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April 2, 2018

Ms. Karlene Fine
Executive Director
ATTN: Lignite Research Program
North Dakota Industrial Commission
600 East Boulevard Avenue
State Capitol, 14th Floor
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: EERC Proposal No. 2018-0089 Entitled "Economical Extraction and Recovery of Rare-Earth Elements and Production of Clean Value-Added Products from Low-Rank Coal Fly Ash"

The Energy & Environmental Research Center (EERC) of the University of North Dakota is pleased to submit an original and one copy of the subject proposal. Also enclosed is the $100 application fee. The EERC is committed to completing the project as described in the proposal if the Commission makes the requested grant.

If you have any questions, please contact me by telephone at (701) 777-5243 or by e-mail at bfolkedahl@undeerc.org.

Sincerely,

Bruce C. Folkedahl
Senior Engineer

Approved by:

Thomas A. Erickson, CEO
Energy & Environmental Research Center

BCF/bjr

Enclosures

Lignite Research, Development and Marketing Program

North Dakota Industrial Commission

Application

Project Title: Economical Extraction and Recovery of Rare-Earth Elements and Production of Clean Value-Added Products from Low-Rank Coal Fly Ash

Applicant: University of North Dakota Energy & Environmental Research Center

Project Manager: Bruce C. Folkedahl

Co-Principal Investigator: Daniel A. Laudal

Date of Application: April 2, 2018

Amount of Request: $30,000

Total Amount of Proposed Project: $510,000

Duration of Project: 18 months

Point of Contact (POC): Bruce C. Folkedahl

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Grand Forks, ND 58202-9018

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ABSTRACT

Objective: The University of North Dakota (UND) Energy & Environmental Research Center (EERC) and Institute for Energy Studies (IES), with assistance from Pacific Northwest National Laboratory (PNNL), propose this project with the objective to develop an economically viable and tailorable rare-earth element (REE) extraction and concentration method for low-rank coal (LRC) fly ash and bottom ash that produces a concentrate containing ≥2 wt% total REEs. The method is tailored based on a detailed understanding of fly ash formation mechanisms, fly ash properties, the form of the REEs in the fly ash and, to some degree, the mode of occurrence of the REEs in the coal. Our proposed technology goals are to produce an economically viable process that will:

- Produce a domestic "green" source of REEs.
- Recover other valuable minerals/elements from coal fly ash.
- Remove toxic metals from the fly ash.
- Convert the fly ash into a value-added product.
- Consume carbon dioxide.
- Generate a selective REE extraction that is not typical with existing approaches targeting REEs from combustion fly ash.

Expected Results: The results of this project will lead to a novel economically viable and tailorable REE extraction and concentration method for LRC fly ash and bottom ash that produces a concentrate containing ≥2 wt% total REEs. This information will be used to develop the techniques and processes in follow-on work at a larger scale.

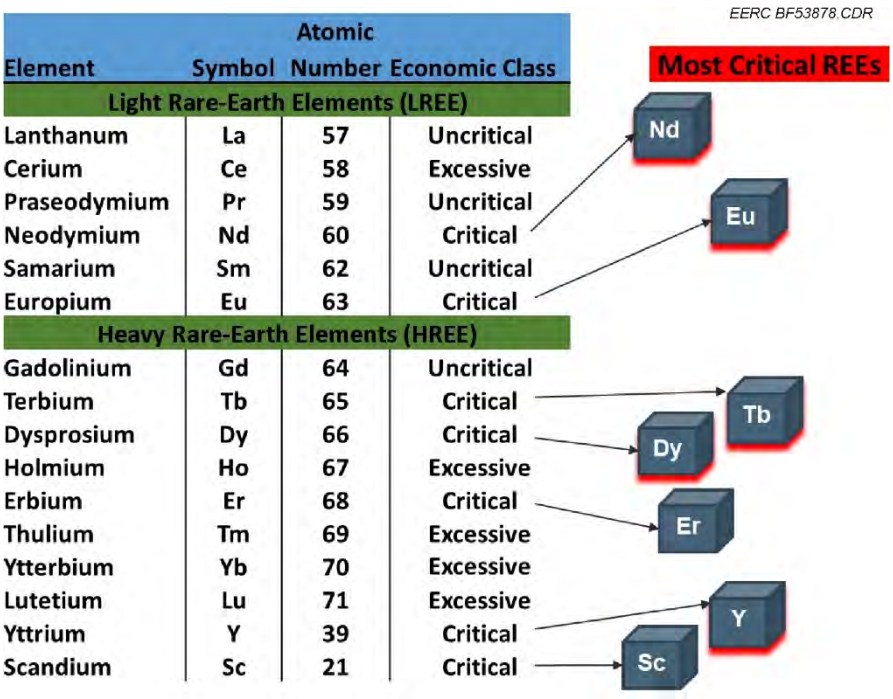
Duration: This project is an 18-month project; however, the project officially started November 16, 2017.

Total Project Cost: The total proposed budget is $510,000. Of this, $400,000 has been secured from the U.S. Department of Energy (DOE), and $80,000 is in the form of cash and in-kind from a consortium of coal companies and utilities. The balance of the funding, $30,000, is requested from the North Dakota Industrial Commission's Lignite Research, Development, and Marketing Program.

Participants: DOE, Great River Energy, Basin Electric Power Cooperative, Southern Company Services

PROJECT SUMMARY

Rare-earth elements (REEs) include a group of elements with atomic numbers from 57 to 71, making up the lanthanide series of elements consisting of lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), and lutetium (Lu). Yttrium (Y) and Scandium (Sc) are often included in the group because of their similar properties. The REEs are not actually "rare," but rather they are very evenly dispersed in Earth's crust. Only in a few unique geologic deposits are they in a concentration and form that is economically minable. As identified in Figure 1, the REEs are generally broken down into groupings, loosely based on molecular weight, into heavy REEs (HREEs) and light REEs (LREEs). The HREEs are less abundant in nature, and their applications are among the fastest-growing market sectors. Correspondingly, the HREEs are typically more expensive. Five of the REEs in particular have been identified in previous studies by the



Element	Symbol	Atomic Number	Economic Class
Light Rare-Earth Elements (LREE)			
Lanthanum	La	57	Uncritical
Cerium	Ce	58	Excessive
Praseodymium	Pr	59	Uncritical
Neodymium	Nd	60	Critical
Samarium	Sm	62	Uncritical
Europium	Eu	63	Critical
Heavy Rare-Earth Elements (HREE)			
Gadolinium	Gd	64	Uncritical
Terbium	Tb	65	Critical
Dysprosium	Dy	66	Critical
Holmium	Ho	67	Excessive
Erbium	Er	68	Critical
Thulium	Tm	69	Excessive
Ytterbium	Yb	70	Excessive
Lutetium	Lu	71	Excessive
Yttrium	Y	39	Critical
Scandium	Sc	21	Critical

Figure 1. REEs identified by molecular weight groupings and economic class or criticality.

U.S. Department of Energy (DOE) as the most critical, in terms of risk of supply disruption and importance to the U.S. economy and national security [1]. These “critical REEs” include Nd, Eu, Tb, Dy, and Y. Figure 1 also identifies other elements that are considered critical, as well as excessive and uncritical.

Coal and coal by-products have recently been recognized as a promising alternative REE resource. The University of North Dakota (UND), through a series of federal grants, has made great strides in this area and has become one of the leaders in REE from coal research.

The goal of this project is to develop an economically viable and tailorable REE extraction and concentration method for low-rank coal (LRC) fly ash and bottom ash that produces a concentrate containing ≥2 wt% total REEs. The method is tailored based on a detailed understanding of fly ash formation mechanisms, fly ash properties, the form of the REEs in the fly ash and, to some degree, the mode of occurrence of the REEs in the coal. This method is being applied to high-calcium-containing fly ash materials derived from the combustion of lignite coal from the Fort Union region in North Dakota and subbituminous coals from the Powder River Basin (PRB), the resource of which has the potential to far exceed the current U.S. REE demand. The REEs are distributed in high-calcium-containing fly ash in associations that include oxides, sulfates, and calcium aluminates and in the fused, glassy silicate materials produced by high-temperature combustion. This results in the need to develop tailored solvent approaches that target the REEs in their respective forms. The glassy ash materials permit poor access by traditional solvents, making selective extraction difficult and resulting in the economically and environmentally challenging aggressive chemical leaching methods that are used in most existing approaches. The proposed technology goals of this project are to produce an economically viable process that will:

- Produce a domestic “green” source of REEs.
- Recover other valuable minerals/elements from coal fly ash.
- Remove toxic metals from the fly ash.

- Convert the fly ash into a value-added product.
- Consume carbon dioxide.
- Generate a selective REE extraction that is not typical with existing approaches targeting REEs from combustion fly ash.

This will be accomplished through the development of novel extraction technologies as described below.

PROJECT DESCRIPTION

Objectives: The overall goal of this project is to develop a novel technology for REE extraction and recovery from coal combustion fly ash. This 18-month project is in the initial stage and builds on UND's decades of experience in the geochemistry of lignite coal and the ash formation processes that occur during combustion. The technology will leverage the unique properties of lignite to provide significant economic and environmental improvements over current state-of-the-art processes to extract REEs from ores. This goal will be accomplished through the following project tasks.

Methodology: Detailed descriptions of all methodology are contained in confidential Appendix C. Because the details of the approach to be taken in this study are unique and potentially patentable, they are listed in a separate section as provided for by the application instructions. Listed below are generalized descriptions by task.

Task 1.0 – Project Management and Planning: The project management and reporting task includes 1) management and summary progress reporting – summary reports will be provided on a quarterly basis; 2) regular conference calls and face-to-face meetings with project participants will be conducted to allow for the exchange of information and input on test plans; and 3) final report – a detailed final report will be provided discussing all of the project results.

Task 2.0 – Sample Procurement and Characterization: This task will involve procurement and production of representative samples of LRC fly ash along with detailed characterization of the materials.

***Subtask 2.1 – Sample Procurement*:** In this subtask, we anticipate sourcing and producing up to 15 fly ash samples that will be analyzed for REE content from which we can pick up to six of the most promising and highest REE concentrations for full characterization utilizing the methods described in Subtask 2.2. Fly ash samples will be collected from the full-scale power plants of project sponsors Southern Company Services, Great River Energy, and Basin Electric, as well as other selected LRC fly ashes that are known to contain >300-ppm total REE.

***Subtask 2.2 – Fly Ash Characterization*:** Characterization will include a suite of techniques to fully elucidate the abundance, form, and association of the REEs, as well as determine the bulk composition, mineralogy, and morphology of the fly ash. The techniques include:

- X-ray fluorescence (XRF) to measure the bulk chemical composition of the ash.
- Inductively coupled plasma–mass spectrometry (ICP–MS) to measure the abundance of REEs, other high-value elements, and potential impurities that could impact REE recovery.
- Powder x-ray diffraction (XRD) to quantify the distribution of the crystalline phases and the amorphous fraction of the ash.
- Scanning electron microscopy–energy-dispersive spectrometry (SEM–EDS) to take high-magnification images and determine point chemical composition of features of interest in samples.
- Sequential leaching techniques to determine the form and association of the REEs and other elements of interest within the samples. Materials will be leached using the Community Bureau of Reference sequential extraction scheme (CBR SES) to fractionate metals into the operationally defined phases of water-soluble, exchangeable, reducible, oxidizable, and residual, with the steps targeting free water-soluble ions, exchangeable and carbonate bound metals, iron and manganese oxide/hydroxide associated metals, metals bound to sulfide and organic phases, and mineral phases, respectively.

- BET analysis to measure the surface area and pore volume/size of the ash samples.

In addition to the above ash analyses, we will also collect and analyze samples of the feed coals to the power plants that generated the fly ashes. These coal samples will be characterized using the standard ASTM International (ASTM) methods for proximate and ultimate analysis (D3172 and D3176), as well as the techniques listed above for bulk chemical composition and REE analysis. Another sequential leaching technique called chemical fractionation will also be used to determine the modes of REE occurrence in the coals for this project. This information will allow us to develop correlations to predict the REE forms and associations in the coal fly ash. Based on the results of this task, we will select two types of ashes (i.e., one lignite and one subbituminous) for testing in Task 3. The selection of materials will be based on the abundance of REE as well as their association and perceived ease of recoverability.

Task 3 – Laboratory-Scale Testing: This task will involve laboratory-scale extraction testing of up to two types of coal ash identified from Task 2. Six subtasks are included as detailed below.

***Subtask 3.1 – Experimental Test System Design and Installation*:** This project will leverage existing test equipment at UND. The existing system is a 20-gram-capacity high-pressure fluid extraction system that is a flow-through system in which the fluid is passed through a fixed bed of solids for the desired time. The main components are a hydraulic pump, three electric heater systems, a reactor cell, a pressure control valve, a pressure letdown vessel, and two condensers. It is fully equipped with instrumentation to continuously monitor flows, temperatures, and pressures. Modifications will include installation of a secondary injection pump and controller, extract trap, and associated plumbing for the various solvents and product streams.

***Subtask 3.2 – Fly Ash Pretreatment Testing*:** This subtask will involve testing of fly ash pretreatment methods, including rapid expansion, thermal treatment, carbonation, and water leaching. With each method and combination of methods tested, the fly ash mineralogy (XRD), composition (XRF), morphology (SEM and BET), and REE forms and associations (sequential leaching and ICP–MS) will be

evaluated to examine their impacts and efficacy to improve the process. This subtask will be performed in coordination with Subtasks 3.3 and 3.4 to provide pretreated ash for REE extraction tests.

***Subtask 3.3 – Dilute Acid Leaching Testing*:** Using the pretreated ashes produced in Subtask 3.2, testing will be accomplished to determine the recoverability of the REEs and other target metals/elements via dilute acid leaching. The primary acid to be tested is HCl, but we may also investigate others such as H_2SO_4. A range of concentrations, temperatures, and contact times will be evaluated to identify the operating window where effective extraction is achieved. This testing will be done in small batches of 5 to 10 grams of ash via existing leaching equipment at UND. REE extraction efficiency will be determined through ICP–MS of both the residual solids and the acid extract, and XRF/XRD/SEM–EDS/BET will be used to examine the impact of the leaching on the composition, mineralogy and morphology of the residual solids. This subtask will identify an effective operating window that will be used in Subtask 3.5 to generate representative materials for REE concentration testing.

***Subtask 3.4 – Compressed Fluid Extraction Testing*:** Both the pretreated and untreated fly ashes and, potentially, the acid leached fly ashes will be evaluated in this subtask. The primary goals are to identify the most effective conditions (the combination of organic ligands, cosolvents and proportions, contact time) required to achieve the highest level of REE extraction. The types of organic ligands to be evaluated are those that are commonly employed with compressed fluid extraction systems as well as novel low-cost ligands being developed by the UND team in current work. In this subtask, the product streams (residual ash and extract) will be recovered by simply evaporating the compressed fluid. The REEs and other complexed metals will be recovered by simple acid stripping or combusting the ligand extract fraction (methods to be competitively studied). REE/metals extraction efficiency can then be determined using ICP–MS of both the residual ash and the mixed metal oxide or acid solution recovered after removal of the ligand. This subtask will identify an effective operating window that will be used in Subtask 3.5 to generate representative materials for REE concentration testing.

***Subtask 3.5 – REE Concentration Testing*:** Based on the results of the previous two subtasks, testing will be accomplished with downselected conditions using one type of (preferred) feedstock. This subtask will explore proven hydrometallurgy techniques, thermal methods, and novel approaches to concentrate and purify the REEs recovered from the extraction methods (as described in Subtasks 3.3 and 3.4). Project work will strive for the highest degree of REE concentration achievable using our proposed simple and low-cost methods, with 50% REE concentration possible and 2 wt% minimum targeted value.

Methods to be explored to concentrate REEs from the leaching approach will include selective impurities precipitation and/or selective REE precipitation using methods that are well-established in the literature and our current work. Recovery of REEs after bulk precipitation from the compressed fluid (evaporation of the fluid) will be examined using traditional hydrometallurgy methods such as acid stripping. Novel methods such as density control precipitation to concentrate and purify extracted REEs will be explored. Methods to selectively recover and further purify REE–organic complexes (precipitated from the compressed fluid extract) will be explored.

***Subtask 3.6 – Rapid Expansion Testing*:** We will evaluate the feasibility of using a rapid expansion process to create value-added particles from the residual ash material left over after extraction of the REEs. The testing will involve a simple experimental setup where the ash/compressed fluid slurry will be rapidly expanded through an orifice or nozzle to alter its physical structure (i.e., particle size and porosity). SEM imaging and BET will be used to examine the morphology of the ash after the testing. The goal of this effort is to produce a clean material with the porosity and particle size that will make it a value-added product salable to industry for a range of applications.

