required to make affordable emissions free energy technologies a reality". Responsibilities include identifying key technical and economic barriers to the development of secure, affordable, and reliable energy production technologies; identifying proposal opportunities and develop new relationships with potential partners; and drawing from resources across campus building teams to deliver the research, education, and outreach required to meet the needs of public and private partners.

*2019-2021 Environmental Manager / Project Tundra Project Manager, Minnkota Power Coop.*
Led the environmental regulatory compliance and environmental planning efforts for a generation & transmission cooperative serving eastern ND and northwestern MN. As Project Tundra Project Manager, led Minnkota's development of a $1.5B world-scale carbon capture and storage project for the Milton R. Young Station, a lignite coal fired power plant in ND. Responsibilities included leading development of the design, permitting and financing of the carbon capture plant and geologic storage facility.

*2016-2018 Manager: Major Projects, UND Institute for Energy Studies.*
Primary roles included developing and writing funding proposals, managing research projects, coordinating IES research staff and students, and process design/development of innovative solutions to challenges in the energy industry. Principal Investigator or Project Manager or several DOE, State and industry funded projects. Research focused on the following major areas: carbon management for the power industry, production of co-products from coal and associated materials, value-added opportunities/technology development for North Dakota's energy industries.

*2012-2015 Research Engineer, UND Institute for Energy Studies.*
Lead researcher or principal investigator on several federal, state and industry funded projects. Work involved early-stage R&D of novel processes and technologies, primarily focusing on laboratory- and bench-scale demonstrations. Areas of focus included chemical looping combustion and post combustion carbon dioxide capture.

*2008-2012 Research Engineer, UND Energy & Environmental Research Center.*
Research involved design and operation of various lab and pilot-scale gasification, combustion and advanced power systems. Gained invaluable experience with high pressure and high temperature systems and fluidized beds.

*2006-2008 Field Engineer, Schlumberger Oilfield Services*.
Design, execution and evaluation of well cementing operations in the Williston Basin.

***Selected Publications***

**Laudal, D.**, Benson, S., Addleman, S., Palo, D. "Leaching behavior of rare earth elements in Fort Union lignite coals of North America." International Journal of Coal Geology 191 (2018) 112-124.

**Laudal, D.**, Benson, S., Addleman, S., Palo, D. "Rare earth elements in North Dakota lignite coal and lignite-related materials." ASME Journal of Energy Resources and Technology 140 (2018).

Van der Watt, J.G., **Laudal, D**., Krishnamoorthy, G., Feilen, H., Mann, M., Shallbetter, R., Nelson, T., Srinivasachar, S. "Development of a spouted bed reactor for chemical looping combustion." Journal of Energy Resources and Technology. 140(11), 112002 (8 pages), November 2018.

Nelson, T., van der Watt, J.G., **Laudal, D**., Feilen, H., Mann, H., Srinivasachar, S. "Reactive jet and cyclonic attrition analysis of ilmenite in chemical looping combustion systems." International Journal of Greenhouse Gas Control. Volume 91, December 2019, 102837.

Nasah, J., Jensen, B., Dyrstad-Cincotta, N., Gerber, J., **Laudal, D**., Mann, M., Srinivasachar, S. "Method for separation of coal conversion products from oxygen carriers." International Journal of Greenhouse Gas Control. Volume 88, September 2019, pages 361-370.

Emerson, S., Zhu, T., Davis, T. Peles, A., She, Y., Willigan, R., Vanderspurt, T., Swanson, M., **Laudal**, **D**. "Liquid Phase Reforming of Woody Biomass to Hydrogen". International Journal of Hydrogen Energy, August 2013.

Benson, S., Srinivasachar, S, **Laudal, D**., Browers, B. "Evaluation of Carbon Dioxide Capture from Existing Coal Fired Plants by Hybrid Sorption using Solid Sorbents." Final Technical Report. US Department of Energy Award Number: DE-FE0007603. May 2015

Park, D., Middleton, A., Smith, R., Deblonde, G., **Laudal, D.,** Theaker, N., Hsu-Kim, H., Jia, Y. "A biosorption-based approach for selective extraction of rare earth elements from coal byproducts." Separation and Purification Technology. Volume 241:116726. June 2020.

Mann, M; **Laudal, D.**; Benson, S. "Maintaining Coal's Prominence in a Carbon Constrained World." Conference Proceedings: 2017 International Conference on Coal Science and Technology and 2017 Australia-China Symposium on Energy. September 25-29, 2017. Beijing, China.

Pei, P., Nasah, J., Solc, J., Korom, S. **Laudal, D**., Barse, K. "Investigation of the feasibility of underground coal gasification in North Dakota, United States." Energy Conversion and Management. Volume 113, 1 April 2016, pages 95-103.

Pei, P., **Laudal, D**., Nasah, J., Johnson, S., Ling, K. "Utilization of Aquifer Storage in Flare Gas Reduction." Journal of Natural Gas Science and Engineering. Volume 27, Part 2, November 2015, 1100-1108.

***Patents***

**Laudal, D.,** Benson, S. "Rare earth element extraction from coal." U.S. Patent No. 10,669,610. March 2017

Theaker, N., **Laudal, D.,** Lucky, C. "Generation of rare earth elements from organically associated leach solutions." U.S. Patent Application No. 17/519,346. Filed May 2022.

Theaker, N., **Laudal, D.** "Method for leaching rare earth elements and critical minerals from organically associated materials." U.S. Patent Application No. 17/519,341. Filed May 2022.

***Synergistic Activities***

Dr. Laudal's primary areas of technical expertise include advanced fuel conversion processes, carbon capture, utilization and storage, and critical minerals recovery technologies. Dr. Laudal was previously the project manager for a $1.5B world-scale carbon capture and storage project, currently under development in North Dakota (Project Tundra). His experience leading UND's development of lignite coal-based minerals recovery projects is also highly relevant. Dr. Laudal is an expert in the inorganic and organic chemistry and utilization of lignite coal. Dr. Laudal brings a unique mix of early-stage technology development, project management and commercial project development expertise. His role in the proposed project will be as a technical and project management advisor.

