UNIVERSITY OF NORTH DAKOTA

UND.edu

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Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

This proposal from the University of North Dakota College of Engineering and Mines requests $434,791 from NDIC which we will match slightly more than 50:50 with funding from our industry partners.

We aim to establish a geothermal energy industry in North Dakota that will add a sustainable, renewable, and ecologically sound sector to the state's energy industry. The decline in oil price due to the Covid-19 pandemic and the pressure to address climate change by transitioning away from fossil fuels severely impact North Dakota's petroleum industry and the state's economy. Our project will show that development of North Dakota's enormous geothermal energy resource is a win-win-win opportunity to address these challenges. It would provide jobs for oil field workers, create a sustainable energy industry, and address climate change using the technology, skills, work force, and infrastructure of North Dakota's petroleum industry.

Our team of industry partners enthusiastically supports the project and we hope to have a positive response to our proposal from NDIC. We are happy to answer any questions NDIC and its proposal reviewers may have.

Sincerely,

DocuSigned by:
Will Gosnold
C33D31931D4043E...

Will Gosnold
Chester Fritz Distinguished Professor
Harold Hamm School of Geology and Geological Engineering
University of North Dakota

APPLICATION CHECKLIST

Use this checklist as a tool to ensure that you have all of the components of the application package. Please note, this checklist is for your use only and does not need to be included in the package.

☐	Application
☐	Transmittal Letter
☐	$100 Application Fee
☐	Tax Liability Statement
☐	Letters of Support (If Applicable)
☐	Other Appendices (If Applicable)

When the package is completed, send an electronic version to Ms. Karlene Fine at kfine@nd.gov, and 2 hard copies by mail to:

Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

For more information on the application process please visit:
http://www.nd.gov/ndic/renew/info/submit-grant-app.pdf

Questions can be addressed to Jonathan Russo at (701) 328-5347.

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Geothermal Development Consortium

Applicant: CEM University of North Dakota

Principal Investigator: Will Gosnold

Date of Application:02/08/2021

Amount of Request: $ 432,895

Total Amount of Proposed Project:

$865,791

Duration of Project: 2 years

Point of Contact (POC): Will Gosnold

POC Telephone: 701-777-2631

POC Email:will.goosnold@und.edu

POC Address: UND Harold Hamm School of Geology and Geological Engineering

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ABSTRACT

Our **objective** is to establish a geothermal energy industry in North Dakota that will add a sustainable, renewable, and ecologically sound sector to North Dakota's economy. We have formed a consortium of University of North Dakota and energy industry partners that have the combined expertise needed to assess and develop North Dakota's huge geothermal resource by conversion of non-economic oil and gas wells to geothermal applications. Many of the skills and technologies used in oil and gas exploration and production are the same as those required to produce geothermal fluids. Thus, development of the resource will lead to a no-gap job transition for oil field workers and oil-field support industries plus new jobs for new workers. The project **duration** is two years with two Stages. Stage I Includes tasks for data acquisition and analysis with sub-tasks for electric power and direct use. Stage II includes tasks for selection and conversion of an existing well to a geothermal well and planning construction of a geothermal power plant. Both stages include community outreach and educational components with the aims of raising awareness and providing the STEM graduates who will carry geothermal development into the future.

Expected Results: In stage I we will identify the optimal areas, formations and wells for geothermal development based on temperature, fluid volume and quality, access to existing infrastructure, and economic impact for both power and direct-use applications. The deliverables will include reports, maps, and tables of data that developers can use for planning. In stage II we will plan conversion of an existing well and plan for building a geothermal power power plant. We believe the results of this project will have positive impacts on the energy future of North Dakota by launching a new industry that will boost employment and provide long-term stability for the state's economy. The consortium of geothermal, oil and gas, and electric power industry professionals formed to steer development of the geothermal resource will grow and realize common interests with mutual benefits and that will foster economic growth.