Task 4 – Technical and Economic Analysis: Based on the results of laboratory testing and sample characterization in this project, a preliminary technical and economic analysis will be completed. Because of the early stage of technical development and overall process definition, this will be a high-level assessment with the goals to estimate preliminary capital and operating expenses and potential revenues

generated from the products produced by our technology. This analysis will serve to direct future process development.

Anticipated Results: It is anticipated that the results of the project testing as described above will lead to a novel, economically viable, and tailorable REE extraction and concentration method for LRC fly ash and bottom ash that produces a concentrate containing ≥2 wt% total REE. In addition, it is anticipated that the work performed in this project will also result in a method to improve the salability of the ash after the REEs have been removed, providing greater economic viability to the overall process. The information from this initial work will be used to develop the techniques and processes in follow-on work at larger scale.

Facilities: The EERC has over 54,000 square feet of demonstration facilities. These facilities contain a variety of demonstration venues for a variety of technologies as well as space for construction of new pilot-scale components to fit client needs. Additionally, the EERC has been involved in many projects that are demonstrated off-site but require EERC technical and field sampling expertise. Much of the mechanical design and modeling of equipment and machinery for our demonstration facilities is done on-site in our in-house machine shop. This allows the EERC to demonstrate technologies in a more rapid, cost-effective way.

Resources: The EERC's staff is a multidisciplinary team of approximately 200 highly skilled scientists, engineers, and support personnel representing more than 140 different disciplines, making it one of the world's leading developers of energy and environmental technologies. The personnel and facilities at the EERC combined with the expertise and resources available through partnership in this project with UND's Institute for Energy Studies (IES) and the Chemical Engineering Department will provide for ample resources to complete the project in a timely and effective manner.

Techniques to Be Used, Their Availability and Capability: The techniques to be used and their capabilities are described above in the Project Description. Their availability will be prioritized with other projects at the EERC and UND to ensure timely completion of this project.

Environmental and Economic Impacts While Project Is under Way: Environmental impacts will be minimal during execution of this project. Sampling at full-scale utilities will not interfere with regular operation of the power generation plants or have any noticeable environmental impacts. Pilot- and lab-scale testing at the EERC will be in a controlled environment with very small amounts of material utilized that will be disposed of according to standard UND Environmental Health and Safety practices once the testing is complete. Economic impacts will also be minimal and will not have appreciable effects on any of the organizations participating, with the exception of regular employment economic effects for those working on the project. The project will provide training opportunities for young engineers and students, ultimately improving the technical capacity of the North Dakota labor force.

Ultimate Technological and Economic Impacts and Why the Project Is Needed: The ultimate impact of this project, if successful, will be the development of a new industry that will benefit both coal producers as well as power generators in North Dakota while providing increased economic activity and jobs in a new industry for North Dakota. This project seeks to develop techniques to extract REEs from LRC ash in a more environmentally benign and economically viable process than traditional methods of REE extraction from ores. These REEs are deemed critical to national security, and new sources and extraction methods are required. Additionally, if these methods can be made economically viable for coal ash, it will open up a new revenue source for both coal and power producers that will be critical to the continued operation of the power generation industry in North Dakota. Figure 2 provides a simple schematic of the overall REE value chain and identifies the locations where UND is currently involved in research. North Dakota has a great opportunity to develop a research presence and, ultimately, a commercial presence in North Dakota in the remaining stages. With a low-cost domestic resource of REE (North Dakota lignite coal and by-products), and economical means to extract and concentrate the REE (current DOE-funded work), we will have the ability to compete in the remaining stages of the value chain.

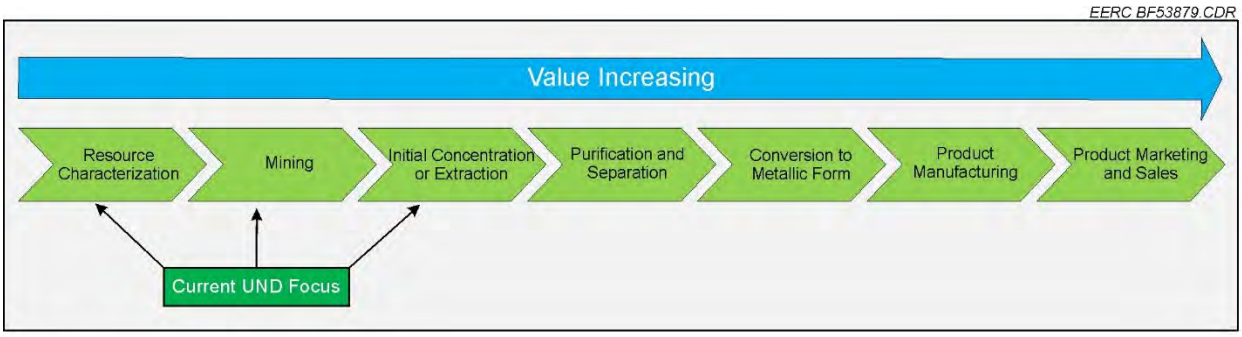


Figure 2. Schematic of the REE value chain. Value of the stages generally increases left to right.

STANDARDS OF SUCCESS

A successful test program will meet all of the deliverables and milestones listed in the Project Description section in a timely manner. Successful development of a novel, environmentally sustainable, and economically viable REE extraction process will be a hallmark of success for the project. This success will justify continued development of the processes in follow-on work at larger scale. The EERC will work closely with its partners and technology providers after conclusion of a successful project to work on taking the lab-scale processes developed in this project to a pilot-scale system to enable a more detailed and robust technical and economic analysis for the overall process.

BACKGROUND

Background: REEs include elements with atomic numbers from 57 to 71, making up the lanthanide series of elements, and also include yttrium and scandium because of similar properties. Groupings into LREE and HREE is generally accepted by molecular weight, with LREEs including La through Sm and HREEs including Eu through Lu as well as Sc and Y. The elements can further be grouped according to their criticality arising from a combination of supply scarcity and end-use importance. The critical REEs are typically accepted to be Y, Nd, Eu, Tb, and Dy [2].

Because of their unique properties, REEs are crucial materials in an incredible array of products and applications. However, the global production and entire value chain are dominated by China [3], with the United States currently 100% import-reliant for these critical materials. Traditional mineral ores including previously mined deposits in the United States, however, have several challenges. Chief among

these is that the content of the most critical and valuable of the REEs is deficient, making mining uneconomical. Further, the supply of these most critical REEs is nearly 100% produced in China from a single resource (ion-adsorbed clays) that is only projected to last another 10 to 20 years [4–6].

Opportunity: The United States currently considers the REE market an issue of national security. It is imperative that alternative domestic sources of REEs be identified and methods developed to produce them. Coal and coal by-products have been identified as promising alternative resources. Ackman and others [7] performed a detailed assessment of the prospects of coal and coal by-products as alternative resources for REE in the United States and found that "unintended production" of REE associated with coal mining potentially exceeds 40,000 tons annually; of that, the HREE may exceed 10,000 tons annually. Therefore, *an effective REE recovery process from domestic coal mining/processing could easily meet domestic REE needs*. In addition to this, the existing coal mines have already absorbed the cost of mining and, in many cases, also the cost of transportation, crushing, grinding, and coal cleaning. Therefore, the potential for value-added recovery of REEs exists at several stages in the coal utilization value chain. For example, waste materials such as combustion ash or coal preparation tailings streams would be attractive resources as they could offer new revenues instead of currently being a cost for disposal. *Fly ash from coal combustion is particularly promising because of its enrichment in the REEs (loss of diluting organic material results in ~10× concentration over coal) and also its presence in fine powder form, eliminating or reducing high-energy fine grinding typically required for REE processing.*

Proposed Feedstock – LRC Fly Ash: We have identified LRC fly ash (lignite and subbituminous) as the proposed feedstock for our technology. Fly ash in general has been identified as a highly promising REE resource. Seredin and Dai [8] have developed a method for resource assessment that is based on the content of the critical REE in the resource. Their outlook coefficient (Coutl) is the ratio of the critical REE to the excessive REE: the higher the coefficient, the more promising the resource is for economic recovery. They have developed the plot shown in Figure 3, which shows clusters of unpromising, promising, and highly promising resources. The plot compares a large number of coal ashes

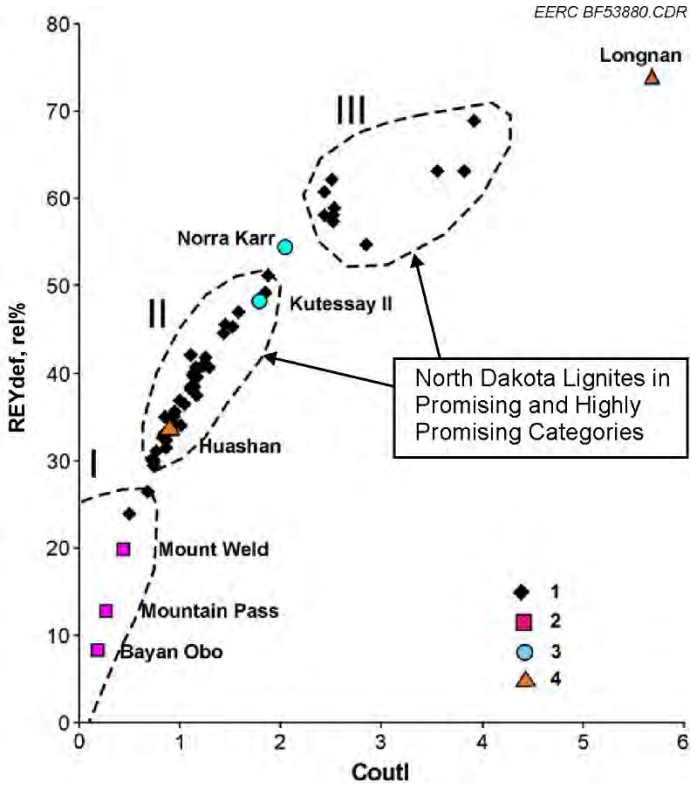


Figure 3. Classification of coal fly ash (black diamonds) REE distribution in comparison with selected conventional REE deposits. The x-axis is the outlook coefficient (Coutl) which is the ratio of the critical REE to the excessive REE: the higher the coefficient, the more promising the resource is for economic recovery. The y-axis is percentage critical REE in the total REE. Again, the higher the value the more promising the resource is: 1 – REE-rich coal ashes, 2 – carbonatite ore deposits, 3 – hydrothermal ore deposits and 4 – weathered crust elution-deposited (ion-adsorbed) ore deposits. Clusters of REE-rich coal distinguished by outlook for REE distribution (numerals in figure): I – unpromising, II – promising, and III – highly promising. Better materials are higher and to the right—it is clear some coal fly ash materials are very promising REE sources, with more value than existing ore deposits in production [8]. ***Based on current UND work, North Dakota lignite coals fit in both the highly promising and promising clusters.***

globally (black diamonds) with some of the traditional mineral ore resources. Seredin and Dai conclude that coal ash is a more promising resource for REEs than most traditional ore deposits currently being mined and, in fact, that mining of such deposits as the Mountain Pass in California will not diminish the REE supply crisis but will only result in overproduction of excessive cerium. In our ongoing work with *North Dakota lignites*, we have identified several coal seams and locations in the state with coals that would provide ashes that *fall into both the promising and highly promising categories established*.

Besides a promising distribution of the critical REE and high total REE content for many LRCs, fly ash is also an attractive REE resource for additional reasons:

- Beneficial value-added use of a traditional waste material can provide new revenues and reduce the environmental footprint of the coal combustion plant.
- A very large fraction of the cost with most REE resources (~60%) is incurred in excavation, pulverization, and grinding of the minerals to a fine powder necessary for chemical processing. Fly ash is already available as a fine powder, avoiding mine-to-mill expenditures associated with mining [9].
- Starting with high REE abundance in the coal, the combustion of coal concentrates the nonvolatile REEs into the fly ash by approximately a factor of 10 for a typical low-ash LRC.
- Coal ash as a REE resource will significantly reduce energy use and accompanying CO_2 emissions relative to conventional mining by ~75% [9].
- Along with the REEs, there is potential (and likelihood) to extract and separate hazardous elements and other valuable commercial by-products during the recovery process.
- Extraction of leachable metal content from the ash will clean it and, thus, improve its value/marketability or eliminate toxicity concerns for waste disposal.

In addition to the above-listed benefits, the resource of REE-rich LRC fly ashes is tremendous. For example, sampling and analysis work by Fan and others [10] has identified at least an annual production of 48 million tons of LRC fly ash with > 300-ppm total REE in the states of Wyoming, Utah, and Wisconsin, with even larger potential up to about 150 million tons annually. At these volumes for an average REE concentration of 300 ppm (on the low end of typical for most LRCs), an REE production from domestic LRC fly ash provides nearly 3× the current U.S. REE demand (~16,000 tons annual REE demand per USGS) [3].

QUALIFICATIONS

Key Personnel: Dr. Bruce C. Folkedahl will serve as project manager for the project. Dr. Folkedahl is a Senior Engineer at the EERC in combustion and gasification for electricity generation; research on the fundamental mechanisms of ash deposition and fouling during firing of fuels; process development for the conversion of coal and biomass feedstocks to fuels, chemicals, and value-added products; computer-based models to predict the performance of combustion and gasification systems; technical and economic feasibility of fuel conversion technologies; and corrosion and development of high-temperature materials to withstand aggressive combustion environments. Dr. Folkedahl has been responsible for the development of two novel technologies for water reduction in power generation systems. He received his Ph.D. degree in Materials Science and Engineering from Pennsylvania State University and his B.S. degree in Computer Science from UND.

Dr. Daniel Laudal will serve as a Co-Project Coordinator. Dr. Laudal conducted his Ph.D. work on REE recovery from LRCs. He has extensive experience in the geochemistry of LRCs and North Dakota lignites, fuels characterization, and coal utilization processes. Dr. Laudal has nearly 10 years of experience managing and executing large multidisciplinary research projects associated with CO_2 capture, chemical looping, mineral separation processes, and advanced power generation technologies. Dr. Laudal has a B.S. and Ph.D. in Chemical Engineering from UND.

Dr. Raymond Addleman will be a Co-Project Coordinator, providing expertise in REE extraction chemistry as well as the use of compressed fluids for chemical and material processing. Dr. Addleman is very experienced with the coordination needs required for successful multi-institutional research, and his work at PNNL presently involves leading or contributing to ~$2M/yr in R&D with support from both government agencies and commercial interests. Dr. Addleman has over 20 years of research experience with extensive work in trace collection and separation of f-block elements as well as broad experience with compressed fluids (both supercritical and near critical) for metals extractions, material processing, and chemical reactions. He recently completed a successful effort as the PI of a multi-institutional

program exploring the recovery of trace REEs from geothermal fluids (DOE-EREE Geothermal Technologies Program). He is currently partnering with the UND team to evaluate REE recovery from North Dakota lignite coal. Dr. Addleman has a Ph.D. degree in Chemistry (with emphasis on metal extraction technology and a dissertation on supercritical CO_2 extraction of uranium), a masters in Materials Chemistry, and B.S. degrees in both Chemistry and Physics.

Resumes for key personnel can be found in Appendix A.

EERC: The EERC is one of the world's major energy and environmental research organizations. Since its founding in 1949, the EERC has conducted research, testing, and evaluation of fuels, combustion and gasification technologies, emission control technologies, ash use and disposal, analytical methods, groundwater, waste-to-energy systems, and advanced environmental control systems. Today's energy and environmental research needs typically require the expertise of a total-systems team that can focus on technical details while retaining a broad perspective.

The EERC has over 65 years of coal research, with extensive experience on low-rank coals (lignite and subbituminous). The EERC has conducted measurement sampling at over 80 coal-fired units at utilities since 1996. The EERC has developed several new methods for characterization of materials and sampling methodologies over the years, including the Ontario Hydro (OH) and M30B for measuring mercury in flue gas at the ppb level, and routinely is called upon to evaluate measurement errors and biases that can be introduced during measurement and ways to overcome sampling problems. On projects, the EERC goes significantly beyond the requirements of the sampling methods to ensure that lessons learned over the years result in quality, reliable data.

VALUE TO NORTH DAKOTA

North Dakota is host to the world's largest lignite coal deposit, with an estimated 25 billion tons of recoverable reserves [11], and its economy and energy portfolio is heavily invested in lignite mining and utilization. This project provides the foundation for a potential, completely new industry focused on LRC fly ash use. The potential exists to significantly offset, and potentially eliminate, current imported REE

and REE product volumes by providing a reliable domestic resource and novel, low-cost technology focused on its development. The ultimate significance of this research is development of a high-performance, environmentally benign, and economically viable technology for REE production from an alternative resource that will limit dependence on foreign supplies and strengthen the economic and national security of the United States. This project will enable technology migration to the next scale (bench-scale) and will be a foundation for subsequent larger demonstrations and eventual commercial deployment.