**Nicole Nguyen, PMP, PE**
Senior Chemical Engineer, Barr Engineering Co. (Barr)
nnguyen@barr.com 419.705.6061

***Education and Training***

| | | |
|---|---|---|
| University of Toledo | Chemical Engineering | BS 2005 |
| Project management Institute | PMP Certification | 2019 |

***Registration***

Professional Engineer: Iowa, Michigan, North Dakota, Ohio, Pennsylvania, Washington

***Research and Professional Experience***

*2012-Present  Senior Chemical Engineer, Barr Engineering Co.*

Serving clients in the power, energy, mining, and fuels industries, as a project manager and lead process-design engineer. Tasks include developing detailed cost estimates and performing budgetary feasibility studies, detailed design and procurement for plant betterment work, construction and commissioning support, risk assessments and contract and subcontract management. Relevant project experience includes: Principal investigator and project manager for a U.S. Department of Energy (DOE) and National Energy Technology Laboratory (NETL) research-and-design, bench-and-demonstration project, which was federally funded, for enabling coal technologies with a total project cost of more than $4.9 million. Managing competitive U.S. DOE and NETL research-and-design concepts and preFEED (preliminary front-end engineering design) studies, which were federally funded, for Coal Plants of the Future under the CoalFIRST program. Concepts included gasification, chemical looping, ultra-supercritical power plant, energy storage, and pre- and post-combustion carbon capture technologies. Managing a dry-transfer-system study and detailed design project for a confidential power producer in North Dakota with engineering fees totaling $1 million.

*2006-2011  Environmental Process Engineer, Babcock and Wilcox Company*

Served as lead process wet FGD engineer and single-point-of-contact discipline lead for the $500 million AQCS installation of five units in the eastern U.S. Performed startup, commissioning, and testing as a field process engineer for a 3,400 MW wet FGD system installation project. Served as resident engineer onsite at power plant for over 1 year. Performed guarantee testing for multiple wet FGD systems along the eastern U.S.

*January 2006-August 2006  Process Engineer, SSOE Group*

Served as a process design engineer for a privately owned, ISO 9001–certified, international engineering, procurement, construction, and maintenance (EPCM) firm based in Ohio for part of a year. Responsibilities included working on contracts with solar-panel manufacturing facilities and refineries.

**Dr. Daniel R. Palo, PhD, PE**
Vice President, Senior Process Engineer, Barr Engineering Co. (Barr)
dpalo@barr.com 801.333-8421

***Education and Training***

| | | |
|---|---|---|
| University of Minnesota | Chemical Engineering | BS 1994 |
| University of Connecticut | Chemical Engineering | PhD 1999 |

***Registration***

Professional Engineer (Chemical): 14 US States and Province of Saskatchewan

***Research and Professional Experience***

*2011-Present Senior Process Engineer, Barr Engineering Co.*
*2018-Present Vice President, Barr Engineering Co.*
Providing process engineering services for scoping, prefeasibility, and feasibility studies for mineral processing clients; conducting technical evaluations and pilot plant testing for new and existing processes; modeling and optimizing equipment, sub-processes, and whole plants using METSIM and/or CHEMCAD software; coordinating vendor trials for new equipment installations and upgrades; providing plant layout, equipment specification, cost estimation, and project oversight for various mineral and chemical process applications building and coordinating teams that conduct advanced research and development in mineral processing, energy, and fuels.
2005-2011 *Deputy Co-Director and Senior Research and Development Leader for the Microproducts Breakthrough Institute, Pacific Northwest* National Laboratory
Providing business development and outreach around key programs and providing project management and technical research services
*1999-2011 Research Engineer, Pacific Northwest National Laboratory*
Leading project tasks in energy and chemical process development; managing a large multi-year development project for the U.S. Army; working to design, fabricate, test, and evaluate new devices and processes; contributing to creation of a spin-off company to commercialize microchannel process technology.
*1995-1999 Graduate Research Assistant, Chemical Engineering Department of University of Connecticut*
Planning and assembling laboratory infrastructure, supervising students, designing custom test equipment, and conducting investigations into various applications of supercritical CO2, including catalysis, conductive polymers, and heavy metal chelation.

***Selected Publications***

RA Dagle, JA Lizarazo-Adarme, V Lebarbier Dagle, MJ Gray, JF White, DL King, DR **Palo**, Syngas conversion to gasoline-range hydrocarbons over Pd/ZnO/Al2O3 and ZSM-5 composite catalyst system, Fuel Processing Technology 2014, 123, 65-74

Yu-Wei Su, Sudhir Ramprasad, Seung-Yeol Han, Wei Wang, Si-Ok Ryu, Daniel R. **Palo**, Brian K. Paul, Chih-hung Chang, Dense CdS Thin Films On Fluorine-Doped Tin Oxide Coated Glass By High-Rate Microreactor-Assisted Solution Deposition, Thin Solid Films, 2013, 532, 16-21.

Sudhir Ramprasad, Yu-Wei Su, Chih-Hung Chang, Brian K. Paul, Daniel R. **Palo**, Continuous Microreactor-Assisted Solution Deposition for Scalable Production of CdS Films, ECS J. Solid State Sci. Technol. 2013, 2(9), P333-P337.

Vanessa M. Lebarbier, Robert A. Dagle, Libor Kovarik, Jair A. Lizarazo-Adarme, David L. King, Daniel R. **Palo**, Synthesis of Methanol and Dimethyl Ether from Syngas over Pd/Zno/Al2O3 Catalysts, Catal. Sci. Technol., 2012, 2, 2116-2127.

Zhu, Y.; Jones, S.B.; Biddy, M.J.; Dagle, R.A.; **Palo**, D.R. Single-step syngas-to-distillates (S2D) process based on biomass-derived syngas – A techno-economic analysis, Bioresource Technology, 2012, 117, 341.

**Palo**, D. R.; Dagle, R. A.; Holladay, J. D. Methanol Steam Reforming for Hydrogen Production, Chem. Rev., 2007, 107, 3992.

**Palo**, D. R.; Stenkamp, V. S.; Dagle, R. A.; Jovanovic, G. N. Industrial Applications of Microchannel Process Technology in the United States. In Applied Micro and Nano Systems, Vol. 5 (AMN5); Wiley VCH, 2006, N. Kockman, Ed.

**Palo**, D. R.; Holladay, J. D.; Dagle, R. A.; Chin, Y.-H. Integrated Methanol Fuel Processors for Portable Fuel Cell Systems. In Microreactor Technology and Process Intensification; ACS Symposium Series, 2005, Y. Wang and J. Holladay, Eds., vol. 914, pp. 209-223.

***Selected Patents***

Robert S. Wegeng, Daniel R. **Palo**, Steven D. Leith, Paul H. Humble, Shankar Krishnan, Robert A. Dagle Solar Thermochemical Reactor System for Concentrated Solar Energy Capture and Storage, U.S. Pat. 9,950,305, 2018.

Daniel R. **Palo**, Jamelyn D. Holladay, Robert A. Dagle, Robert T. Rozmiarek, Compact Integrated Combustion Reactors, Systems and Methods of Conducting Integrated Combustion Reactions, US Pat. 8,696,771, 2014.

**Ryan R. Rayda, PE**
Senior Structural Engineer, Barr Engineering Co. (Barr)
rrayda@barr.com 701.221.5419

***Education and Training***

| | | |
|---|---|---|
| University of Wyoming | Architectural Engineering | BS 2001 |
| University of Wyoming | Structural Engineering | MS 2003 |

***Registration***

Professional Engineer: Connecticut, Michigan, Minnesota, Montana, North Dakota, Rhode Island, South Carolina, South Dakota, Texas, Wyoming

***Research and Professional Experience***

*2016-Present Senior Structural Engineer, Barr Engineering Co.*
Leading preliminary design and project development for a phosphate rock bio-leach facility in the western US, assisting the client with navigating the challenges associated with a unique funding mechanism, and developing a larger EPC-type team to progress the project through final design and construction. Leading a large, multidisciplinary team on a fast-track project to restore critical material handling infrastructure to a central North Dakota mining facility that was damaged during a severe weather event; coordinating a diverse team of engineers, scientists, field personnel, and forensic investigators in emergency response, assessment, strategy development, planning, design, detailing, and ultimately restoration of this facility in an aggressive timeframe; collaborating with the owner, many subcontractors, fabricators, and suppliers. Leading a structural design team for an ash handling conversion project at power plants in North Dakota and South Dakota; Designing the conversion of the plants' existing wet ash handling systems to dry conveyor systems included 3D scanning, modeling, clash detection, modifying existing structural steel for support of new equipment, designing new equipment supports and an ash storage bunker, detailed coordination with equipment suppliers, and extensive support during construction. Leading a regional team through planning and field operations for a demonstration test implementing a novel sorbent injection system designed to reduce fouling in a North Dakota power generating facility; collaborating with equipment suppliers, material suppliers, plant personnel, researchers, laboratories, and designers to lay out the demonstrations system and integrate it with the existing infrastructure at the test facility.
*2006-2016 Senior Project Structural Engineer, CWSTRUCTURAL Engineers*
Designing structures to accommodate addition of a material analysis equipment and new material handling equipment at a central North Dakota power plant; the design required modification of an existing conveyor gallery to house a material analyzer used to monitor the presence of nuclear elements; the new conveyor sections and analyzer were integrated into an existing conveyor system, requiring detailed analysis of the existing structure and coordination with the expanded conveyor housing. Managing and leading structural design for a horizontal-collector-well pumphouse for a municipality in central North Dakota; several innovative construction techniques were developed for this project in coordination with the contractor to facilitate sinking of the caisson into the riverbed and erection of the complex, bi-axial, elliptically rolled framing members.

Appendix 10-I

| Task | Task Title | Duration (Mo) | 2023 | | | | 2024 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | QTR 1 | QTR 2 | QTR 3 | QTR 4 | QTR 1 | QTR 2 | QTR 3 | QTR 4 |
| **1** | **Engineering Feasibility Study** | 9 | | | | | | | | |
| | | | | | | | | | | M1.2 |
| **2** | **Coal Feedstock Supply and Characterization** | 1 | | | | | | | | |
| | | | | | M2.1 | | | | | |
| **3** | **Asphalt - Experimental Prod Dev, Eval…Studies** | 18 | | | | | | | | |
| | | | | | | M3.1 | | M3.2 | | |
| **4** | **Graphite - Experimental Prod Dev, Eval…Studies** | 18 | | | | | | | | |
| | | | | | | | | | M4.1 | |
| **5** | **Technoeconomic Study** | 6 | | | | | | | | |
| | | | | | | | | | | M5.1 |

| Task | Milestone Title & Description | Planned Completion Date | Verification Method |
|---|---|---|---|
| 1 | M1.1 - Engineering Design Study | Project Completion | Topical Report |
| 2 | M2.1 - Coal Supply & Characterization | 60 d after award | Shipped/Delivered |
| 3 | M3.1 - Initial Pitch Samples for Test | 3 mo after award | Shipped/Delivered |
| 3 | M3.2 - Optimized Pitch Samples for Test | 12 mo after award | Shipped/Delivered |
| 4 | M4.1 - Optimized Battery Grade Graphite Testing | 14 mo after award | Final Report |
| 5 | M5.1 - Technoeconomic Results | Project Completion | Final Report |

Appendix 11-I

# Instructions and Summary

**Award Number:** ____________ **Date of Submission:** 4/3/2023

**Award Recipient:** AmeriCarbon Products LLC **Form submitted by:** AmeriCarbon Products, LLC

(May be award recipient or sub-recipient)

**Please read the instructions on each worksheet tab before starting. If you have any questions, please ask your DOE contact!**

**1.** If using this form for award application, negotiation, or budget revision, fill out the blank white cells in workbook tabs a. through j. with total project costs. If using this form for invoice submission, fill out tabs a. through j. with total costs for just the proposed invoice and fill out tab k. per the instructions on that tab.

**2.** Blue colored cells contain instructions, headers, or summary calculations and should not be modified. Only blank white cells should be populated.

**3.** Enter detailed support for the project costs identified for each Category line item within each worksheet tab to autopopulate the summary tab.

**4.** The total budget presented on tabs a. through i. must include both Federal (DOE) and Non-Federal (cost share) portions.

**5.** All costs incurred by the preparer's sub-recipients, vendors, and Federal Research and Development Centers (FFRDCs), should be entered only in section f. Contractual. All other sections are for the costs of the preparer only.

**6.** Ensure all entered costs are allowable, allocable, and reasonable in accordance with the administrative requirements prescribed in 2 CFR 200, and the applicable cost principles for each entity type: FAR Part 31 for For-Profit entities; and 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

**7.** Add rows as needed throughout tabs a. through j. If rows are added, formulas/calculations may need to be adjusted by the preparer. Do not add rows to the Instructions and Summary tab. If your project contains more than three budget periods, consult your DOE contact before adding additional budget period rows or columns.