MANAGEMENT

Figure 4 provides an organizational chart. Overall project direction will come from an advisory committee formed with members from the industrial partners funding the project, including NDIC. This advisory committee will provide project guidance to Project Manager Dr. Folkedahl. Dr. Laudal and Dr. Addelman will be co-project coordinators. All key personnel will be responsible for interpretation of results and writing reports. Resumes of all key personnel are enclosed in Appendix A.

Once the project is initiated, monthly or as-needed conference calls will be held with project sponsors and team members to review project status. Quarterly reports will be prepared and submitted to project sponsors for review.

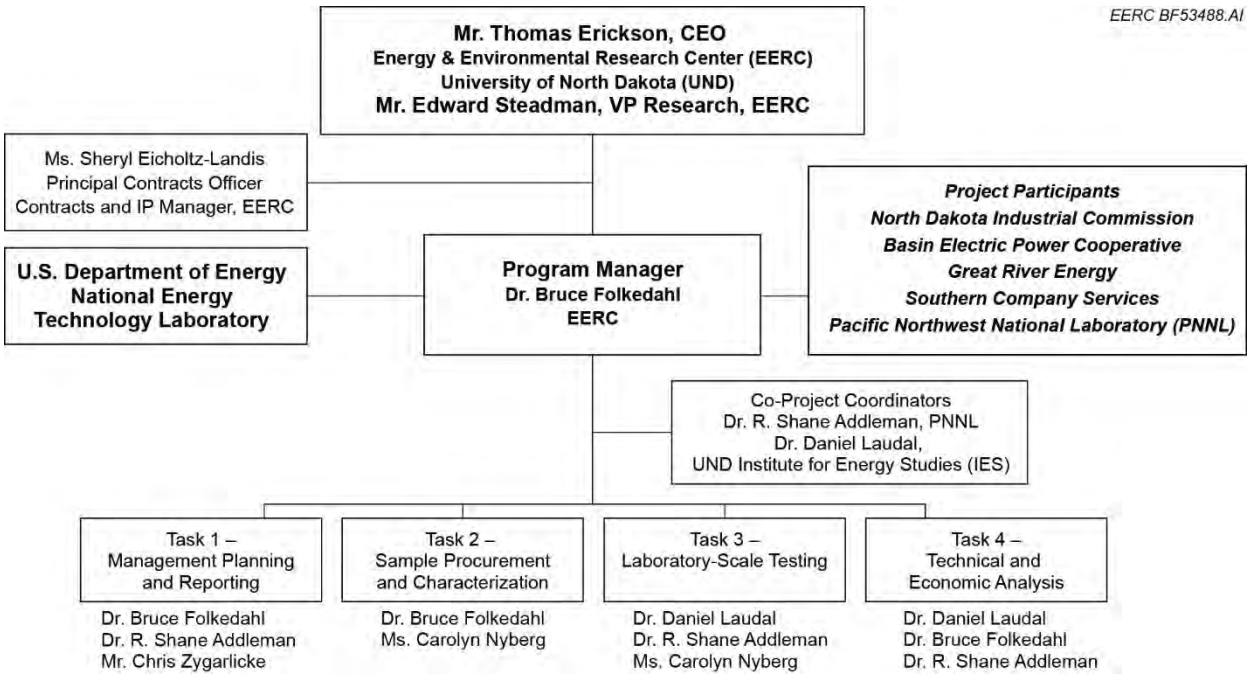


Figure 4. Project management and organizational chart.

TIME TABLE AND DELIVERABLES

Figure 5 shows the time line for the project including Milestones and Deliverables. It should be noted that the project officially started November 16, 2017. Should NDIC provide sponsorship funding for this project, the EERC will provide quarterly reports to NDIC 30 days after the end of each calendar quarter.

BUDGET

The total estimated cost of this proposed work is $510,000 as shown in the following table. This proposal requests sponsorship of $30,000 from NDIC's Lignite Research, Development, and Marketing Program.

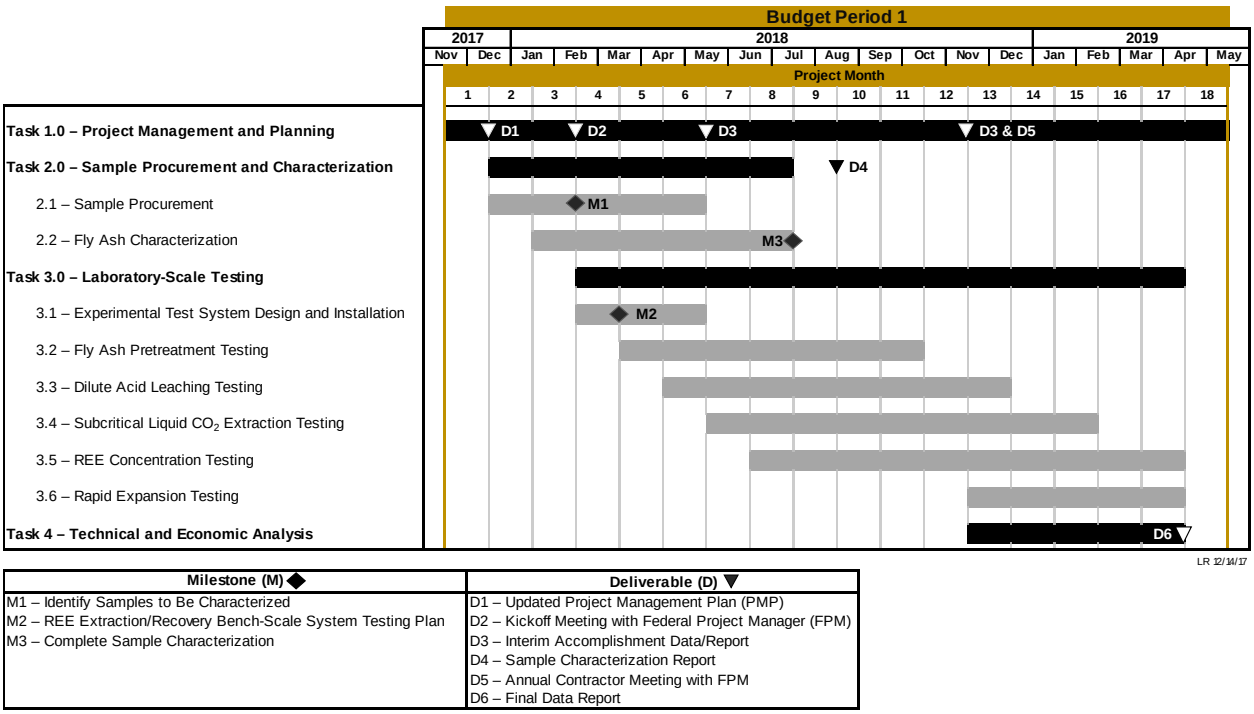


Figure 5. Time table and deliverables.

Project Associated Expenses	NDIC Share Cash	Matching Funds	Total Project
Labor	$ 19,852	$ 166,445	$ 186,297
Travel	$ -	$ 4,509	$ 4,509
Supplies	$ -	$ 6,450	$ 6,450
Communications	$ 27	$ 154	$ 181
Printing & Duplicating	$ 54	$ 352	$ 406
Food	$ -	$ 340	$ 340
Laboratory Fees & Services			$ -
Natural Materials Analytical Research Lab	$ -	$ 5,941	$ 5,941
Analytical Research Lab	$ -	$ 53,560	$ 53,560
Graphics Service	$ -	$ 1,648	$ 1,648
IES Lab	$ -	$ 1,854	$ 1,854
Facilities & Administration	$ 10,067	$ 113,747	$ 123,814
Federal Lab – PNNL		$ 75,000	$ 75,000
In-Kind			
Great River Energy	$ -	$ 30,000	$ 30,000
Southern Company	$ -	$ 10,000	$ 10,000
Basin Electric	$ -	$ 10,000	$ 10,000
Total Project Costs	**$ 30,000**	**$ 480,000**	**$ 510,000**

MATCHING FUNDS

Cost share of $480,000 will be provided for this project by the U.S. DOE National Energy Technology Laboratory, UND, and industry sponsors as shown below. The EERC fully executed an agreement with DOE effective November 16, 2017, through May 15, 2019. In-kind agreements have also been fully executed with Basin Electric Power Cooperative and Great River Energy, and EERC is in contract negotiations with Southern Company Services. Matching fund documentation is included in Appendix D.

Sponsor	Matching Funds	Comments
U.S DOE – Cash	$400,000	DOE will provide $75,000 directly to PNNL.*
UND – Cash	$10,000	–
Southern Company Services – Cash and In-Kind	$30,000	$20,000 in cash and $10,000 of in-kind in the form of consultation on ash handling, waste disposal, and economic analysis and samples of coal combustion by-products.
Basin Electric Power Cooperative – In-Kind	$10,000	In-kind in the form of sampling, ash analyses, and participation in review meetings.
Great River Energy – In-Kind	$30,000	In-kind in the form of project support and coal supply.
Total Matching Funds	**$480,000**	

* The DOE agreement provided in Appendix D indicates that DOE will provide $75,000 of its $400,000 contribution to PNNL. It is likely that the EERC will not have access to information on PNNL's actual expenditures for purposes of the quarterly reports.

TAX LIABILITY

The EERC is a special research center within UND, which is a state-controlled institution of higher education and is not a taxable entity; therefore, the EERC has no tax liability.

CONFIDENTIAL INFORMATION

The confidential material for this proposal is included in Appendix C. Because the details of the approach to be taken in this study are unique and potentially patentable, they are listed in a separate section as provided for by the application instructions.

APPENDIX A

RESUMES OF KEY PERSONNEL

DR. BRUCE C. FOLKEDAHL
Senior Engineer, Renewables
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5243, Fax: (701) 777-5181, E-Mail: bfolkedahl@undeerc.org

Principal Areas of Expertise

Dr. Folkedahl's principal areas of interest and expertise include biomass conversion to energy; biomass to fuels and chemicals; development of methodologies to mitigate the effects of inorganic components on the performance of combustion, gasification, and air pollution control systems; and fuel inorganic transformations and deposition and development of predictive models to assess these processes. He is also interested in the study and development of high-temperature materials for aggressive environments.

Qualifications

Ph.D., Materials Science and Engineering, Pennsylvania State University, 1997.
B.S., Computer Science, University of North Dakota, 1990.

Professional Experience

2001–Present: Senior Engineer, Renewables, EERC, UND. Dr. Folkedahl's responsibilities include studies of biomass combustion and gasification in conjunction with conventional combustion for electricity generation; research on the fundamental mechanisms of ash deposition and fouling during cofiring of biomass fuels with coal; process development for the conversion of biomass feedstocks to fuels, chemicals, and value-added products; and studies of corrosion and development of high-temperature materials to withstand aggressive combustion environments.

2000–2001: Product Manager, 3M Industrial Mineral Products Division, Little Rock, Arkansas. Dr. Folkedahl's responsibilities included managing a crushing and screening business unit 24-hr/day, 7-day/week manufacturing operation, including hiring, training, and directing 40 employees; managing a $12,000,000 annual budget; forecasting budgets; developing and implementing cost reduction plans; and developing automated labor-reducing equipment and routines.

1999–2000: Senior Product Engineer, 3M Industrial Mineral Products Division, St. Paul, Minnesota. Dr. Folkedahl's responsibilities included developing ceramer-coated roofing granules, developing automated dry powder-handling system for slurry-making process, investigating the mechanism of fluorine alkalinity reduction and coating enhancement in roofing granules, and investigating mechanisms of rust formation in mild steel storage tanks for roofing granules.

1994–1998: Graduate Assistant, Pennsylvania State University, University Park, Pennsylvania. Dr. Folkedahl's responsibilities included proctoring and grading exams and teaching lab classes. Thesis work consisted of development of a neural network model of inorganic ash viscosity in high-temperature systems; development of an image analysis program to identify graphitizability of cokes; and statistical cluster analysis of the chemical composition of ash deposits in electrical generation boilers.

1989–1999: Research Scientist, EERC, UND. Dr. Folkedahl's projects and responsibilities included corrosion studies of high-temperature alloys, modeling of slag and silicate material viscosities, and crystallization studies of coal. Other responsibilities included design, development, and maintenance of

analytical software; development and implementation of new analysis techniques; and operation and performance analysis with x-ray diffraction, x-ray fluorescence, scanning electron microscopy, and processing and manipulation of raw data.

Publications and Presentations

Dr. Folkedahl has authored or coauthored numerous professional publications.

DR. R. SHANE ADDLEMAN
Senior Staff Scientist, Principal Investigator, and Program Manager
Pacific Northwest National Laboratory (PNNL), U.S. Department Energy (DOE)
902 Battelle Boulevard, PO Box 999, Richland, Washington 99352
509.375.6824 (phone), shane.addleman@pnnl.gov

Education and Training
Ph.D. Analytical Physical Chemistry, University of Idaho, 1999
M.S. Chemistry, Washington State University, 1996
B.S. Physics, B.S. Chemistry, and B.S. General Studies, Eastern Oregon State College, 1990

Research and Professional Experience
2001–Present: Senior Staff Scientist, Principal Investigator, and Program Manager, PNNL. Dr. Addleman's work at PNNL presently involves leading or contributing to ~$1.5M/yr in research and development (R&D). Programmatic support is from DOE, the U.S. Department of Defense (DoD), the National Institutes of Health (NIH), other government agencies and a number of commercial interests. Current work involves the development of advanced materials and methods for enhanced chemical and nuclear detection, novel separation (inorganic and organic) and critical material recovery (e.g., rare earths from industrial waste) applications. Additional research efforts have involved supercritical fluid extractions, polymer modifications, magnetic separations, optical spectroscopy, and inorganic chemistry (nuclear and catalytic). To date, Dr. Addleman has published over 60 peer-reviewed manuscripts and a number of book chapters. He has six patents granted, six patents pending, and four patents in preparation. He has won two R&D100 awards and a Popular Science Best 100 Technologies for innovative technologies. He has been awarded two Federal Laboratory Technology Awards for successful development and technology commercialization. He speaks nationally and internationally as invited and necessary.

1999–2001: Postdoctoral Research Fellow, PNNL. Dr. Addleman's work involved development and application of a novel spectrometer for the study of complexed metals in supercritical fluid systems.

1998–2001: Consultant. Dr. Addleman consulted on industrial instrumentation, chemical process modeling, and environmental remediation.

1990–1995: Scientist, Special Studies Group, Westinghouse. Dr. Addleman explored separation and purification methods for f-block elements and developed instruments to enable nuclear and chemical in situ measurements systems for process and environmental monitoring.

In addition to the above experience, Dr Addleman has teaching and instructor experience, serving as Adjunct Faculty at the University of Idaho and Visiting Faculty at the University of Oregon. He has hosted over 30 student interns (most continued on successfully in graduate school or a postgraduate position) and seven postdoctoral researchers who have gone on to positions in industry, academia, and at PNNL.

Synergistic Activities
- PNNL Outstanding Performance Awards (2003–2011, 2013)
- 2011 Federal Laboratory Consortium Award for successful technology transfer of IncubATR
- 2010 PNNL R&D 100 Award for IncubATR, a the Live-Cell Monitoring Technology
- 2009 Popular Science Best 100 Technologies Award
- 2008 R&D 100 Award for Functionalized Nanoporous Thin Films

DR. DANIEL A. LAUDAL
Manager: Major Projects
Institute for Energy Studies (IES), University of North Dakota (UND)
Collaborative Energy Complex Room 246
2844 Campus Road, Stop 8153, Grand Forks, North Dakota 58202-8153
Phone: 701.777.3456, E-Mail: daniel.laudal@engr.UND.edu

Education and Training
Ph.D., Chemical Engineering, University of North Dakota, 2017
B.S., Chemical Engineering, University of North Dakota, 2006

Research and Professional Experience
2018-Present: Graduate Faculty, IES, UND. Dr. Laudal advises graduate students for completion of M.S. and Ph.D. programs.

2016–Present: Manager, Major Projects, IES, UND. Dr. Laudal develops and writes major funding proposals, manages major research projects, coordinates IES research staff and students, and performs process design/development of innovative solutions to challenges in the energy industry. Primary research areas include recovery of REEs from coal and coal by-products, chemical-looping combustion (CLC), postcombustion CO_2 capture, novel gas/solid contacting reactor designs, and development of novel designs for the aging fleet of North Dakota University System steam generation plants.