**8.** ALL budget period cost categories are rounded to the nearest dollar.



## SUMMARY OF BUDGET CATEGORY COSTS PROPOSED

**The values in this summary table are from entries made in subsequent tabs, only blank white cells require data entry**

Section A - Budget Summary

| | | Federal | Cost Share | Total Costs | Cost Share % | Proposed Budget Period Dates |
|---|---|---|---|---|---|---|
| | **Budget Period 1** | $700,000 | $700,000 | $1,400,000 | 50.00% | |
| | **Budget Period 2** | $0 | $0 | $0 | 0.00% | |
| | **Budget Period 3** | $0 | $0 | $0 | 0.00% | |
| | **Total** | $700,000 | $700,000 | $1,400,000 | 50.00% | |

Section B - Budget Categories

| CATEGORY | Budget Period 1 | Budget Period 2 | Budget Period 3 | Total Costs | % of Project | Comments (as needed) |
|---|---|---|---|---|---|---|
| **a. Personnel** | $460,350 | $0 | $0 | $460,350 | 32.88% | |
| **b. Fringe Benefits** | $80,222 | $0 | $0 | $80,222 | 5.73% | |
| **c. Travel** | $6,544 | $0 | $0 | $6,544 | 0.47% | |
| **d. Equipment** | $15,779 | $0 | $0 | $15,779 | 1.13% | |
| **e. Supplies** | $17,450 | $0 | $0 | $17,450 | 1.25% | |
| **f. Contractual** | | | | | | |
| **Sub-recipient** | $0 | $0 | $0 | $0 | 0.00% | |
| **Vendor** | $674,000 | $0 | $0 | $674,000 | 48.14% | |
| **FFRDC** | $0 | $0 | $0 | $0 | 0.00% | |
| **Total Contractual** | $674,000 | $0 | $0 | $674,000 | 48.14% | |
| **g. Construction** | $0 | $0 | $0 | $0 | 0.00% | |
| **h. Other Direct Costs** | $0 | $0 | $0 | $0 | 0.00% | |
| **Total Direct Costs** | $1,254,345 | $0 | $0 | $1,254,345 | 89.60% | |
| **i. Indirect Charges** | $145,655 | $0 | $0 | $145,655 | 10.40% | |
| **Total Costs** | $1,400,000 | $0 | $0 | $1,400,000 | 100.00% | |

Additional Explanation (as needed):

# a. Personnel

**INSTRUCTIONS - PLEASE READ!!!**

**1.** List project costs solely for employees of the entity completing this form. All personnel costs for subrecipients and vendors must be included under f. Contractual.

**2.** All personnel should be identified by position title and not employee name. Enter the amount of time (e.g., hours or % of time) and the base pay rate and the total direct personnel compensation will automatically calculate. Rate basis (e.g., actual salary, labor distribution report, state civil service rates, etc.) must also be identified.

**3.** If loaded labor rates are utilized, a description of the costs the loaded rate is comprised of must be included in the Additional Explanation section below. DOE must review all components of the loaded labor rate for reasonableness and unallowable costs (e.g. fee or profit).

**4.** If a position and hours are attributed to multiple employees (e.g. Technician working 4000 hours) the number of employees for that position title must be identified.

5. Each budget period is rounded to the nearest dollar.

| SOPO Task # | Position Title | Budget Period 1 | | | Budget Period 2 | | | Budget Period 3 | | | Project Total Hours | Project Total Dollars | Rate Basis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time (Hrs) | Pay Rate ($/Hr) | Total Budget Period 1 | Time (Hrs) | Pay Rate ($/Hr) | Total Budget Period 2 | Time (Hrs) | Pay Rate ($/Hr) | Total Budget Period 3 | | | |
| 1 | Sr. Engineer **(EXAMPLE!!!)** | 2000 | $85.00 | $170,000 | 200 | $50.00 | $10,000 | 200 | $50.00 | $10,000 | 2400 | $190,000 | Actual Salary |
| 2 | Technicians (2) | 4000 | $20.00 | $80,000 | 0 | $0.00 | $0 | 0 | $0.00 | $0 | 4000 | $80,000 | Actual Salary |
| | Principal Investigator | 950 | $175.00 | $166,250 | | $175.00 | $0 | | | $0 | 950 | $166,250 | |
| | Chemical Engr Executive | 550 | $125.00 | $68,750 | | $125.00 | $0 | | | $0 | 550 | $68,750 | |
| | Chemical Engineer | 1825 | $50.00 | $91,250 | | $50.00 | $0 | | | $0 | 1825 | $91,250 | |
| | Chemical Technician (2) | 2980 | $45.00 | $134,100 | | $45.00 | $0 | | | $0 | 2980 | $134,100 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | | | | $0 | | | $0 | | | $0 | 0 | $0 | |
| | Total Personnel Costs | **6305** | | **$460,350** | **0** | | **$0** | **0** | | **$0** | **0** | **$460,350** | |

Additional Explanation (as needed):

## b. Fringe Benefits

**INSTRUCTIONS - PLEASE READ!!!**
**1.** Fill out the table below by position title. If all employees receive the same fringe benefits, you can show "Total Personnel" in the Labor Type column instead of listing out all position titles.
**2.** The rates and how they are applied should not be averaged to get one fringe cost percentage. Complex calculations should be described/provided in the Additional Explanation section below.
**3.** The fringe benefit rates should be applied to all positions, regardless of whether those funds will be supported by Federal Share or Recipient Cost Share.
4. Each budget period is rounded to the nearest dollar.

| Labor Type | Budget Period 1 | | | Budget Period 2 | | | Budget Period 3 | | | Total Project |
|---|---|---|---|---|---|---|---|---|---|---|
| | Personnel Costs | Rate | Total | Personnel Costs | Rate | Total | Personnel Costs | Rate | Total | |
| **EXAMPLE!!!** Sr. Engineer | $170,000 | 20% | $34,000 | $10,000 | 20% | $2,000 | $10,000 | 20% | $2,000 | $38,000 |
| Principal Investigator | 166,250 | 12.34% | $20,515 | 0 | 12.34% | $0 | | | $0 | $20,515 |
| Chemical Engr Executive | 68,750 | 13.61% | $9,357 | 0 | 13.61% | $0 | | | $0 | |
| Chemical Engineer | 91,250 | 17.85% | $16,288 | 0 | 17.85% | $0 | | | $0 | $16,288 |
| Chemical Technician (2) | 134,100 | 25.40% | $34,061 | 0 | 25.40% | $0 | | | $0 | $34,061 |
| | | | $0 | | | $0 | | | $0 | $0 |
| **Total:** | **$460,350** | | **$80,222** | **$0** | | **$0** | **$0** | | **$0** | **$80,222** |

**A federally approved fringe benefit rate agreement, or a proposed rate supported and agreed upon by DOE for estimating purposes is required at the time of award negotiation if reimbursement for fringe benefits is requested. Please check (X) one of the options below and provide the requested information if not previously submitted.**

**______ A fringe benefit rate has been negotiated with, or approved by, a federal government agency. A copy of the latest rate agreement is/was included with the project application.***

**__X___ There is not a current federally approved rate agreement negotiated and available.****

*Unless the organization has submitted an indirect rate proposal which encompasses the fringe pool of costs, please provide the organization’s benefit package and/or a list of the components/elements that comprise the fringe pool and the cost or percentage of each component/element allocated to the labor costs identified in the Budget Justification.