2012–2015: Research Engineer, IES, UND. Dr. Laudal's research focused on CO_2 capture, advanced fuel conversion systems, and natural gas processing. Work included concept development, process design, and testing of innovative solid sorbent-based technologies. Dr. Laudal served as a PI on multiple projects and a key contributor on several successful research proposals. He was lead research engineer on multiple projects relating to CLC technology, developing concepts for innovative methods to characterize both the physical attrition and reactivity of oxygen carriers for CLC. He was a codeveloper of a unique technology for segregation of oxygen carriers and fuel combustion products (ash, unburned char) in CLC, a significant challenge in advancing the technology, developing new oxygen carrier compositions and optimizing process conditions to maximize fuel conversion and increase carrier durability. Dr. Laudal was lead research engineer in developing UND's CACHYS™ technology for postcombustion CO_2 capture. He led the design, construction, and testing of the small pilot-scale slipstream test system installed at the UND steam plant. He was coinventor and lead developer of a novel sorbent-based technology for capture and processing of associated natural gas for reduction of gas flaring from oil fields.

2008–2012: Research Engineer, Energy & Environmental Research Center (EERC), UND. Dr. Laudal's research involved design and operation of lab- and pilot-scale gasification, combustion, and advanced power systems. He was lead researcher on a project aimed at developing a process for the production of hydrogen by catalytic hydrolysis of biomass. He gained invaluable experience with high-pressure/high-temperature systems and fluidized beds.

2006–2008: Field Engineer, Schlumberger Oilfield Services. Dr. Laudal designed, executed, and evaluated well cementing operations in the Williston Basin. He led a team of three to five operators in performing various types of cement and workover operations and was lead cement lab operator, designing, testing, and validating cement compositions for each job.

Selected Publications
Laudal, D.; Benson, S.; Addleman, R.; Palo, D. Leaching behavior of rare earth elements in Fort Union lignite coals of North America. *International Journal of Coal Geology*. In press, 2018. DOI: 10.1016/j.coal.2018.03.010.

Laudal, D.; Benson, S.; Addleman, R.; Palo, D. Recovery of Rare Earth Elements from North Dakota Lignite Coal and Related Feedstocks. *ASME Journal of Energy Resources & Technology*. In press, 2018. DOI: 10.1115/1.4039738.

Van der Watt, J.; Laudal, D. Development of a spouted bed reactor for chemical looping combustion. Conference Proceedings: 2017 Clearwater Clean Energy Conference, Clearwater, FL, June 2017.

Feilen, H.; Laudal, D. Development of an Advanced Oxygen Carrier Attrition Characterization Methodology for Chemical Looping Combustion. In *Conference Proceedings* 2017 Clearwater Clean Energy Conference, Clearwater, FL, June 2017.

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* **2016**, *113*, 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* **2015**, *27* (2), 1100–1108.

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* **2013**, Aug.

Synergistic Activities

- 10 years of experience managing and executing large multidisciplinary and multiorganizational research projects.
- Serves as PI on multiple projects and a key contributor on several successful research proposals.
- Primary research areas include recovery of REEs from coal and coal by-products.
- Currently PI on UND's DOE-funded project DE-FE0027006 evaluating a novel REE recovery method for North Dakota lignite coal.
- Proposal reviewer, University Coalition for Fossil Energy Research.

APPENDIX B

REFERENCES

REFERENCES

[1] U.S. Department of Energy. *Critical Materials Strategy*; U.S. Department of Energy, 2017.

[2] U.S. Department of Energy National Energy Technology Laboratory. Rare Earth Elements from Coal and Coal By-Products. www.netl.doe.gov/research/coal/rare-earth-elements (accessed 2017).

[3] U.S. Department of the Interior U.S. Geological Survey. Mineral Commodity Summaries 2017. USGS, 2017.

[4] Bao, Z.; Zhao, Z. Geochemistry of Mineralization with Exchangeable REY in the Weathering Crusts of Granitic Rocks in South China. *Ore Geology Reviews* **2008**, *33*, 519–535.

[5] Chi, R.; Tian, J. *Weathered Crust Elution-Deposited Rare Earth Ores*; Nova Science Publishers: New York, 2008.

[6] Chegwidden, J.; Kingsnorth, D.J. Rare Earths – An Evaluation of Current and Future Supply. www.tremcenter.org/index/php?option=com_attachements&task=download&id=412011 (accessed 2017), 2011.

[7] Ackman, T.; Ekmann, J.; Kirchner, C.; Lopert, E.; Pierre, J. Rare Earth Elements in Coal – The Case for Research and Development into Co-Production with Coal. Leonardo Technologies, Inc., 2012.

[8] Seredin, V.V.; Dai, S. Coal Deposits as Potential Alternative Sources for Lanthanides and Yttrium. *International Journal of Coal Geology* **2012**, *94*, 67–93.

[9] Joshi, P. A Low-Cost Rare Earth Elments Recovery Technology. Presented at World of Coal Ash Conference, Lexington, KY, 2013.

[10] Fan, M.; Tian, H.; Radosz, M.; Williams, E.; Gaustad, G.; Adidharma, H. A Pollution-Prevention and Economically-Viable Technology for Separation of Rare Earth Elements from Powder River Basin Coal Ashes. Presented at 2016 NETL Crosscutting Technology Research Review Meeting, Pittsburgh, PA, 2016.

[11] Murphy, E. Mineral resources of North Dakota—coal: North Dakota Geological Survey, www.dmr.nd.gov/ndgs/mineral/nd_coalnew.asp (accessed 2017).

APPENDIX D

MATCHING FUND DOCUMENTATION

DOE COOPERATIVE AGREEMENT DE-FE0031490

ASSISTANCE AGREEMENT

1. Award No.	2. Modification No.	3. Effective Date	4. CFDA No.
DE-FE0031490		11/16/2017	81.089

5. Awarded To	6. Sponsoring Office	7. Period of Performance
University Of North Dakota Attn: BARRY MILAVETZ 264 Centennial Dr Stop 7306 Grand Forks ND 58202	Office of Fossil Energy	11/16/2017 through 05/15/2019

8. Type of Agreement	9. Authority	10. Purchase Request or Funding Document No.
☐ Grant ☒ Cooperative Agreement ☐ Other	PL 95-91 DOE Organization Act as amended by PL 109-58 Energy Policy Act 2005	18FE005845

11. Remittance Address	12. Total Amount	13. Funds Obligated
University Of North Dakota Attn: UNIVERSITY OF NORTH DAKOTA TWAMLEY HALL CENTENNIAL DRIVE PO BOX 8356 GRAND FORKS ND 582028356	Govt. Share: $325,000.00 Cost Share : $108,812.00 Total : $433,812.00	This action: $325,000.00 Total : $325,000.00

14. Principal Investigator	15. Program Manager	16. Administrator
Bruce Folkedahl 701-777-5423 bfolkedahl@undeerc.org	Anthony N. Zinn Phone: 304-285-5424	U.S. DOE/NETL NATIONAL ENERGY TECH LAB 3610 Collins Ferry Road PO Box 880 Morgantown WV 26507-0880

17. Submit Payment Requests To	18. Paying Office	19. Submit Reports To
Payment - Direct Payment from U.S. Dept of Treasury	Payment - Direct Payment from U.S. Dept of Treasury	See Reporting Requirement Checklist

20. Accounting and Appropriation Data

21. Research Title and/or Description of Project

ECONOMIC EXTRACTION AND RECOVERY OF REES AND PRODUCTION OF CLEAN VALUE-ADDED PRODUCTS FROM LOW-RANK COAL FLY ASH

For the Recipient		For the United States of America	
22. Signature of Person Authorized to Sign		25. Signature of Grants/Agreements Officer Signature on File	
23. Name and Title	24. Date Signed	26. Name of Officer Angela M. Harshman	27. Date Signed 11/14/2017

NAME OF OFFEROR OR CONTRACTOR
University Of North Dakota

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	DUNS Number: 102280781 ---------- Project Period: 11/16/2017 thru 05/15/2019 Budget Period: 11/16/2017 thru 05/15/2019 DOE Award Administrator: Harolynne Blackwell Phone: 412-386-4829 Email: Harolynne.blackwell@netl.doe.gov Recipient Business Point of Contact: Name: Sheryl A. Eicholtz-Landis Phone: 701-777-5124 Email: slandis@undeerc.org ---------- ASAP: YES Extent Competed: COMPETED Davis-Bacon Act: NO PI: Bruce Folkedahl Fund: 00150 Appr Year: 2017 Allottee: 31 Report Entity: 232424 Object Class: 25500 Program: 1611081 Project: 0000000 WFO: 0000000 Local Use: 0000000				

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SPECIAL TERMS AND CONDITIONS

LEGAL AUTHORITY AND EFFECT (JUNE 2015)

(a) A DOE financial assistance award is valid only if it is in writing and is signed, either in writing or electronically, by a DOE Contracting Officer.
(b) Recipients are free to accept or reject the award. A request to draw down DOE funds constitutes the Recipient's acceptance of the terms and conditions of this Award.

RESOLUTION OF CONFLICTING CONDITIONS

Any apparent inconsistency between Federal statutes and regulations and the terms and conditions contained in this award must be referred to the DOE Award Administrator for guidance.

AWARD AGREEMENT TERMS AND CONDITIONS (DECEMBER 2014)

This award/agreement consists of the Assistance Agreement cover page, plus the following:
a. Special terms and conditions.
b. Attachments:

Attachment No.	Title
1	Intellectual Property Provisions
2	Statement of Project Objectives
3	Federal Assistance Reporting Checklist
4	Budget Pages
5	Data Management Plan

c. Applicable program regulations -None- at http://www.eCFR.gov.
d. DOE Assistance Regulations, 2 CFR part 200 as amended by 2 CFR part 910 at http://www.eCFR.gov.
e. Federal-Wide Research Terms and Conditions and the DOE Agency Specific Requirements at http://www.nsf.gov/bfa/dias/policy/rtc/index.jsp (if the Award is for research and the Award is to a university or non-profit).
f. Application/proposal as approved by DOE.
g. National Policy Assurances to Be Incorporated as Award Terms in effect on date of award at http: http://www.nsf.gov/awards/managing/rtc.jsp.

CONFERENCE SPENDING (FEBRUARY 2015)

The recipient shall not expend any funds on a conference not directly and programmatically related to the purpose for which the grant or cooperative agreement was awarded that would defray the cost to the United States Government of a conference held by any Executive branch department, agency, board, commission, or office for which the cost to the United States Government would otherwise exceed $20,000, thereby circumventing the required notification by the head of any such Executive Branch department, agency, board, commission, or office to the Inspector General (or senior ethics official for any entity without an Inspector General), of the date, location, and number of employees attending such conference.

PAYMENT PROCEDURES - REIMBURSEMENT THROUGH THE AUTOMATED STANDARD APPLICATION FOR PAYMENTS (ASAP) SYSTEM

a. Method of Payment. Payment will be made by reimbursement through the Department of Treasury's ASAP system.

b. Requesting Reimbursement. Requests for reimbursements must be made through the ASAP system. Your requests for reimbursement should coincide with your normal billing pattern, but not more frequently than every two weeks. Each request must be limited to the amount of disbursements made for the federal share of direct project costs and the proportionate share of allowable indirect costs incurred during that billing period.

c. Adjusting payment requests for available cash. You must disburse any funds that are available from repayments to and interest earned on a revolving fund, program income, rebates, refunds, contract settlements, audit recoveries, credits, discounts, and interest earned on any of those funds before requesting additional cash payments from DOE/NNSA.

d. Payments. All payments are made by electronic funds transfer to the bank account identified on the ASAP Bank Information Form that you filed with the U.S. Department of Treasury.

COST SHARING FFRDC'S PARTICIPATE

a. Total Estimated Project Cost is the sum of the Government share, including Federally Funded Research and Development Corporation (FFRDC) contractor costs, and Recipient share of the estimated project costs. The DOE/NNSA FFRDC contractor cost is not included in the total approved budget for this award, because DOE/NNSA will pay the DOE/NNSA FFRDC contractor portion of the effort under an existing DOE/NNSA contract. Recipient is not responsible for reporting on that portion of the total estimated cost that is paid directly to the DOE/NNSA FFRDC contractor.

The Recipient's cost share must come from non-Federal sources unless otherwise allowed by law. By accepting federal funds under this award, you agree that you are liable for your percentage share of allowable project costs, on a budget period basis, even if the project is terminated early or is not funded to its completion. This cost is shared as follows:

Budget Period No.	Budget Period Start	Government Share $/%	FFRDC Share $/%	Recipient Share $/%	Total Estimated Cost
1	11/16/2017	$325,000 (63.88%)	$75,000 (14.74%)	$108,812 (21.38%)	$508,812
TOTAL		**$325,000 (63.88%)**	**$75,000 (14.74%)**	**$108,812 (21.38%)**	**$508,812**

b. If you discover that you may be unable to provide cost sharing of at least the amount identified in paragraph a of this term, you should immediately provide written notification to the DOE Award Administrator indicating whether you will continue or phase out the project. If you plan to continue the project, the notification must describe how replacement cost sharing will be secured.

c. You must maintain records of all project costs that you claim as cost sharing, including in-kind costs, as well as records of costs to be paid by DOE/NNSA. Such records are subject to audit.

d. Failure to provide the cost sharing required by this term may result in the subsequent recovery by DOE/NNSA of some or all the funds provided under the award.

REBUDGETING AND RECOVERY OF INDIRECT COSTS - REIMBURSABLE INDIRECT COSTS AND FRINGE BENEFITS

a. If actual allowable indirect costs are less than those budgeted and funded under the award, you may use the difference to pay additional allowable direct costs during the project period. If at the completion of the award the Government's share of total allowable costs (i.e., direct and indirect), is less than the total costs reimbursed, you must refund the difference.

b. Recipients are expected to manage their indirect costs. DOE will not amend an award solely to provide additional funds for changes in indirect cost rates. DOE recognizes that the inability to obtain full reimbursement for indirect costs means the recipient must absorb the underrecovery. Such underrecovery may be allocated as part of the organization's required cost sharing.

USE OF PROGRAM INCOME - COST SHARING

If you earn program income during the project period as a result of this award, you may use the program income to meet your cost sharing requirement.

STATEMENT OF FEDERAL STEWARDSHIP

DOE/NNSA will exercise normal Federal stewardship in overseeing the project activities performed under this award. Stewardship activities include, but are not limited to, conducting site visits; reviewing performance and financial reports; providing technical assistance and/or temporary intervention in unusual circumstances to correct deficiencies which develop during the project; assuring compliance with terms and conditions; and reviewing technical performance after project completion to ensure that the award objectives have been accomplished.

STATEMENT OF SUBSTANTIAL INVOLVEMENT

There will be substantial involvement between the DOE and the Recipient during performance of this Cooperative Agreement. The DOE and Recipient will collaborate and share responsibility for the management of the project. The Statement of Substantial Involvement may include, but not limited to, the following:

Recipient's Responsibilities. The Recipient is responsible for:

Performing the activities supported by this award in accordance with the Project Management Plan (PMP), including providing the required personnel, facilities, equipment, supplies and services;

Managing and controlling project activities in accordance with established processes and procedures to ensure tasks and subtasks are completed within schedule and budget constraints defined by the current Project Management Plan (PMP);

Implementing an approach to identify, analyze, and respond to project risks that is commensurate with the complexity of the project;

Defining and revising approaches and plans, submitting the plans to DOE for review, and consider incorporating DOE comments;

Coordinating related project activities with external suppliers, including subcontractors, to ensure effective integration of all work elements;

Attending annual project review meetings and reporting project status;

Submitting technical reports and publically releasable documents that adequately address DOE comments; and

Presenting the project results at appropriate technical conferences or meetings as coordinated with the DOE Project Officer (number of external, non-DOE conferences/meetings will not exceed two (2) per budget period).

DOE Responsibilities. DOE is responsible for:

Reviewing in a timely manner project plans, including project management, testing and technology transfer plans, and recommending alternate approaches, if the plans do not address critical programmatic issues;

Participating in project management planning activities, including risk analysis, to ensure DOE's program requirements or limitations are considered in performance of the work elements;

Conducting annual project review meetings to ensure adequate progress and that the work accomplishes the program and project objectives. Recommending alternate approaches or shifting work emphasis, if needed;

Promoting and facilitating technology transfer activities, including disseminating program results through presentations and publications;

Serving as scientific/technical liaison between awardees and other program or industry staff;

Integrating and directing the work effort to ensure that project results address critical system and programmatic goals established by the DOE Office of Fossil Energy, in coordination with the DOE REE Program;

DOE has the right to intervene in the conduct or performance of project activities for programmatic reasons. Intervention includes the interruption or modification of the conduct or performance of project activities. Suspension or termination of the cooperative agreement under 2 CFR Parts 200 and 910 (DOE Financial Assistance Regulations) does not constitute intervention in the conduct or performance of project activities.