**When this option is checked, the entity preparing this form shall submit an indirect rate proposal in the format provided in the Sample Rate Proposal at http://www1.eere.energy.gov/financing/resources.html, or a format that provides the same level of information and which will support the rates being proposed for use in the performance of the proposed project.

Additional Explanation (as necessary): Please use this box (or an attachment) to list the elements that comprise your fringe benefits and how they are applied to your base (e.g. Personnel) to arrive at your fringe benefit rate.

## c. Travel

**INSTRUCTIONS - PLEASE READ!!!**

**1.** Identify Foreign and Domestic Travel as separate items. Examples of Purpose of Travel are subrecipient site visits, DOE meetings, project mgmt. meetings, etc. Examples of Basis for Estimating Costs are past trips, travel quotes, GSA rates, etc.

**2.** All listed travel must be necessary for performance of the Statement of Project Objectives.

**3.** Federal travel regulations are contained within the applicable cost principles for all entity types. Travel costs should remain consistent with travel costs incurred by an organization during normal business operations as a result of the organizations written travel policy. In absence of a written travel policy, organizations must follow the regulations prescribed by the General Services Administration.

4. Each budget period is rounded to the nearest dollar.

| SOPO Task # | Purpose of Travel | Depart From | Destination | No. of Days | No. of Travelers | Lodging per Traveler | Flight per Traveler | Vehicle per Traveler | Per Diem Per Traveler | Cost per Trip | Basis for Estimating Costs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Domestic Travel** | **Budget Period 1** | | | | | | | | | |
| 1 | **EXAMPLE!!!** Visit to PV manufacturer | | | 2 | 2 | $250 | $500 | $100 | $160 | $2,020 | Current GSA rates |
| 1-5 | Project Kickoff | Pittsburgh, PA | North Dakota | 4 | 2 | $450 | $800 | $150 | $236 | $3,272 | |
| 1-5 | Project Review | Pittsburgh, PA | North Dakota | 4 | 2 | $450 | $800 | $150 | $236 | $3,272 | |
| | **International Travel** | | | | | | | | | | |
| | | | | | | | | | | $0 | |
| | **Budget Period 1 Total** | | | | | | | | | **$6,544** | |
| | **Domestic Travel** | **Budget Period 2** | | | | | | | | | |
| | | | | | | | | | | $0 | |
| | | | | | | | | | | $0 | |
| | | | | | | | | | | $0 | |
| | **International Travel** | | | | | | | | | | |
| | | | | | | | | | | $0 | |
| | **Budget Period 2 Total** | | | | | | | | | **$0** | |
| | **Domestic Travel** | **Budget Period 3** | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | $0 | |
| | | | | | | | | | | $0 | |
| | **International Travel** | | | | | | | | | | |
| | | | | | | | | | | $0 | |
| | **Budget Period 3 Total** | | | | | | | | | **$0** | |
| | **PROJECT TOTAL** | | | | | | | | | **$6,544** | |

Additional Explanation (as needed):

# d. Equipment

**INSTRUCTIONS - PLEASE READ!!!**

**1.** Equipment means tangible personal property (including information technology systems) having a useful life of more than one year and a per-unit acquisition cost which equals or exceeds the lesser of the capitalization level established by the non-Federal entity for financial statement purposes, or $5,000. Please refer to the applicable Federal regulations in 2 CFR 200 for specific equipment definitions and treatment.

**2.** List all equipment below, providing a basis of cost (e.g. vendor quotes, catalog prices, prior invoices, etc.). Briefly justify items as they apply to the Statement of Project Objectives. If it is existing equipment, provide logical support for the estimated value shown.

**3.** During award negotiations, provide a vendor quote for all equipment items over $50,000 in price. If the vendor quote is not an exact price match, provide an explanation in the additional explanation section below. If a vendor quote is not practical, such as for a piece of equipment that is purpose-built, first of its kind, or otherwise not available off the shelf, provide a detailed engineering estimate for how the cost estimate was derived.

4. Each budget period is rounded to the nearest dollar.

| SOPO Task # | Equipment Item | Qty | Unit Cost | Total Cost | Basis of Cost | Justification of need |
|---|---|---|---|---|---|---|
| | | | Budget Period 1 | | | |
| 3,4,5 | **EXAMPLE!!!** Thermal shock chamber | 2 | $70,000 | $140,000 | Vendor Quote - Attached | Reliability testing of PV modules- Task 4.3 |
| 3,4 | Lignite coal dryer/grinder | 1 | $15,779 | $15,779 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | **Budget Period 1 Total** | | | $15,779 | | |
| | | | Budget Period 2 | | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | **Budget Period 2 Total** | | | $0 | | |
| | | | Budget Period 3 | | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | **Budget Period 3 Total** | | | $0 | | |
| | **PROJECT TOTAL** | | | **$15,779** | | |

Additional Explanation (as needed):

# e. Supplies

**INSTRUCTIONS - PLEASE READ!!!**

**1.** Supplies are generally defined as an item with an acquisition cost of $5,000 or less and a useful life expectancy of less than one year. Supplies are generally consumed during the project performance. Please refer to the applicable Federal regulations in 2 CFR 200 for specific supplies definitions and treatment. A computing device is a supply if the acquisition cost is less than the lesser of the capitalization level established by the non-Federal entity for financial statement purposes or $5,000, regardless of the length of its useful life.

**2.** List all proposed supplies below, providing a basis of costs (e.g. vendor quotes, catalog prices, prior invoices, etc.). Briefly justify the need for the Supplies as they apply to the Statement of Project Objectives. Note that Supply items must be direct costs to the project at this budget category, and not duplicative of supply costs included in the indirect pool that is the basis of the indirect rate applied for this project.

**3.** Multiple supply items valued at $5,000 or less used to assemble an equipment item with a value greater than $5,000 with a useful life of more than one year should be included on the equipment tab. If supply items and costs are ambiguous in nature, contact your DOE representative for proper categorization.