SITE VISITS

DOE/NNSA's authorized representatives have the right to make site visits at reasonable times to review project accomplishments and management control systems and to provide technical assistance, if required. You must provide, and must require your subrecipients to provide, reasonable access to facilities, office space, resources, and assistance for the safety and convenience of the government representatives in the performance of their duties. All site visits and evaluations must be performed in a manner that does not unduly interfere with or delay the work.

REPORTING REQUIREMENTS

a. Requirements. The reporting requirements for this award are identified on the Federal Assistance Reporting Checklist, DOE F 4600.2, attached to this award. Failure to comply with these reporting requirements is considered a material noncompliance with the terms of the award. Noncompliance may result in withholding of future payments, suspension, or termination of the current award, and withholding of future awards. A willful failure to perform, a history of failure to perform, or unsatisfactory performance of this and/or other financial assistance awards, may also result in a debarment action to preclude future awards by Federal agencies.

b. Dissemination of scientific/technical reports. Scientific/technical reports submitted under this award will be disseminated on the Internet via the DOE Information Bridge (www.osti.gov/bridge), unless the report contains patentable material, protected data, or SBIR/STTR data. Citations for journal articles produced under the award will appear on the DOE Energy Citations Database (www.osti.gov/energycitations).

c. Restrictions. Reports submitted to the DOE Information Bridge must not contain any Protected Personal Identifiable Information (PII), limited rights data (proprietary data), classified information, information subject to export control classification, or other information not subject to release.

PUBLICATIONS

a. You are encouraged to publish or otherwise make publicly available the results of the work conducted under the award.

b. An acknowledgment of Federal support and a disclaimer must appear in the publication of any material, whether copyrighted or not, based on or developed under this project, as follows:

Acknowledgment: "This material is based upon work supported by the Department of Energy National Energy Technology Laboratory under Award Number(s) **DE-FE0031490**."

Disclaimer: "This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."

FEDERAL, STATE, AND MUNICIPAL REQUIREMENTS

You must obtain any required permits and comply with applicable federal, state, and municipal laws, codes, and regulations for work performed under this award.

NATIONAL SECURITY: CLASSIFIABLE RESULTS ORIGINATING UNDER AN AWARD (DECEMBER 2014)

This award is intended for unclassified, publicly releasable research. You will not be granted access to classified information. DOE/NNSA does not expect that the results of the research project will involve classified information. Under certain circumstances, however, a classification review of information originated under the award may be required. The Department may review research work generated under this award at any time to determine if it requires classification.

b. Executive Order 12958 (60 Fed. Reg. 19,825 (1995)) states that basic scientific research information not clearly related to the national security shall not be classified. Nevertheless, some information concerning (among other things) scientific, technological, or economic matters relating to national security or cryptology may require classification. If you originate information during the course of this award that you believe requires classification, you must promptly:

1. Notify the DOE Project Officer and the DOE Award Administrator;

2. Submit the information by registered mail directly to the Director, Office of Classification and Information Control, SO-10.2; U.S. Department of Energy; P.O. Box A; Germantown, MD 20875-0963, for classification review.

3. Restrict access to the information to the maximum extent possible until you are informed that the information is not classified, but no longer than 30 days after receipt by the Director, Office of Classification and Information Control.

c. If you originate information concerning the production or utilization of special nuclear material (i.e., plutonium, uranium enriched in the isotope 233 or 235, and any other material so determined under section 51 of the Atomic Energy Act) or nuclear energy, you must:

1. Notify the DOE Project Officer and the DOE Award Administrator;

2. Submit the information by registered mail directly to the Director, Office of Classification and Information Control, SO-10.2; U.S. Department of Energy; P. O. Box A; Germantown, MD 20875-0963 for classification review within 180 days of the date the recipient first discovers or first has reason to believe that the information is useful in such production or utilization; and

3. Restrict access to the information to the maximum extent possible until you are informed that the information is not classified, but no longer than 90 days after receipt by the Director, Office of Classification and Information Control.

d. If DOE determines any of the information requires classification, you agree that the Government may terminate the award with consent of the recipient in accordance with 2 CFR part 200.339(a)(3). All material deemed to be classified must be forwarded to the DOE, in a manner specified by DOE.

e. If DOE does not respond within the specified time periods, you are under no further obligation to restrict access to the information.

NOTICE REGARDING THE PURCHASE OF AMERICAN-MADE EQUIPMENT AND PRODUCTS -- SENSE OF CONGRESS

It is the sense of the Congress that, to the greatest extent practicable, all equipment and products purchased with funds made available under this award should be American-made.

INSURANCE COVERAGE (DECEMBER 2014)

See 2 CFR 200.310 for insurance requirements for real property and equipment acquired or improved with Federal funds.

SUPPLIES (DECEMBER 2014)

See 2 CFR Part 200.314 for requirements pertaining to supplies acquired under a Federal award.
See also § 200.453 Materials and supplies costs, including costs of computing devices.

EQUIPMENT (DECEMBER 2014)

Subject to the conditions provided in 2 CFR Part 200.313, title to equipment (property) acquired under a Federal award will vest conditionally with the non-Federal entity.

The non-Federal entity cannot encumber this property and must follow the requirements of 2 CFR Part 200.313 before disposing of the property.

States must use equipment acquired under a Federal award by the state in accordance with state laws and procedures.

Equipment must be used by the non-Federal entity in the program or project for which it was acquired as long as it is needed, whether or not the project or program continues to be supported by the Federal award. When no longer needed for the originally authorized purpose, the equipment may be used by programs supported by the Federal awarding agency in the priority order specified in 2 CFR Part 200.313(c)(1)(i) and (ii).

Management requirements, including inventory and control systems, for equipment are provided in 2 CFR Part 200.313(d).

When equipment acquired under a Federal award is no longer needed, the non-Federal entity must obtain disposition instructions from the Federal awarding agency or pass-through entity.

Disposition will be made as follows: (a) items of equipment with a current fair market value of $5,000 or less may be retained, sold, or otherwise disposed of with no further obligation to the Federal awarding agency; (b) Non-Federal entity may retain title or sell the equipment after compensating the Federal awarding agency as described in 2 CFR Part 200.313(e)(2); or (c) transfer title to the Federal awarding agency or to an eligible third Party as specified in CFR Part 200.313(e)(3).

See 2 CFR Part 200.313 for additional requirements pertaining to equipment acquired under a Federal award. Also see 2 CFR Part 200.439 Equipment and other capital expenditures.

See 2 CFR Part 910.360 for amended requirements for Equipment for For-Profit recipients.

PERFORMANCE OF WORK IN UNITED STATES

The Recipient agrees that at least 75% of the direct labor cost for the project (including subrecipient labor) shall be incurred in the United States, unless the Recipient can demonstrate to the satisfaction of the Department of Energy that the United States economic interest will be better served through a greater percentage of the work being performed outside the United States.

REPORTING SUBAWARDS AND EXECUTIVE COMPENSATION

a. Reporting of first-tier subawards.

1. Applicability. Unless you are exempt as provided in paragraph d. of this award term, you must report each action that obligates $25,000 or more in Federal funds that does not include Recovery funds (as defined in section 1512(a)(2) of the American Recovery and Reinvestment Act of 2009, Pub. L. 111-5) for a subaward to an entity (see definitions in paragraph e. of this award term).

2. Where and when to report.
i. You must report each obligating action described in paragraph a.1. of this award term to http://www.fsrs.gov.
ii. For subaward information, report no later than the end of the month following the month in which the obligation was made. (For example, if the obligation was made on November 7, 2010, the obligation must be reported by no later than December 31, 2010.)

3. What to report. You must report the information about each obligating action that the submission instructions posted at http://www.fsrs.gov specify.

b. Reporting Total Compensation of Recipient Executives.

1. Applicability and what to report. You must report total compensation for each of your five most highly compensated executives for the preceding completed fiscal year, if

i. the total Federal funding authorized to date under this award is $25,000 or more;
ii. in the preceding fiscal year, you received;
(A) 80 percent or more of your annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and
(B) $25,000,000 or more in annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and
iii. The public does not have access to information about the compensation of the executives through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986. (To determine if the public has access to the compensation information, see the U.S. Security and Exchange Commission total compensation filings at http://www.sec.gov/answers/execomp.htm.)

2. Where and when to report. You must report executive total compensation described in paragraph b.1. of this award term:
i. As part of your registration profile at http://www.sam.gov.
ii. By the end of the month following the month in which this award is made, and annually thereafter.

c. Reporting of Total Compensation of Subrecipient Executives.

1. Applicability and what to report. Unless you are exempt as provided in paragraph d. of this award term, for each first-tier subrecipient under this award, you shall report the names and total compensation of each of the subrecipient's five most highly compensated executives for the subrecipient's preceding completed fiscal year, if;
i. in the subrecipient's preceding fiscal year, the subrecipient received;
(A) 80 percent or more of its annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and
(B) $25,000,000 or more in annual gross revenues from Federal procurement contracts (and subcontracts), and Federal financial assistance subject to the Transparency Act (and subawards); and
ii. The public does not have access to information about the compensation of the executives through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986. (To determine if the public has access to the compensation information, see the U.S. Security and Exchange Commission total compensation filings at http://www.sec.gov/answers/execomp.htm.)

2. Where and when to report. You must report subrecipient executive total compensation described in paragraph c.1. of this award term:
i. To the recipient.
ii. By the end of the month following the month during which you make the subaward. For example, if a subaward is obligated on any date during the month of October of a given year (i.e., between October 1 and 31), you must report any required compensation information of the subrecipient by November 30 of that year.

d. Exemptions

If, in the previous tax year, you had gross income, from all sources, under $300,000, you are exempt from the requirements to report:
i. Subawards,
and
ii. The total compensation of the five most highly compensated executives of any subrecipient.

e. Definitions. For purposes of this award term:

1. Entity means all of the following, as defined in 2 CFR part 25:
i. A Governmental organization, which is a State, local government, or Indian tribe;
ii. A foreign public entity;
iii. A domestic or foreign nonprofit organization;
iv. A domestic or foreign for-profit organization;
v. A Federal agency, but only as a subrecipient under an award or subaward to a non-Federal entity.

2. Executive means officers, managing partners, or any other employees in management positions.

3. Subaward:

i. This term means a legal instrument to provide support for the performance of any portion of the substantive project or program for which you received this award and that you as the recipient award to an eligible subrecipient.

ii. The term does not include your procurement of property and services needed to carry out the project or program (for further explanation, see Sec. __ .210 of the attachment to OMB Circular A-133, Audits of States, Local Governments, and Non-Profit Organizations).

iii. A subaward may be provided through any legal agreement, including an agreement that you or a subrecipient considers a contract.

4. Subrecipient means an entity that:

i. Receives a subaward from you (the recipient) under this award; and

ii. Is accountable to you for the use of the Federal funds provided by the subaward.

5. Total compensation means the cash and noncash dollar value earned by the executive during the recipient's or subrecipient's preceding fiscal year and includes the following (for more information see 17 CFR 229.402(c)(2)):

i. Salary and bonus.

ii. Awards of stock, stock options, and stock appreciation rights. Use the dollar amount recognized for financial statement reporting purposes with respect to the fiscal year in accordance with the Statement of Financial Accounting Standards No. 123 (Revised 2004) (FAS 123R), Shared Based Payments.

iii. Earnings for services under non-equity incentive plans. This does not include group life, health, hospitalization or medical reimbursement plans that do not discriminate in favor of executives, and are available generally to all salaried employees.

iv. Change in pension value. This is the change in present value of defined benefit and actuarial pension plans.

v. Above-market earnings on deferred compensation which is not tax-qualified.

vi. Other compensation, if the aggregate value of all such other compensation (e.g. severance, termination payments, value of life insurance paid on behalf of the employee, perquisites or property) for the executive exceeds $10,000.

SYSTEM FOR AWARD MANAGEMENT AND UNIVERSAL IDENTIFIER REQUIREMENTS

A. Requirement for Registration in the System for Award Management (SAM)

Unless you are exempted from this requirement under 2 CFR 25.110, you as the recipient must maintain the currency of your information in SAM until you submit the final financial report required under this award or receive the final payment, whichever is later. This requires that you review and update the information at least annually after the initial registration, and more frequently if required by changes in your information or another award term.

If you had an active registration in the CCR, you have an active registration in SAM.

B. Requirement for Data Universal Numbering System (DUNS) Numbers

If you are authorized to make subawards under this award, you:

1. Must notify potential subrecipients that no entity (see definition in paragraph C of this award term) may receive a subaward from you unless the entity has provided its DUNS number to you.

2. May not make a subaward to an entity unless the entity has provided its DUNS number to you.

C. Definitions

For purposes of this award term:

1. System for Award Management (SAM) means the Federal repository into which an entity must provide information required for the conduct of business as a recipient. Additional information about registration procedures may be found at the SAM Internet site (currently at http://www.sam.gov).

2. Data Universal Numbering System (DUNS) number means the nine-digit number established and assigned by Dun and Bradstreet, Inc. (D&B) to uniquely identify business entities. A DUNS number may be obtained from D&B by telephone (currently

866-705-5711) or the Internet (currently at http://fedgov.dnb.com/webform).

3. Entity, as it is used in this award term, means all of the following, as defined at 2 CFR part 25, subpart C:
a. A Governmental organization, which is a State, local government, or Indian Tribe;
b. A foreign public entity;
c. A domestic or foreign nonprofit organization;
d. A domestic or foreign for-profit organization; and
e. A Federal agency, but only as a subrecipient under an award or subaward to a non-Federal entity.

4. Subaward:
a. This term means a legal instrument to provide support for the performance of any portion of the substantive project or program for which you received this award and that you as the recipient award to an eligible subrecipient.
b. The term does not include your procurement of property and services needed to carry out the project or program (for further explanation, see Sec. __.210 of the attachment to OMB Circular A-133, Audits of States, Local Governments, and Non-Profit Organizations).
c. A subaward may be provided through any legal agreement, including an agreement that you consider a contract.

5. Subrecipient means an entity that:
a. Receives a subaward from you under this award; and
b. Is accountable to you for the use of the Federal funds provided by the subaward.

LOBBYING RESTRICTIONS (MARCH 2012)

By accepting funds under this award, you agree that none of the funds obligated on the award shall be expended, directly or indirectly, to influence congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. 1913. This restriction is in addition to those prescribed elsewhere in statute and regulation.

CORPORATE FELONY CONVICTION AND FEDERAL TAX LIABILITY ASSURANCES (MARCH 2014)

By entering into this agreement, the undersigned attests that University of North Dakota has not been convicted of a felony criminal violation under Federal law in the 24 months preceding the date of signature.

The undersigned further attests that University of North Dakota does not have any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

For purposes of these assurances, the following definitions apply:
A Corporation includes any entity that has filed articles of incorporation in any of the 50 states, the District of Columbia, or the various territories of the United States [but not foreign corporations]. It includes both for-profit and non-profit organizations.

NONDISCLOSURE AND CONFIDENTIALITY AGREEMENTS ASSURANCES (JUNE 2015)

(1) By entering into this agreement, the undersigned attests that University of North Dakota does not and will not require its employees or contractors to sign internal nondisclosure or confidentiality agreements or statements prohibiting or otherwise restricting its employees or contactors from lawfully reporting waste, fraud, or abuse to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information.

(2) The undersigned further attests that University of North Dakota does not and will not use any Federal funds to implement or enforce any nondisclosure and/or confidentiality policy, form, or agreement it uses unless it contains the following provisions:

a. ‘‘These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions,

requirements, obligations, rights, sanctions, and liabilities created by controlling Executive orders and statutory provisions are incorporated into this agreement and are controlling.''

b. The limitation above shall not contravene requirements applicable to Standard Form 312, Form 4414, or any other form issued by a Federal department or agency governing the nondisclosure of classified information.

c. Notwithstanding provision listed in paragraph (a), a nondisclosure or confidentiality policy form or agreement that is to be executed by a person connected with the conduct of an intelligence or intelligence-related activity, other than an employee or officer of the United States Government, may contain provisions appropriate to the particular activity for which such document is to be used. Such form or agreement shall, at a minimum, require that the person will not disclose any classified information received in the course of such activity unless specifically authorized to do so by the United States Government. Such nondisclosure or confidentiality forms shall also make it clear that they do not bar disclosures to Congress, or to an authorized official of an executive agency or the Department of Justice, that are essential to reporting a substantial violation of law.

REPORTING OF MATTERS RELATED TO RECIPIENT INTEGRITY AND PERFORMANCE (DECEMBER 2015)

a. General Reporting Requirement
If the total value of your currently active grants, cooperative agreements, and procurement contracts from all Federal awarding agencies exceeds $10,000,000 for any period of time during the period of performance of this Federal award, then you as the recipient during that period of time must maintain the currency of information reported to the System for Award Management (SAM) that is made available in the designated integrity and performance system (currently the Federal Awardee Performance and Integrity Information System (FAPIIS)) about civil, criminal, or administrative proceedings described in paragraph 2 of this award term and condition. This is a statutory requirement under section 872 of Public Law 110-417, as amended (41 U.S.C. 2313). As required by section 3010 of Public Law 111-212, all information posted in the designated integrity and performance system on or after April 15, 2011, except past performance reviews required for Federal procurement contracts, will be publicly available.

b. Proceedings About Which You Must Report
Submit the information required about each proceeding that:
1. Is in connection with the award or performance of a grant, cooperative agreement, or procurement contract from the Federal Government;
2. Reached its final disposition during the most recent five-year period; and
3. Is one of the following:
(A) A criminal proceeding that resulted in a conviction, as defined in paragraph 5 of this award term and condition;
(B) A civil proceeding that resulted in a finding of fault and liability and payment of a monetary fine, penalty, reimbursement, restitution, or damages of $5,000 or more;
(C) An administrative proceeding, as defined in paragraph 5. of this award term and condition, that resulted in a finding of fault and liability and your payment of either a monetary fine or penalty of $5,000 or more or reimbursement, restitution, or damages in excess of $100,000; or
(D) Any other criminal, civil, or administrative proceeding if:
(i) It could have led to an outcome described in paragraph 2.c.(1), (2), or (3) of this award term and condition;
(ii) It had a different disposition arrived at by consent or compromise with an acknowledgment of fault on your part; and
(iii) The requirement in this award term and condition to disclose information about the proceeding does not conflict with applicable laws and regulations.

c. Reporting Procedures
Enter in the SAM Entity Management area the information that SAM requires about each proceeding described in paragraph 2 of this award term and condition. You do not need to submit the information a second time under assistance awards that you received if you already provided the information through SAM because you were required to do so under Federal procurement contracts that you were awarded.

d. Reporting Frequency
During any period of time when you are subject to the requirement in paragraph 1 of this award term and condition, you must report proceedings information through SAM for the most recent five year period, either to report new information about any proceeding(s) that you have not reported previously or affirm that there is no new information to report. Recipients that have Federal contract, grant, and cooperative agreement awards with a cumulative total value greater than $10,000,000 must disclose semiannually any information

about the criminal, civil, and administrative proceedings.

e. Definitions
For purposes of this award term and condition:
1. Administrative proceeding means a non-judicial process that is adjudicatory in nature in order to make a determination of fault or liability (e.g., Securities and Exchange Commission Administrative proceedings, Civilian Board of Contract Appeals proceedings, and Armed Services Board of Contract Appeals proceedings). This includes proceedings at the Federal and State level but only in connection with performance of a Federal contract or grant. It does not include audits, site visits, corrective plans, or A. Reporting of Matters Related to Recipient Integrity and Performance.
2. Conviction, for purposes of this award term and condition, means a judgment or conviction of a criminal offense by any court of competent jurisdiction, whether entered upon a verdict or a plea, and includes a conviction entered upon a plea of nolo contendere.
3. Total value of currently active grants, cooperative agreements, and procurement contracts includes—
(A) Only the Federal share of the funding under any Federal award with a recipient cost share or match; and
(B) The value of all expected funding increments under a Federal award and options, even if not yet exercised.

CATEGORICAL EXCLUSION (CX)

DOE must comply with the National Environmental Policy Act (NEPA) prior to authorizing the use of federal funds. Based on all information provided by the Recipient, DOE has made a NEPA determination by issuing a CX, thereby authorizing use of funds for the defined project activities. If the Recipient later adds to or modifies the activities reviewed and approved under the original DOE NEPA determination, the Recipient must notify the DOE Contracting Officer before proceeding with the new and/or modified activities. Those additions or modifications may be subject to review by the DOE NEPA Compliance Officer and approval by the DOE Contracting Officer, and may require a new NEPA determination.

SUBAWARD/SUBCONTRACT CHANGE NOTIFICATION

Except for subawards and/or subcontracts specifically proposed as part of the Recipient's Application for award, the Recipient must notify the DOE Contracting Officer and Project Officer in writing 30 days prior to the execution of new or modified subawards/subcontracts. This notification does not constitute a waiver of the prior approval requirements outlined in 2 CFR 200, nor does it relieve the Recipient from its obligation to comply with applicable Federal statutes, regulations, and executive orders.

In order to satisfy this notification requirement, Recipient documentation must, as a minimum, include the following:

1. A description of the research to be performed, the service to be provided, or the equipment to be purchased;
2. Cost share commitment letter if the subawardee is providing cost share to the award;
3. An assurance that the process undertaken by the Recipient to solicit the subaward/subcontract complies with their written procurement procedures as outlined in 2 CFR 200.318.
4. An assurance that no planned, actual or apparent conflict of interest exists between the Recipient and the selected subawardee/subcontractor and that the Recipient's written standards of conduct were followed;[1]
5. A completed Environmental Questionnaire, if applicable;
6. An assurance that the subawardee/subcontractor is not a debarred or suspended entity; and
7. An assurance that all required award provisions will be flowed down in the resulting subaward/subcontract.

The Recipient is responsible for making a final determination to award or modify subawards/subcontracts under this agreement, but the Recipient may not proceed with the subaward/subcontract until the Contracting Officer determines, and provides the Recipient written notification, that the information provided is adequate.

Should the Recipient not receive a written notification of adequacy from the Contracting Officer within 30 days of the submission of the subaward/subcontract documentation stipulated above, Recipient may proceed to award or modify the proposed subaward/subcontract.

[1] It is DOE's position that the existence of a "covered relationship" as defined in 5 C.F.R. § 2635.502(a)&(b) between a member of a Recipient's owners or senior management and a member of a subawardee's/subcontractor's owners or senior management creates at a minimum an apparent conflict of interest that would require the Recipient to notify the Contracting Officer and provide detailed information and justification (including, for example, mitigation measures) as to why the subaward or subcontract does not create an actual conflict of interest. Recipients must also notify the Contracting Officer of any new subcontract or subaward to: (1) an entity

that is owned or otherwise controlled by the Recipient; or (2) an entity that is owned or otherwise controlled by another entity that also owns or otherwise controls the Recipient, as it is DOE's position that these situations also create at a minimum an apparent conflict of interest.

FOREIGN NATIONAL ACCESS UNDER DOE ORDER 142.3A, "UNCLASSIFIED FOREIGN VISITS AND ASSIGNMENTS PROGRAM"

Pursuant to DOE Order 142.3A, the Recipient, including its subrecipients and subcontractors, may be required to provide information to the Department of Energy (DOE) in order to satisfy requirements for foreign nationals' access to DOE sites, information, technologies, equipment, programs, and personnel. A "foreign national" is any person who was born outside the jurisdiction of the United States, is a citizen of a foreign government, and has not been naturalized under U.S. law.

If the Recipient (including its subrecipients and subcontractors) anticipates involving foreign nationals in the performance of its award, the Recipient may be required to provide DOE with specific information about each foreign national to ensure compliance with the requirements of DOE Order 142.3A for access approval. Recipients that are institutions of higher education (and subrecipients and subcontractors that are institutions of higher education) are exempt from obtaining DOE approval for foreign nationals' access to DOE information provided that: (1) the foreign national is an employee, student, or other individual with a direct affiliation with the institution of higher education; (2) the institution of higher education is performing research under the award; (3) the award is sponsored by a DOE program office that reports to the Under Secretary for Science and Energy; and (4) the institution of higher education intends to publish the results of its research for access by the general public. However, this exemption does not apply to visits by any foreign nationals to DOE sites, or any access to DOE information, equipment or personnel that are not exempted in DOE Order 142.3A (e.g., to awards sponsored by DOE program offices that do not report to the Under Secretary for Science and Energy).

Access approval for foreign nationals from countries identified on the U.S. Department of State's list of State Sponsors of Terrorism and who are not employees, students, or other individuals with a direct affiliation with a recipient, subrecipient, or subcontractor that is an institution of higher education must be granted by the Secretary of Energy before they can commence any work under the award.

The Recipient must include this term in any subaward or subcontract associated with this award.

Intellectual Property Provisions (GNP-115)
Grant and Cooperative Agreement Research, Development, or Demonstration
Non-Federal Entity
(State, Local government, Indian tribe, Institution of higher education, or Nonprofit organization)

A Non-Federal Entity is subject to the intellectual property requirements at 2 CFR 200.315.

2 CFR 200.315 Intangible Property

(a) Title to intangible property (see §200.59 Intangible property) acquired under a Federal award vests upon acquisition in the non-Federal entity. The non-Federal entity must use that property for the originally-authorized purpose, and must not encumber the property without approval of the Federal awarding agency. When no longer needed for the originally authorized purpose, disposition of the intangible property must occur in accordance with the provisions in §200.313 Equipment paragraph (e).

(b) The non-Federal entity may copyright any work that is subject to copyright and was developed, or for which ownership was acquired, under a Federal award. The Federal awarding agency reserves a royalty-free, nonexclusive and irrevocable right to reproduce, publish, or otherwise use the work for Federal purposes, and to authorize others to do so.

(c) The non-Federal entity is subject to applicable regulations governing patents and inventions, including governmentwide regulations issued by the Department of Commerce at 37 CFR Part 401, “Rights to Inventions Made by Nonprofit Organizations and Small Business Firms Under Government Awards, Contracts and Cooperative Agreements.”

(d) The Federal government has the right to:

(1) Obtain, reproduce, publish, or otherwise use the data produced under a Federal award; and

(2) Authorize others to receive, reproduce, publish, or otherwise use such data for Federal purposes.

(e) Freedom of Information Act (FOIA).

(1) In response to a Freedom of Information Act (FOIA) request for research data relating to published research findings produced under a Federal award that were used by the Federal government in developing an agency action that has the force and effect of law, the Federal awarding agency must request, and the non-Federal entity must provide, within a reasonable time, the research data so that they can be made available to the public through the procedures established under the FOIA. If the Federal awarding agency obtains the research data solely in response to a FOIA request, the Federal awarding agency may charge the requester a reasonable fee equaling the full incremental cost of obtaining the research data. This fee should reflect costs incurred by the Federal agency and the non-Federal entity. This fee is in addition to any fees the Federal awarding agency may assess under the FOIA (5 U.S.C. 552(a)(4)(A)).

(2) Published research findings means when:

(i) Research findings are published in a peer-reviewed scientific or technical journal; or

(ii) A Federal agency publicly and officially cites the research findings in support of an agency action that has the force and effect of law. “Used by the Federal government in developing an agency action that has the force and effect of law” is defined as when an agency publicly and officially cites the research findings in support of an agency action that has the force and effect of law.

(3) Research data means the recorded factual material commonly accepted in the scientific community as necessary to validate research findings, but not any of the following: preliminary analyses, drafts of scientific papers, plans for future research, peer reviews, or communications with colleagues. This “recorded” material excludes physical objects (e.g., laboratory samples). Research data also do not include:

(i) Trade secrets, commercial information, materials necessary to be held confidential by a researcher until they are published, or similar information which is protected under law; and

(ii) Personnel and medical information and similar information the disclosure of which would constitute a clearly unwarranted invasion of personal privacy, such as information that could be used to identify a particular person in a research study.

37 CFR 401.14 Standard Patent Rights Clauses.

(a) The following is the standard patent rights clause to be used as specified in §401.3(a).

Patent Rights (Small Business Firms and Nonprofit Organizations)

(a) Definitions

(1) *Invention* means any invention or discovery which is or may be patentable or otherwise protectable under Title 35 of the United States Code, or any novel variety of plant which is or may be protected under the Plant Variety Protection Act (7 U.S.C. 2321 *et seq.*).

(2) *Subject invention* means any invention of the *contractor* conceived or first actually reduced to practice in the performance of work under this *contract,* provided that in the case of a variety of plant, the date of determination (as defined in section 41(d) of the Plant Variety Protection Act, 7 U.S.C. 2401(d)) must also occur during the period of *contract* performance.

(3) *Practical Application* means to manufacture in the case of a composition or product, to practice in the case of a process or method, or to operate in the case of a machine or system; and, in each case, under such conditions as to establish that the invention is being utilized and that its benefits are, to the extent permitted by law or government regulations, available to the public on reasonable terms.

(4) *Made* when used in relation to any invention means the conception or first actual reduction to practice of such invention.

(5) *Small Business Firm* means a small business concern as defined at section 2 of Pub. L. 85-536 (15 U.S.C. 632) and implementing regulations of the Administrator of the Small

Business Administration. For the purpose of this clause, the size standards for small business concerns involved in government procurement and subcontracting at 13 CFR 121.3-8 and 13 CFR 121.3-12, respectively, will be used.

(6) *Nonprofit Organization* means a university or other institution of higher education or an organization of the type described in section 501(c)(3) of the Internal Revenue Code of 1954 (26 U.S.C. 501(c) and exempt from taxation under section 501(a) of the Internal Revenue Code (25 U.S.C. 501(a)) or any nonprofit scientific or educational organization qualified under a state nonprofit organization statute.

(b) Allocation of Principal Rights

The *Contractor* may retain the entire right, title, and interest throughout the world to each subject invention subject to the provisions of this clause and 35 U.S.C. 203. With respect to any subject invention in which the *Contractor* retains title, the Federal government shall have a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States the subject invention throughout the world.

(c) Invention Disclosure, Election of Title and Filing of Patent Application by *Contractor*

(1) The *contractor* will disclose each subject invention to the *Federal Agency* within two months after the inventor discloses it in writing to *contractor* personnel responsible for patent matters. The disclosure to the agency shall be in the form of a written report and shall identify the *contract* under which the invention was made and the inventor(s). It shall be sufficiently complete in technical detail to convey a clear understanding to the extent known at the time of the disclosure, of the nature, purpose, operation, and the physical, chemical, biological or electrical characteristics of the invention. The disclosure shall also identify any publication, on sale or public use of the invention and whether a manuscript describing the invention has been submitted for publication and, if so, whether it has been accepted for publication at the time of disclosure. In addition, after disclosure to the *agency,* the *Contractor* will promptly notify the *agency* of the acceptance of any manuscript describing the invention for publication or of any on sale or public use planned by the *contractor.*

(2) The *Contractor* will elect in writing whether or not to retain title to any such invention by notifying the *Federal agency* within two years of disclosure to the *Federal agency.* However, in any case where publication, on sale or public use has initiated the one year statutory period wherein valid patent protection can still be obtained in the United States, the period for election of title may be shortened by the *agency* to a date that is no more than 60 days prior to the end of the statutory period.

(3) The *contractor* will file its initial patent application on a subject invention to which it elects to retain title within one year after election of title or, if earlier, prior to the end of any statutory period wherein valid patent protection can be obtained in the United States after a publication, on sale, or public use. The *contractor* will file patent applications in additional countries or international patent offices within either ten months of the corresponding initial patent application or six months from the date permission is granted by the Commissioner of Patents and Trademarks to file foreign patent applications where such filing has been prohibited by a Secrecy Order.

(4) Requests for extension of the time for disclosure, election, and filing under

subparagraphs (1), (2), and (3) may, at the discretion of the *agency,* be granted.

(d) Conditions When the Government May Obtain Title

The *contractor* will convey to the *Federal agency,* upon written request, title to any subject invention—

(1) If the *contractor* fails to disclose or elect title to the subject invention within the times specified in (c), above, or elects not to retain title; provided that the *agency* may only request title within 60 days after learning of the failure of the *contractor* to disclose or elect within the specified times.

(2) In those countries in which the *contractor* fails to file patent applications within the times specified in (c) above; provided, however, that if the *contractor* has filed a patent application in a country after the times specified in (c) above, but prior to its receipt of the written request of the *Federal agency,* the *contractor* shall continue to retain title in that country.

(3) In any country in which the *contractor* decides not to continue the prosecution of any application for, to pay the maintenance fees on, or defend in reexamination or opposition proceeding on, a patent on a subject invention.

(e) Minimum Rights to *Contractor* and Protection of the *Contractor* Right to File

(1) The *contractor* will retain a nonexclusive royalty-free license throughout the world in each subject invention to which the Government obtains title, except if the *contractor* fails to disclose the invention within the times specified in (c), above. The *contractor's* license extends to its domestic subsidiary and affiliates, if any, within the corporate structure of which the *contractor* is a party and includes the right to grant sublicenses of the same scope to the extent the *contractor* was legally obligated to do so at the time the *contract* was awarded. The license is transferable only with the approval of the *Federal agency* except when transferred to the successor of that party of the *contractor's* business to which the invention pertains.

(2) The *contractor's* domestic license may be revoked or modified by the *funding Federal agency* to the extent necessary to achieve expeditious practical application of the subject invention pursuant to an application for an exclusive license submitted in accordance with applicable provisions at 37 CFR part 404 and *agency* licensing regulations (if any). This license will not be revoked in that field of use or the geographical areas in which the *contractor* has achieved practical application and continues to make the benefits of the invention reasonably accessible to the public. The license in any foreign country may be revoked or modified at the discretion of the *funding Federal agency* to the extent the *contractor,* its licensees, or the domestic subsidiaries or affiliates have failed to achieve practical application in that foreign country.