**4.** Add rows as needed. If rows are added, formulas/calculations may need to be adjusted by the preparer.

5. Each budget period is rounded to the nearest dollar.

| SOPO Task # | General Category of Supplies | Qty | Unit Cost | Total Cost | Basis of Cost | Justification of need |
|---|---|---|---|---|---|---|
| | | | **Budget Period 1** | | | |
| 4,6 | **EXAMPLE!!!** Wireless DAS components | 10 | $360.00 | $3,600 | Catalog price | For Alpha prototype - Task 2.4 |
| | Chemicals, solvents and lubricants | 1 | $3,750.00 | $3,750 | | |
| | Heat tracing and insulation | 1 | $6,350.00 | $6,350 | | |
| | Piping, fittings, seals, gaskets | 1 | $7,350.00 | $7,350 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | **Budget Period 1 Total** | | | **$17,450** | | |
| | | | **Budget Period 2** | | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | **Budget Period 2 Total** | | | $0 | | |
| | | | **Budget Period 3** | | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | | | | $0 | | |
| | **Budget Period 3 Total** | | | $0 | | |
| | **PROJECT TOTAL** | | | **$17,450** | | |

Additional Explanation (as needed):

# f. Contractual

**INSTRUCTIONS - PLEASE READ!!!**

**1.** The entity completing this form must provide all costs related to subrecipients, vendors, and FFRDC partners in the applicable boxes below.

**2.** Subrecipients (partners, sub-awardees): Subrecipients shall submit a Budget Justification describing all project costs and calculations when their total proposed budget exceeds either (1) $100,000 or (2) 50% of total award costs. These subrecipient forms may be completed by either the subrecipients themselves or by the preparer of this form. The budget totals on the subrecipient's forms must match the subrecipient entries below. A subrecipient is a legal entity to which a subaward is made, who has performance measured against whether the objectives of the Federal program are met, is responsible for programmatic decision making, must adhere to applicable Federal program compliance requirements, and uses the Federal funds to carry out a program of the organization. All characteristics may not be present and judgment must be used to determine subrecipient vs. vendor status.

**3.** Vendors (including contractors): List all vendors and contractors supplying commercial supplies or services used to support the project. For each Vendor cost with total project costs of $250,000 or more, a Vendor quote must be provided. A vendor is a legal entity contracted to provide goods and services within normal business operations, provides similar goods or services to many different purchasers, operates in a competitive environment, provides goods or services that are ancillary to the operation of the Federal program, and is not subject to compliance requirements of the Federal program. All characteristics may not be present and judgment must be used to determine subrecipient vs. vendor status.

**4.** Federal Funded Research and Development Centers (FFRDCs): FFRDCs must submit a signed Field Work Proposal during award application. The award recipient may allow the FFRDC to provide this information directly to DOE, however project costs must also be provided below.

5. Each budget period is rounded to the nearest dollar.

| SOPO Task # | Sub-Recipient Name/Organization | Purpose and Basis of Cost | Budget Period 1 | Budget Period 2 | Budget Period 3 | Project Total |
|---|---|---|---|---|---|---|
| 2,4 | **EXAMPLE!!!** XYZ Corp. | Partner to develop optimal lens for Gen 2 product. Cost estimate based on personnel hours. | $48,000 | $32,000 | $16,000 | **$96,000** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | **Sub-total** | **$0** | **$0** | **$0** | **$0** |

| SOPO Task # | Vendor Name/Organization | Purpose and Basis of Cost | Budget Period 1 | Budget Period 2 | Budget Period 3 | Project Total |
|---|---|---|---|---|---|---|
| **6** | **EXAMPLE!!!** ABC Corp. | Vendor for developing robotics to perform lens inspection. Estimate provided by vendor. | $32,900 | $86,500 | | **$119,400** |
| 1 | Barr Engineering | Engineering Contractor for Plant Design Services | $100,000 | | | **$100,000** |
| 2 | The North American Coal Corporation | Coal Supplier | $20,000 | | | **$20,000** |
| 3,4,5 | University of North Dakota | Experimental R&D Services/Collaborator | $551,000 | | | **$551,000** |
| 3,4 | West Virginia University | Analytical Laboratory Services | $3,000 | | | **$3,000** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | **Sub-total** | **$674,000** | **$0** | **$0** | **$674,000** |

| SOPO Task # | FFRDC Name/Organization | Purpose and Basis of Cost | Budget Period 1 | Budget Period 2 | Budget Period 3 | Project Total |
|---|---|---|---|---|---|---|
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | **Sub-total** | **$0** | **$0** | **$0** | **$0** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Total Contractual** | | **$674,000** | **$0** | **$0** | **$674,000** |

Additional Explanation (as needed):

# i. Indirect Costs

**INSTRUCTIONS - PLEASE READ!!!**

**1.** Fill out the table below to indicate how your indirect costs are calculated. Use the box below to provide additional explanation regarding your indirect rate calculation.

**2.** The rates and how they are applied should not be averaged to get one indirect cost percentage. Complex calculations or rates that do not do not correspond to the below categories should be described/provided in the Additional Explanation section below. If questions exist, consult with your DOE contact before filling out this section.

**3.** The indirect rate should be applied to both the Federal Share and Recipient Cost Share. **4.**

**NOTE:** A Recipient who elects to employ the 10% de minimis Indirect Cost rate **cannot claim resulting costs as a Cost Share contribution, nor can the Recipient claim "unrecovered indirect costs" as a Cost Share contribution.** Neither of these costs can be reflected as actual indirect cost rates realized by the organization, and therefore are not verifiable in the Recipient records as required by Federal Regulation (§200.306(b)(1)).

5. Each budget period is rounded to the nearest dollar.

| | Budget Period 1 | Budget Period 2 | Budget Period 3 | Total | Explanation of BASE |
|---|---|---|---|---|---|
| **Provide ONLY Applicable Rates:** | | | | | |
| Overhead Rate | 50.89% | | | | **Direct Wages** |
| General & Administrative (G&A) | 31.64% | | | | **Total Program Costs** |
| FCCM Rate, if applicable | | | | | |
| OTHER Indirect Rate | | | | | |
| **Indirect Costs (As Applicable):** | | | | | |
| Overhead Costs | ` | | | **$0** | |
| G&A Costs | $145,655 | | | **$145,655** | |
| FCCM Costs, if applicable | | | | **$0** | |
| OTHER Indirect Costs | | | | **$0** | |
| **Total indirect costs requested:** | **$145,655** | **$0** | **$0** | **$145,655** | |

**A federally approved indirect rate agreement, or rate proposed (supported and agreed upon by DOE for estimating purposes) is required if reimbursement of indirect costs is requested. Please check (X) one of the options below and provide the requested information if it has not already been provided as requested, or has changed.**

**______ An indirect rate has been approved or negotiated with a federal government agency. A copy of the latest rate agreement is included with this application, and will be provided electronically to the Contracting Officer for this project.**

**__X___ There is not a current, federally approved rate agreement negotiated and available*.**

***When this option is checked, the entity preparing this form shall submit an indirect rate proposal in the format provided by your DOE contact, or a format that provides the same level of information and which will support the rates being proposed for use in performance of the proposed project. Additionally, any non-Federal entity that has never received a negotiated indirect cost rate, except for those non-Federal entities described in Appendix VII to Part 200—States and Local Government and Indian Tribe Indirect Cost Proposals, paragraph D.1.b, may elect to charge a de minimis rate of 10% of modified total direct costs (MTDC) which may be used indefinitely.As described in §200.403 Factors affecting allowability of costs, costs must be consistently charged as either indirect or direct costs, but may not be double charged or inconsistently charged as both. If chosen, this methodology once elected must be used consistently for all Federal awards until such time as a non-Federal entity chooses to negotiate for a rate, which the non-Federal entity may apply to do at any time.**

**You must provide an explanation (below or in a separate attachment) and show how your indirect cost rate was applied to this budget in order to come up with the indirect costs show**

Additional Explanation (as needed): *IMPORTANT: Please use this box (or an attachment) to further explain how your total indirect costs were calculated. If the total indirect costs are a cumulative amount of more than one calculation or rate application, the explanation and calculations should identify all rates used, along with the base they were applied to (and how the base was derived), and a total for each (along with grand total).

# Cost Share

**PLEASE READ!!!**

**1.** A detailed presentation of the cash or cash value of all cost share proposed must be provided in the table below. All items in the chart below must be identified within the applicable cost category tabs a. through i. in addition to the detailed presentation of the cash or cash value of all cost share proposed provided in the table below. Identify the source organization & amount of each cost share item proposed in the award.

**2.** Cash Cost Share - encompasses all contributions to the project made by the recipient, subrecipient, or third party (an entity that does not have a role in performing the scope of work) for costs incurred and paid for during the project. This includes when an organization pays for personnel, supplies, equipment, etc. for their own company with organizational resources. If the item or service is reimbursed for, it is cash cost share. All cost share items must be necessary to the performance of the project. Any partial donation of goods or services is considered a discount and is not allowable.

**3.** In Kind Cost Share - encompasses all contributions to the project made by the recipient, subrecipient, or third party (an entity that does not have a role in performing the scope of work) where a value of the contribution can be readily determined, verified and justified but where no actual cash is transacted in securing the good or service comprising the contribution. In Kind cost share items include volunteer personnel hours, the donation of space or use of equipment, etc. The cash value and calculations thereof for all In Kind cost share items must be justified and explained in the Cost Share Item section below. All cost share items must be necessary to the performance of the project. If questions exist, consult your DOE contact before filling out In Kind cost share in this section. Vendors may not provide cost share. Any partial donation of goods or services is considered a discount and is not allowable.

**4.** Funds from other Federal sources MAY NOT be counted as cost share. This prohibition includes FFRDC sub-recipients. Non-Federal sources include any source not originally derived from Federal funds. Cost sharing commitment letters from subrecipients and third parties must be provided with the original application.

**5.** Fee or profit, including foregone fee or profit, **are not allowable** as project costs (including cost share) under any resulting award. The project may only incur those costs that are allowable and allocable to the project (including cost share) as determined in accordance with the applicable cost principles prescribed in FAR Part 31 for For-Profit entities and 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

**6. NOTE:** A Recipient who elects to employ the 10% de minimis Indirect Cost rate **cannot claim the resulting indirect costs as a Cost Share contribution.**

7. **NOTE:** A Recipient **cannot claim "unrecovered indirect costs"** as a Cost Share contribution, **without prior approval.**

**8.** Each budget period is rounded to the nearest dollar.

| Organization/Source | Type (Cash or In Kind) | Cost Share Item | Budget Period 1 | Budget Period 2 | Budget Period 3 | Total Project Cost Share |
|---|---|---|---|---|---|---|
| ABC Company **EXAMPLE!!!** | Cash | Project partner ABC Company will provide 20 PV modules for product development at the price of $680 per module | $13,600 | | | **$13,600** |
| AmeriCarbon | In Kind | | $566,000 | | | **$566,000** |
| NACoal | In Kind | | $20,000 | | | **$20,000** |
| Univ of North Dakota | In Kind | | $100,000 | | | **$100,000** |
| Barr Engineering | In Kind | | $14,000 | | | **$14,000** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | | | | | **$0** |
| | | **Totals** | **$700,000** | **$0** | **$0** | **$700,000** |

**Total Project Cost: $1,400,000** **Cost Share Percent of Award: 50.00%**

Additional Explanation (as needed):

# Appendix 12-I

North American COAL

March 31, 2023

AmeriCarbon Products, LLC
Attention: Mr. David A. Berry, CEO
3001 Cityview Drive
Morgantown, WV 26501

Subject: Matching Funds Commitment Letter

The North American Coal Corporation (NACoal), a NACCO Natural Resources company, is pleased to support your application for the AmeriCarbon Products, LLC ("AmeriCarbon") in its proposal to the Lignite Energy Council with respect to the North Dakota Industrial Commission (NDIC) research grant program under the title *Engineering Design and Feasibility Analysis for Commercial Graphite and Asphalt Manufacturing from Lignite-Derived Carbon Pitch*. The conversion of coal resources into beneficial value-added products is an important area of interest for NACoal.

NACoal is the largest lignite producer in the United States and one of the top 10 coal producers in the United States. We mine and market coal for use in power generation, SNG production, activated carbon production, as well as, providing selected value-added mining services for other natural resources companies. Our corporate headquarters are in Plano, Texas, near Dallas, and we operate surface coal mines in North Dakota, Mississippi, Texas, and Louisiana.

We support the NDIC's and AmeriCarbon's efforts of developing lignite coal as a feedstock for the manufacture of critical materials and advanced carbon products. Successful implementation of a strategic approach to developing this critical supply chain opportunity can lead to significant job creation and economic development in North Dakota.

If the grant is awarded to your project, NACoal will be pleased to provide up to US$20,000 in-kind support in the form of coal samples and time for the project that can be used as cost share. We look forward to working with the you on this exciting opportunity. If you have questions or require additional information, please do not hesitate to contact me at the letterhead address or Gerard Goven at 701-250-2604.