(3) Before revocation or modification of the license, the *funding Federal agency* will furnish the *contractor* a written notice of its intention to revoke or modify the license, and

(4) the *contractor* will be allowed thirty days (or such other time as may be authorized by the *funding Federal agency* for good cause shown by the *contractor*) after the notice to show cause why the license should not be revoked or modified. The *contractor* has the right to appeal, in accordance with applicable regulations in 37 CFR part 404 and *agency* regulations (if

any) concerning the licensing of Government-owned inventions, any decision concerning the revocation or modification of the license.

(f) *Contractor* Action to Protect the Government's Interest

(1) The *contractor* agrees to execute or to have executed and promptly deliver to the *Federal agency* all instruments necessary to (i) establish or confirm the rights the Government has throughout the world in those subject inventions to which the *contractor* elects to retain title, and (ii) convey title to the *Federal agency* when requested under paragraph (d) above and to enable the government to obtain patent protection throughout the world in that subject invention.

(2) The *contractor* agrees to require, by written agreement, its employees, other than clerical and nontechnical employees, to disclose promptly in writing to personnel identified as responsible for the administration of patent matters and in a format suggested by the *contractor* each subject invention made under *contract* in order that the *contractor* can comply with the disclosure provisions of paragraph (c), above, and to execute all papers necessary to file patent applications on subject inventions and to establish the government's rights in the subject inventions. This disclosure format should require, as a minimum, the information required by (c)(1), above. The *contractor* shall instruct such employees through employee agreements or other suitable educational programs on the importance of reporting inventions in sufficient time to permit the filing of patent applications prior to U.S. or foreign statutory bars.

(3) The *contractor* will notify the *Federal agency* of any decisions not to continue the prosecution of a patent application, pay maintenance fees, or defend in a reexamination or opposition proceeding on a patent, in any country, not less than thirty days before the expiration of the response period required by the relevant patent office.

(4) The *contractor* agrees to include, within the specification of any United States patent applications and any patent issuing thereon covering a subject invention, the following statement, “This invention was made with government support under (identify the *contract*) awarded by (identify the Federal agency). The government has certain rights in the invention.”

(g) Subcontracts

(1) The *contractor* will include this clause, suitably modified to identify the parties, in all subcontracts, regardless of tier, for experimental, developmental or research work to be performed by a small business firm or domestic nonprofit organization. The subcontractor will retain all rights provided for the *contractor* in this clause, and the *contractor* will not, as part of the consideration for awarding the subcontract, obtain rights in the subcontractor's subject inventions.

(2) The *contractor* will include in all other subcontracts, regardless of tier, for experimental developmental or research work the patent rights clause required by 2 CFR 910.362(c)

(3) In the case of subcontracts, at any tier, when the prime award with the Federal agency was a contract (but not a grant or cooperative agreement), the *agency,* subcontractor, and the contractor agree that the mutual obligations of the parties created by this clause constitute a contract between the subcontractor and the Federal agency with respect to the matters covered by the clause; provided, however, that nothing in this paragraph is intended to confer any jurisdiction under the Contract Disputes Act in connection with proceedings under paragraph (j)

of this clause.

(h) Reporting on Utilization of Subject Inventions

The *Contractor* agrees to submit on request periodic reports no more frequently than annually on the utilization of a subject invention or on efforts at obtaining such utilization that are being made by the *contractor* or its licensees or assignees. Such reports shall include information regarding the status of development, date of first commercial sale or use, gross royalties received by the contractor, and such other data and information as the *agency* may reasonably specify. The *contractor* also agrees to provide additional reports as may be requested by the *agency* in connection with any march-in proceeding undertaken by the *agency* in accordance with paragraph (j) of this clause. As required by 35 U.S.C. 202(c)(5), the *agency* agrees it will not disclose such information to persons outside the government without permission of the *contractor.*

(i) Preference for United States Industry

Notwithstanding any other provision of this clause, the *contractor* agrees that neither it nor any assignee will grant to any person the exclusive right to use or sell any subject inventions in the United States unless such person agrees that any products embodying the subject invention or produced through the use of the subject invention will be manufactured substantially in the United States. However, in individual cases, the requirement for such an agreement may be waived by the *Federal agency* upon a showing by the *contractor* or its assignee that reasonable but unsuccessful efforts have been made to grant licenses on similar terms to potential licensees that would be likely to manufacture substantially in the United States or that under the circumstances domestic manufacture is not commercially feasible.

(j) March-in Rights

The *contractor* agrees that with respect to any subject invention in which it has acquired title, the *Federal agency* has the right in accordance with the procedures in 37 CFR 401.6 and any supplemental regulations of the *agency* to require the *contractor,* an assignee or exclusive licensee of a subject invention to grant a nonexclusive, partially exclusive, or exclusive license in any field of use to a responsible applicant or applicants, upon terms that are reasonable under the circumstances, and if the *contractor,* assignee, or exclusive licensee refuses such a request the *Federal agency* has the right to grant such a license itself if the *Federal agency* determines that:

(1) Such action is necessary because the *contractor* or assignee has not taken, or is not expected to take within a reasonable time, effective steps to achieve practical application of the subject invention in such field of use.

(2) Such action is necessary to alleviate health or safety needs which are not reasonably satisfied by the *contractor,* assignee or their licensees;

(3) Such action is necessary to meet requirements for public use specified by Federal regulations and such requirements are not reasonably satisfied by the *contractor,* assignee or licensees; or

(4) Such action is necessary because the agreement required by paragraph (i) of this

clause has not been obtained or waived or because a licensee of the exclusive right to use or sell any subject invention in the United States is in breach of such agreement.

(k) Special Provisions for *Contracts* with Nonprofit Organizations

If the *contractor* is a nonprofit organization, it agrees that:

(1) Rights to a subject invention in the United States may not be assigned without the approval of the *Federal agency,* except where such assignment is made to an organization which has as one of its primary functions the management of inventions, provided that such assignee will be subject to the same provisions as the *contractor;*

(2) The *contractor* will share royalties collected on a subject invention with the inventor, including Federal employee co-inventors (when the agency deems it appropriate) when the subject invention is assigned in accordance with 35 U.S.C. 202(e) and 37 CFR 401.10;

(3) The balance of any royalties or income earned by the *contractor* with respect to subject inventions, after payment of expenses (including payments to inventors) incidental to the administration of subject inventions, will be utilized for the support of scientific research or education; and

(4) It will make efforts that are reasonable under the circumstances to attract licensees of subject invention that are small business firms and that it will give a preference to a small business firm when licensing a subject invention if the *contractor* determines that the small business firm has a plan or proposal for marketing the invention which, if executed, is equally as likely to bring the invention to practical application as any plans or proposals from applicants that are not small business firms; provided, that the *contractor* is also satisfied that the small business firm has the capability and resources to carry out its plan or proposal. The decision whether to give a preference in any specific case will be at the discretion of the *contractor.* However, the *contractor* agrees that the Secretary may review the *contractor's* licensing program and decisions regarding small business applicants, and the *contractor* will negotiate changes to its licensing policies, procedures, or practices with the Secretary when the Secretary's review discloses that the *contractor* could take reasonable steps to implement more effectively the requirements of this paragraph (k)(4).

(l) Communication

All communications required by this Patent Rights clause should be sent to the DOE Patent Counsel address listed in the Award Document.

(m) Electronic Filing

Unless otherwise specified in the award, the information identified in paragraphs (f)(2) and (f)(3) may be electronically filed.

ATTACHMENT 2 STATEMENT OF PROJECT OBJECTIVES

ECONOMIC EXTRACTION AND RECOVERY OF REEs AND PRODUCTION OF CLEAN VALUE-ADDED PRODUCTS FROM LOW-RANK COAL FLY ASH

A. OBJECTIVES

The overall proposed project goal is to demonstrate at the laboratory-scale a novel, economically viable and environmentally benign process for extraction and concentration of rare earth elements (REEs) to ≥ 2 weight percent from low-rank coal (LRC) fly ash. To demonstrate the proof of concept for the novel technology in the proposed project, the following specific objectives have been established:

- Build on the Recipient's unique and deep knowledge regarding LRC geochemistry, ash transformation mechanisms during combustion, and fly ash chemistry and mineralogy to predict the form, associations, and partitioning of the REEs in the fly ash.
- Perform a comprehensive characterization effort to fully elucidate the form, associations, and partitioning of the REEs and other elements/minerals of interest in the fly ash, as well as the ash chemistry, mineralogy, and morphology. This information is essential to inform the development of intelligent REE extraction and concentration methods.
- Develop methods of REE extraction that take advantage of advantageous properties of LRC fly ash, such as by alteration and control of the mineralogy to improve REE mobilization and solubility.
- Improve on existing approaches for REE recovery from fly ash by avoiding aggressive leaching processes and harsh chemicals, and instead focusing on generating a highly selective extraction to minimize waste and reduce costs of purification.
- Evaluate multiple complementary approaches that combine both novel and proven methods to offer a technology that can provide large technological and economic progress on the current state of the art for REE extraction/concentration from coal fly ash.
- Evaluate methods that can synergistically remove toxic metals to generate a clean, safe material, in combination with a unique method of altering the physical structure of the clean fly ash to transform it into a value-added product. This will eliminate waste and offer significant additional revenue potential.
- Based on the laboratory-scale testing, perform an initial technical and economic analysis to estimate capital and operating expenses and product revenues.

B. SCOPE OF WORK

Besides project management and planning, three main efforts are to be completed in this project: i) sample procurement and characterization, ii) laboratory- scale REE extraction and concentration testing, and iii) preliminary technical and economic analysis. This project will focus on LRC (lignite, subbituminous) combustion/gasification ashes. The ash samples will be collected from industry partner facilities, as well as from the Recipient's existing sample database for North Dakota (ND) lignites. The characterization to be performed will fully elucidate the abundance, form, and association of the REEs both in the feed coals that produced the ash and the ashes. Additionally, the chemical composition, mineralogy, and morphology of the ash will be determined. This information will be essential to inform the development of effective approaches to extract and concentrate the REEs. Based on the characterization results, two ash samples will be downselected for laboratory-scale REE extraction and concentration testing. The laboratory-scale testing will involve evaluation of ash pretreatment methods, dilute acid leaching, and subcritical liquid CO_2 extraction testing, which will be following by REE concentration testing at downselected conditions and materials. The project will also evaluate a novel method of value- added beneficiation of the clean fly ash. Finally, based on the

experimental testing, a preliminary technical and economic analysis will be completed to estimate capital and operating expenses and product revenues. TRL 3—proof of concept validated—is expected at project completion.

C. TASKS TO BE PERFORMED

Task 1.0 – Project Management and Planning: This task shall include all work elements required to maintain and revise the *Project Management Plan*, and to manage and report on activities in accordance with the plan. It shall also include the necessary activities to ensure coordination and planning of the project with DOE/NETL and other project participants. These shall include, but are not limited to, the submission and approval of required National Environmental Policy Act (NEPA) documentation and accomplishment data/reports.

Task 2.0 – Sample Procurement and Characterization: This task will involve procurement and production of representative samples of LRC fly ash along with detailed characterization of the materials.

Subtask 2.1 – Sample Procurement: In this subtask, the Recipient anticipates sourcing and producing up to 15 fly ash samples that will be analyzed for REE content from which it can pick up to six of the most promising and highest REE concentrations for full characterization utilizing the methods described below in Subtask 2.2. Fly ash samples will be collected from the full-scale power plants of several project sponsors, as well as other selected LRC fly ashes that are known to contain >300 parts per million (ppm) total REE concentration. Additionally, as part of current work evaluating ND lignites for REE recovery, the Recipient has procured coal samples containing total REE in excess of 2000 ppm on an ash basis. To prepare a representative fly ash from this exceptionally REE-enriched coal, it will be combusted in an existing laboratory-scale downfired combustor to generate suitable fly ash for further testing.

Subtask 2.2 – Fly Ash Characterization: Characterization will include a suite of techniques to fully elucidate the abundance, form, and association of the REEs, as well as determine the bulk composition, mineralogy, and morphology of the fly ash. The techniques include:

- X-Ray Fluorescence (XRF) to measure the bulk chemical composition of the ash.
- Inductively Coupled Plasma Mass Spectrometry (ICP–MS) to measure the abundance of REEs, other high value elements, and potential impurities that could impact REE recovery.
- Powder X-Ray Diffraction (XRD) to quantify the distribution of the crystalline phases and the amorphous fraction of the ash.
- Scanning Electron Microscope – Energy Dispersive X-Ray Spectrometry (SEM–EDS) to take high-magnification images and determine point chemical composition of features of interest in samples.
- Sequential leaching techniques to determine the form and association of the REEs and other elements of interest within the samples. Materials will be leached using the Community Bureau of Reference sequential extraction scheme (BCR SES) to fractionate metals into the operationally defined phases of water-soluble, exchangeable, reducible, oxidizable, and residual, with the steps targeting free water-soluble ions, exchangeable and carbonate bound metals, iron and manganese oxide/hydroxide associated metals, metals bound to sulfide and organic phases, and mineral phases, respectively.
- Brunauer-Emmett-Teller (BET) analysis to measure the surface area and pore volume/size of the ash samples.

In addition to the above ash analyses, we will also collect and analyze samples of the feed coals to the power plants that generated the fly ashes. These coal samples will be characterized using

the standard ASTM methods for proximate and ultimate analysis (D3172 and D3176), as well as the techniques listed above for bulk chemical composition and REE analysis. Another sequential leaching technique called chemical fractionation, which is currently being used in the Recipient's work with ND lignites, will also be used to determine the modes of REE occurrence in the coals for this project. This information will allow for the development of correlations to predict the REE forms and associations in the coal fly ash.

Based on the results of this task, two types of ashes (i.e., one lignite and one subbituminous) will be selected for testing in Task 3. The selection of materials will be based on the abundance of REE as well as their association and perceived ease of recoverability.

Task 3 – Laboratory-Scale Testing: This task will involve laboratory-scale extraction testing of up to two types of coal ash identified from Task 2.

Subtask 3.1 – Experimental Test System Design and Installation: This project will leverage existing supercritical/near-critical CO_2 test equipment. A multigram extraction system will be modified in this project to accommodate the requirements of the planned test program. The existing system is a 20-gram capacity supercritical fluid extraction system that is a flow-through system in which the supercritical fluid is passed through a fixed bed of solids for the desired time. The main components are a hydraulic pump, three electric heater systems, a reactor cell, a pressure control valve, a pressure letdown vessel, and two condensers. It is fully equipped with instrumentation to continuously monitor flows, temperatures, and pressures. Modifications will include installation of a secondary injection pump and controller, ligand extract trap, and associated plumbing for the organic ligands and cosolvents to be evaluated.

Subtask 3.2 – Fly Ash Pretreatment Testing: This subtask will involve testing of fly ash pretreatment methods, including rapid expansion, thermal, carbonation, and water leaching. With each method and combination of methods tested, the fly ash mineralogy (XRD), composition (XRF), morphology (SEM and BET) and REE forms and associations (sequential leaching and ICP–MS) will be evaluated to examine their impacts and efficacy to improve the process. This subtask will be performed in coordination with Subtasks 3.3 and 3.4 to provide pretreated ash for REE extraction tests.

Subtask 3.3 – Dilute Acid Leaching Testing: Using the pretreated ashes produced in Subtask 3.2, testing will be accomplished to determine the recoverability of the REEs and other target metals/elements via dilute acid leaching. The primary acid to be tested is HCl, but others such as H_2SO_4 may also be tested. A range of concentrations (0.5 to 2M), temperatures (20° to 90°C), and contact times (1 to 24 hours) will be evaluated to identify the operating window where effective extraction is achieved. This testing will be done in small batches of 5 to 10 grams of ash via existing leaching equipment. REE extraction efficiency will be determined through ICP–MS of both the residual solids and the acid extract, and XRF/XRD/SEM–EDS/BET will be used to examine the impact of the leaching on the composition, mineralogy and morphology of the residual solids. This subtask will identify an effective operating window that will be used in Subtask 3.5 to generate representative materials for REE concentration testing.