Regards,
The North American Coal Corporation

George Lovland

George Lovland, P.E.
Engineering Manager

**North American Coal**
5340 Legacy Drive, Suite #300
Plano, TX 75024
972.448.5400
**NACoal.com**

A NACCO COMPANY

UNIVERSITY OF NORTH DAKOTA

UND.edu

COLLEGE OF ENGINEERING & MINES

**Office of the Dean**
Upson II, Room 165
243 Centennial Dr Stop 8155
Grand Forks, ND 58202-8155
Phone: 701.777.3411
Fax: 701.777.4838
Website: engineering.UND.edu

March 28, 2023

Dave Berry
CEO
AmeriCarbon LLC

**Subject**: Letter of commitment from the University of North Dakota for AmeriCarbon's proposal to the North Dakota Industrial Commission – Lignite Research, Marketing and Development Program.

Dear Mr. Berry,

The University of North Dakota is pleased to provide this letter of commitment that outlines our cost share commitment and proposed scope of work for your application to the NDIC. We are excited to continue our collaboration with AmeriCarbon and to advance our work related to developing lignite coal-based carbon products.

Our commitment to the proposed project includes $100,000 in cash cost share towards the purchase of a graphitization furnace, which will be installed in our facilities. This furnace is needed to manufacture the proposed synthetic graphite materials.

Our proposed scope of work includes supporting your team, including Barr Engineering, in the completion of engineering design and techno-economic assessments. We will also lead product development testing and optimization associated with the lignite-derived asphalts and battery-grade synthetic graphites.

Our scope of work will be led by Xiaodong Hou (xiaodong.hou@und.edu), with support from Daba Gedafa relating to the asphalt testing. Our total estimated budget for the 12-month project is $551,692.

We wish you luck with your proposal to NDIC and look forward to continuing our exciting collaboration with AmeriCarbon.

Sincerely,

DocuSigned by:
Daniel Laudal
9CFF8579D0B9464...

Daniel Laudal, Ph.D.
Executive Director for Research
College of Engineering & Mines
University of North Dakota
Daniel.laudal@und.edu

DocuSigned by:
Karen Katrinak
DD9BE15BC81D4AA...

Karen Katrinak, Ph.D.
Proposal Development Officer
Research & Sponsored Programs Development
University of North Dakota
Karen.katrinak@und.edu

resourceful. naturally.
engineering and environmental consultants

BARR

March 28, 2023

David A. Berry
AmeriCarbon Products, LLC
3001 Cityview Drive
Morgantown, WV 26501

**Re: Matching Funds Commitment Letter**

Dear Mr. Berry:

Barr Engineering Co. (Barr) is pleased to support AmeriCarbon Products, LLC (AmeriCarbon) in its proposal to the Lignite Research Council with respect to the North Dakota Industrial Commission (NDIC) research grant program under the title Engineering Design and Feasibility Analysis for Commercial Graphite and Asphalt Manufacturing from Lignite-Derived Carbon Pitch. The conversion of coal resources into beneficial value-added products is an important area of interest for Barr.

Barr Engineering Co. is a full-service consulting firm that has worked on projects for thousands of clients in manufacturing, power, and mining over our more than 50-year history as a company. Our clients appreciate that Barr brings together engineering and environmental expertise to provide innovative solutions in the face of changing regulations, markets, and political climates. Barr is a proud member of the Lignite Energy Council and has been working with clients in North Dakota for over 40 years. Furthermore, our full-service office in Bismarck has over 30 personnel and is a short drive from the proposed project site.

We support the NDIC's and AmeriCarbon's efforts of developing Lignite coal as a feedstock for the manufacture of critical materials and advanced carbon products. Successful implementation of a strategic approach to developing this critical supply chain opportunity can lead to significant job creation and economic development in North Dakota.

If the grant is awarded to your project, Barr will be pleased to perform our scope of work at reduced billing rates for an approximately 7% reduction in labor fees provided as in-kind support in the form of time contributed to the project that can be used as cost share. We look forward to working with you on this exciting opportunity. If you have questions or require additional information, please do not hesitate to contact me at the letterhead address or by email to dpalo@barr.com.

Sincerely

Daniel R. Palo
Vice President and Sr. Process Engineer

AmeriCarbon

April 3, 2023

State of North Dakota
The Industrial Commission
State Capitol
Bismarck, ND 58505
ATTN: Lignite Research Program

**RE: Matching Funds Commitment Letter**

This is to confirm that the applicant, AmeriCarbon Products, LLC, is committed to providing $566,000 in in-kind services, including personnel time, indirect, and overhead expenses, with respect to the project proposed with the title *Engineering Design and Feasibility Analysis for Commercial Graphite and Asphalt Manufacturing from Lignite-Derived Carbon Pitch.*

We look forward to working with the North Dakota Industrial Commission and the Lignite Energy Council to discuss the enclosed proposal. If you have any questions, I may be reached at (304) 685-6017 or greg.henthorn@americarbon.com.

Sincerely,

Greg Henthorn
Vice President of Corporate Development
AmeriCarbon Products, LLC

# Appendix 13-I

# AFFIDAVIT

In reference to Section 43-03-04-01, North Dakota Century Code, the undersigned, Gregory Henthorn, Vice President, Corporate Development of AmeriCarbon Products, LLC, a West Virginia limited liability company with a tax mailing address of 3001 Cityview Drive, Morgantown, West Virginia, 26501, being first duly sworn according to law, deposes and states as follows:

1. I am at least 18 years of age.

2. I have personal knowledge regarding the facts as set forth herein.

3. I am the Vice President, Corporate Development of AmeriCarbon Products, LLC, a West Virginia limited liability company ("**AmeriCarbon**").

4. AmeriCarbon does not have an outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

5. I declare under penalty of perjury under the law of North Dakota that the foregoing is true and correct.

Further Affiant sayeth naught.

***Executed and acknowledged by:***

Gregory Henthorn

[Continued on the following page.]

**JURAT**

STATE OF Pennsylvania :

:

COUNTY OF Allegheny :

The foregoing instrument was subscribed to and sworn before me this 3 day of April, 2023, by Gregory Henthorn.

[Notarial Seal]

Commonwealth of Pennsylvania - Notary Seal
NICOLE MAGNONE - Notary Public
Allegheny County
My Commission Expires November 16, 2026
Commission Number 1258955

Nicole Magnone
Notary Public

My Commission Expires: 11-16-26

This instrument was prepared by:
AmeriCarbon Products, LLC, 3001 Cityview Drive, Morgantown, West Virginia, 26501