Subtask 3.4 – Subcritical Liquid CO_2 Extraction Testing: Both the pretreated and untreated fly ashes and, potentially, the acid leached fly ashes will be evaluated in this subtask. The primary goals are to identify the most effective conditions (the combination of organic ligands, cosolvents and proportions, contact time) required to achieve the highest level of REE extraction. The types of organic ligands to be evaluated are those that are commonly employed with the sc-CO_2 system

as well as novel low-cost ligands currently being developed. In this subtask, the product streams (residual ash and ligand extract) will be recovered by simply evaporating the liquid CO_2. The REEs and other complexed metals will be recovered by simple acid stripping or combusting the ligand extract fraction (methods to be competitively studied). REE/metals extraction efficiency can then be determined using ICP–MS of both the residual ash and the mixed metal oxide or acid solution recovered after removal of the ligand. This subtask will identify an effective operating window that will be used in Subtask 3.5 to generate representative materials for REE concentration testing.

Subtask 3.5 – REE Concentration Testing: Based on the results of the previous two subtasks, testing will be accomplished with downselected conditions using one type of (preferred) feedstock. This subtask will explore proven hydrometallurgy techniques, thermal methods, and novel approaches to concentrate and purify the REEs recovered from the extraction methods (as described in Subtasks 3.3 and 3.4). Project work will strive for the highest degree of REE concentration achievable using the proposed simple and low-cost methods, with 50% REE concentration possible and 2 wt% minimum targeted value.

Methods to be explored to concentrate REEs from the dilute acid leaching approach will include selective impurities precipitation and/or selective REE precipitation using methods that are well-established in the literature and current work. Recovery of REEs after bulk precipitation from the CO_2 (using partial depressurization) will be examined using traditional hydrometallurgy methods such as acid stripping. Novel methods such as density control precipitation to concentrate and purify extracted REEs will be explored. Methods to selectively recover and further purify REE–organic complexes (precipitated from CO_2) will be explored.

Subtask 3.6 – Rapid Expansion Testing: The feasibility of using a rapid expansion process to create value-added particles from the residual ash material left over after extraction of the REEs will be evaluated. The testing will involve a simple experimental setup where the ash/liquid CO_2 slurry will be rapidly expanded through an orifice or nozzle to alter its physical structure (i.e., particle size and porosity). SEM imaging and BET will be used to examine the morphology of the ash after the testing. The goal of this effort is to produce a clean material with the porosity and particle size that will make it a value-added product salable to industry for a range of applications.

Task 4 – Technical and Economic Analysis: Based on the results of laboratory testing and sample characterization in this project, a preliminary technical and economic analysis will be completed. Because of the early stage of technical development and overall process definition, this will be a high-level assessment with the goals to estimate preliminary capital and operating expenses and potential revenues generated from the products produced by the technology. This analysis will serve to direct future process development.

D. DELIVERABLES

The periodic and final reports shall be submitted in accordance with the attached "Federal Assistance Reporting Checklist" and the instructions accompanying the checklist. In addition to the reports specified in the "Federal Assistance Reporting Checklist," the Recipient must provide the following to the NETL Federal Project Manager (identified in Block 15 of the Assistance Agreement as the Program Manager):

DOE, in accordance with 2 CFR 910, Appendix A of Subpart D 3., Rights in Data – General, will require delivery of state-specific, county-specific, and site-specific information on the proposed sources of coal and coal by-products. All analytical results, which include characterization of the REE concentrations in the original feedstock material and/or separated/extracted preconcentrate or high-purity fractions, are to be presented in the financial assistance application and on any awarded

projects: 1) on a dry mass/dry whole sample basis and 2) if any samples are "ashed" (decarbonized), results should also be expressed on a dry ash basis. Analytical results are to be provided on an individual elemental basis (i.e., dysprosium metal, Dy), as well as on an oxide basis (i.e., dysprosium oxide, Dy_2O_3). Similarly, compositional phase identification of the original feedstock and resulting preconcentrate or high-purity fractions is to be provided. NETL intends to publicly post general feedstock sampling location and type, in addition to analytical characterization of feedstock and pre-concentrate materials at https://edx.netl.doe.gov/ree/.

- Task 1 – Project Management Plan, to be updated within 30 days after award and to be subsequently updated as requested by the NETL Federal Project Manager/Project Officer.
- Task 1 – Interim accomplishment data/report, providing updated technical progress towards meeting the project objectives due every 6 months. The report is envisioned to be 1 page or less and to offer a succinct update on project performance to-date, emphasizing any accomplishments that can be made publicly available on DOE's EDX Web site.
- Task 1 – Data/Report including, at a minimum, 1) results of any required identification and characterization of domestic U.S. feedstocks; 2) estimating of available resource quantities and mineral reserves; 3) results of any laboratory testing to prepare for design; 4) drawings showing the system configuration with approximate sizes of the needed equipment; and 5) flow sheets/mass balance diagrams showing the recovery, yield, and mass/water/energy balances for economic and environmentally benign recovery of REE products from domestic U.S. coal and coal by-products due no later than 90 days after the end of the award.
- Task 2 – Sample characterization report, to be submitted within 30 days after completion of Task 2. The report will provide all results for samples analyzed, as well as the justification for down-selection of the two samples to be evaluated within the laboratory testing campaign in Task 3.
- Task 4 – Preliminary Technical and Economic Analysis based on results of laboratory testing, to be submitted within 90 days after the end of the award.

E. BRIEFINGS/TECHNICAL PRESENTATIONS

The Recipient shall prepare detailed briefings for presentation to the Project Officer at the Project Officer's facility located in Pittsburgh, PA, or Morgantown, WV, or via Web-ex. The Recipient shall make a presentation to the NETL Project Officer/Manager at a project kickoff meeting held within 90 days of project start date. At minimum, annual briefings shall also be given by the Recipient to explain the plans, progress, and results of the technical effort. A final project briefing prior to the end of the period of performance of the project shall also be given.

The Recipient should allow for an informal telephone status update each quarter, at a minimum. The Recipient should provide and present project overview(s) and/or technical paper(s) at the Program Peer Review Meetings or other designated program meetings that are held annually, typically at the NETL facility located in Pittsburgh, PA or Morgantown, WV.

IN-KIND AGREEMENT WITH GREAT RIVER ENERGY

EERC
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018 • Grand Forks, ND 58202-9018 • P. 701.777.5000 • F. 701.777.5181
www.undeerc.org

February 16, 2018

Ms. Sandra Broekema
Director Corporate and Business Development
Great River Energy
12300 Elm Creek Boulevard
Maple Grove, MN 55369-4718

Dear Ms. Broekema:

Subject: Financial Cost-Share Reporting for "Economic Extraction and Recovery of REEs and Production of Clean Value-Added Products From Low-Rank Coal Fly Ash;" 41000/22485

The U.S. Department of Energy (Prime Sponsor) recently awarded the University of North Dakota Energy & Environmental Research Center (EERC) funding for the subject Project (the Project). Great River Energy (Sponsor) agrees to contribute in-kind cost-share funding to the Project in the amount of US$30,000 in the form of project support and coal supply (sampling and preparing) as further described within the attached Enclosure One and in accordance with this agreement (Agreement). The period of performance for this portion of the Project is November 16, 2017, through May 15, 2019. The EERC and Sponsor are sometimes hereinafter referred to individually as a "Party" and collectively as the "Parties."

Sponsor shall submit in-kind cost-share reports by e-mail to the EERC Contracts Officer, Corey R. Irion (cirion@undeerc.org), on a monthly basis within thirty (30) days after the close of the calendar month. A sample format is enclosed for use in submitting these costs as (Enclosure Two). All in-kind cost share must be allowable in accordance with 2 CFR Part 200, as amended by 2 CFR Part 910, and the applicable federal cost principles listed below in order to qualify as Sponsor's cost share commitment.

The applicable cost principles outlining allowable costs are established at 2 CFR Part 200, Subpart E, Cost Principles.

The Parties recognize the importance and necessity of the cost-share support. If the agreed-upon level of cost share is not reached, nor adequate documentation submitted, then the Parties will arrive at a mutually amicable solution to address the shortcoming and any consequences that may arise. Potential remedies include, but are not limited to, securing alternate in-kind cost share, provision of a cash contribution by the Sponsor equivalent to the shortfall of cost share, revision of Project scope, etc. Any such remedy will likely necessitate the explicit concurrence of the Prime Sponsor(s).

Sponsor and the EERC consider certain data, know-how, and other privileged information which may be disclosed between the Parties to be confidential and proprietary. The Parties agree to maintain in confidence such data, know-how, and other privileged information (including without limitation

commercial and financial information and trade secret) that have not been publicly released, published, or patented (hereinafter referred to collectively as Information).

In order to be maintained in confidence under this section, Information must be marked confidential. In the event of oral disclosures, the Information will be reduced to writing within thirty (30) days of disclosure and submitted to the receiving Party to remain confidential.

The Parties recognize the proprietary rights of the disclosing Party in and to the Information and the confidential nature of the Information. Thus, the Parties agree to take every reasonable precaution to safeguard and treat the Information as confidential and to take every appropriate action by instruction, agreement, or notice to its directors, officers, agents, and employees of the confidential and proprietary nature of the Information submitted by the disclosing Party. Reasonable precautions to safeguard the Information shall mean using a standard of care which is no less stringent than that which the receiving Party uses to protect its own confidential Information.

The confidentiality requirements do not apply to Information that is a) already known by the receiving Party, b) disclosed by a third party having a bona fide right to do so, c) presently in the public domain, or d) independently developed by the receiving Party.

The Prime Sponsor of the Project will have the right to examine/review all confidential Information of this Project as necessary to evaluate the subject Project and Project progress. In addition, any confidential Information submitted by Sponsor that is included in the technical progress reports will be submitted in a separate appendix, and Prime Sponsor will be requested to hold that appendix in confidence for a period of five (5) years in accordance with the Energy Policy Act.

Other than the process described for progress reports, it is hereby agreed between the Parties that the Information will be held in confidence for a period of ten (10) years from disclosure or until written permission to disclose is given by the disclosing Party, whichever is shorter.

The EERC will promptly notify Sponsor and Prime Sponsor if any inventions, discoveries, or improvements are developed under this Project which are potentially patentable or otherwise protectable.

Such notification shall be marked confidential. The Parties recognize the proprietary rights of the EERC in and to the notification and the confidential nature of the notification. It is hereby agreed by the SPONSOR that the disclosed information will be held in confidence for a period of ten (10) years from notification or until written permission to disclose is given by the EERC, whichever is shorter.

In the event that intellectual property (IP) with the potential to generate revenue to which the EERC is entitled is developed under this Agreement, such IP, including rights, title, interest, and obligations, may be transferred to the EERC Foundation, a separate legal entity.

The Sponsor is aware that the EERC is also receiving federal funding for the Project and that the EERC's obligations to Sponsor regarding intellectual property such as patents, data, and copyrights that may be secondary to the EERC's obligations to the U.S. federal government. Nothing in this Agreement prevents Sponsor from asserting its rights in such property against the U.S. federal government.

The Parties acknowledge that any material, item, article, information, technical data, source code or services, or the direct products thereof provided by the other under this Agreement may be subject to U.S. export control laws and regulations, including, but not limited to, the International Traffic in Arms Regulations, the Export Administration Regulations, and sanctions regulations administered by the Office of Foreign Asset Controls of the U.S. Department of Treasury. Sponsor agrees, prior to providing or disclosing any material, item, article, information, technical data, or source code or services subject to U.S. export controls, to notify the EERC in writing that the material is export-controlled and shall include the identification and classification of any item or information that is export-controlled and an identification of any restrictions on the disclosure or use of the export-controlled item.

In the event of default by Sponsor of the obligations under this Agreement, or in the event that Prime Sponsor terminates work by the EERC on the subject Project, then performance by Sponsor may be terminated by the EERC at any time by giving written notice. Such notice shall be effective upon the receipt of written notice by Sponsor.

Sponsor herein is an Independent Contractor, not a partner or joint venturer, and shall not act as an agent for the EERC, nor shall Sponsor be deemed to be an employee of the EERC for any purposes whatsoever. Sponsor shall not have any authority, either express or implied, to enter any agreement, incur any obligations on the EERC's behalf, or commit the EERC in any manner whatsoever without the EERC's express prior written consent.

Any changes, alterations, or modifications to this Agreement will be in writing and signed by the authorized officials of the parties hereto.

Sincerely,

Corey R. Irion
Contracts Officer/Intellectual Property Specialist
Contracts and Intellectual Property

CRI/pjr

Enclosures

The Parties hereto have executed this Agreement by their duly authorized representatives on the day and year last specified below.

GREAT RIVER ENERGY

By _____

Name Mark Fagan

Title Vice President Member Services

Date 2/20/18

UNIVERSITY OF NORTH DAKOTA ENERGY & ENVIRONMENTAL RESEARCH CENTER

By _____

Name Sheryl A. Eicholtz-Landis

Title Principal Contracts Officer
Contracts and IP Manager

Date 2/16/18

IN-KIND AGREEMENT WITH BASIN ELECTRIC POWER COOPERATIVE

EERC
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018 · Grand Forks, ND 58202-9018 · P. 701.777.5000 · F. 701.777.5181
www.undeerc.org

February 16, 2018

Mr. Matthew Greek
Senior Vice President, Engineering and Construction
Basin Electric Power Cooperative
1717 East Interstate Avenue
Bismarck, ND 58503-0564

Dear Mr. Greek:

Subject: Financial Cost-Share Reporting for "Economic Extraction and Recovery of REEs and Production of Clean Value-Added Products From Low-Rank Coal Fly Ash;" 41000/22485

The U.S. Department of Energy (Prime Sponsor) recently awarded the University of North Dakota Energy & Environmental Research Center (EERC) funding for the subject Project (the Project). Basin Electric Power Cooperative (Sponsor) agrees to contribute in-kind cost-share funding to the Project in the amount of US$10,000 in the form of the cost of sampling at Sponsor's lignite-fired facilities in North Dakota, ash analyses, and participation of Sponsor's personnel in project review meetings as further described within the attached Enclosure One and in accordance with this agreement (Agreement). The period of performance for this portion of the Project is November 16, 2017, through May 15, 2019. The EERC and Sponsor are sometimes hereinafter referred to individually as a "Party" and collectively as the "Parties."

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Any changes, alterations, or modifications to this Agreement will be in writing and signed by the authorized officials of the parties hereto.

Sincerely,

Corey R. Irion
Contracts Officer/Intellectual Property Specialist
Contracts and Intellectual Property

CRI

Enclosures

c/enc: Bruce Folkedahl, EERC

The Parties hereto have executed this Agreement by their duly authorized representatives on the day and year last specified below.

BASIN ELECTRIC POWER COOPERATIVE		**UNIVERSITY OF NORTH DAKOTA ENERGY & ENVIRONMENTAL RESEARCH CENTER**	
By	Matt E. Greek	By	John M. Lennon
Name	Matt E. Greek	Name	Sheryl A. Eicholtz-Landis
Title	SVP, EIC	Title	Principal Contracts Officer Contracts and IP Manager
Date	2-19-18	Date	2/16/18

LETTER OF SUPPORT FROM SOUTHERN COMPANY

Southern Company

Southern Company Services, Inc.
600 18th St N
Birmingham, AL 35203
205 257 6645 tel
205 257 5367 fax
bjgallag@southernco.com

July 14, 2017

Dr. Steve Benson
Associate Vice President for Research
University of North Dakota
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Subject: Letter of Support for University of North Dakota Energy & Environmental Research Center's response to DOE Solicitation DE-FOA-0001718 for Development of Separation and Extraction Processes for Production of Rare Earth Element (REEs) Materials from Domestic U.S. Coal and Coal By-products

Dr. Benson,

Southern Company Services, Inc. appreciates this opportunity to support University of North Dakota Energy & Environmental Research Center's proposal to DOE to develop processes for production of REE materials from coal combustion byproducts. As a leading energy company, we have an interest in the development of technologies to process coal combustion byproducts and recover valuable elements. Sales of recovered elements and minerals could help reduce customer costs and diversify our beneficial reuse program. In addition, we believe that reliable, economical sources of REEs are a strategic advantage for domestic industry.

Southern Company Services, Inc. supports the work to develop low-cost green extraction technology targeted for subbituminous coal derived byproducts and is proposing to provide a cost share contribution on this important project. Southern Company Services, Inc. proposes to contribute up to $20,000 of cash and 100 hours of in-kind support from our research staff for consultation on ash handling, waste disposal, and economical analysis. In addition, we will furnish samples of coal combustion by-products for study. The total value of our cash and in-kind contributions will be about $30,000, and is contingent upon successful execution of agreements and mutually agreed statement of work by all parties. This cost share funding will be provided during the project performance period, and will not involve funding from federal sources.

Southern Company Services, Inc. serves the operating companies of Southern Company, the premier energy company in the southeastern United States. We are meeting our challenge to serve the ever-growing need for electricity while continuing to minimize the environmental impact of electricity production. This work aligns well with the overall goals of Southern Company and will benefit the operating companies and their customers into the future.

Sincerely,

Jeffrey Wilson
Environmental Controls R&D Manager
Southern Company Services, Inc.