Total Project Cost: $865,791

Participants: University of North Dakota College of Engineering and Mines, Neset Consulting, ElectraTherm, Climeon, GeothermEx, Inc., and Basin Electric Power Cooperative. *We have invited ConocoPhillips, XTO, Hess, and Schlumberger and are awaiting approval.*

Project Description

Objectives:

Our objective is to establish a geothermal energy industry in North Dakota that will add a sustainable, renewable, and ecologically sound sector to our energy industry. We have formed a consortium of university and energy industry partners that have the combined expertise needed to lead the way in developing North Dakota's huge geothermal resource. Task 1 in Stage 1 will focus on data collection and analysis for identification and quantification of the resource. Task 2 will focus on an economic analysis of development of the geothermal resource for power generation and for district heating systems that would serve communities, industry, and academic and military campuses in the Basin. Stage II will initiate a program for conversion of non-economic oil and gas wells to geothermal applications. We include outreach and education as essential tasks for raising awareness and training STEM graduates who will carry geothermal development into the future.

The Resource The geological setting of the Williston Basin gives the region a huge geothermal resource in laterally extensive, permeable formations having temperatures ranging from 60 °C to greater than 150 °C at depths ranging from 1,000 m to 4,500 m (Gosnold, 1999; Crowell, Klenner, and Gosnold, 2011; Poro et al., 2012; Gosnold, McLaughlin, and Colby, 2016). The quantity of thermal energy stored in the Williston Basin is estimated to be 28 EJ (6.8 PWh) (Porro, et al., 2012) which exceeds the energy in oil and gas reserves in the Basin, i.e., 3.6 PJ, (9.97 TWh) (EIA, 2020), by four orders of magnitude. Although a barrel of oil contains thousands of times more energy than a barrel of water at 150 °C, that barrel of oil can be produced once, and it is gone. Geothermal heat mining at the scale we envision with looping injection and production wells can produce 10s of barrels of water per minute. With good reservoir management, such a system can produce power for 20 to 30 years before requiring new the wells. Because the heat source is conduction from Earth's interior, a geothermal field will recover over time and new wells can be added thus sustaining this renewable resource.

The existence of intermediate temperature (90 °C to 150 °C) and low-temperature geothermal resources (T < 90 °C) has been known for decades. Still, the resource has not been developed for short-term economic reasons and because specific target reservoirs have yet to be described and quantified. Now the economic outlook has changed.

An October 2020 report by the IMF suggests that a "green infrastructure push" would lead to *faster* economic growth over the next few decades. The report states explicitly, "…an initial green investment push combined with steadily rising carbon prices would deliver the needed emission reductions at reasonable transitional global output effects, putting the global economy on a stronger and more sustainable footing over the medium term." The advantages of geothermal energy are many. Geothermal heating and cooling systems are the most energy-efficient, environmentally clean, and cost-effective space conditioning systems (EPA, 1993). Advances with machine learning and 4th generation district heating systems currently being implemented in Europe have made great gains in cost effectiveness (Averfalk, 2020). Geothermal power plants have the smallest footprint per kilowatt (kW) and the highest capacity factor of any power generation technology, including coal, nuclear, and other renewables (GEA, 2012). Unlike solar and wind, geothermal power is dispatchable, continuous baseload. On a global scale, geothermal energy could supply more energy than the total of the worlds supply of oil and gas (Feder, 2020).

Stage I

We have formed a consortium of university and energy industry partners that have the combined expertise needed to develop North Dakota's huge geothermal resource for electric power and district heating systems. In preparation of this proposal, we have obtained agreement for participation from five energy industry partners:

Neset Consulting Service, Inc. Our contact is RC Neset rcneset@nesetconsulting.com

ElectraTherm, Our contact is Robert Emrich, Managing Director at ElectraTherm. remrich@electratherm.com.

Climeon. Our contact is Laure Mora Regional Sales Manager. Laure.mora@climeon.com. https://climeon.com/

GeothermEx, Inc. Our contact is Ann Robertson-Tait, President of GeothermEx. ann1@slb.com

Basin Electric Power Cooperative Representative to Board meetings to be determined.

We are pursuing additional partners in the oil and gas industries and see the consortium eventually encompassing representation from the full range of potential applications including large-scale grid power projects to small- and medium-scale implementations for oil and gas sites, rural municipalities, industrial parks, and business, commercial and education campuses. Working with these partners and stakeholders will enable us to demonstrate the reliability and efficiency of geothermal energy and prove that the business case economics show ever-decreasing payback periods due to ongoing innovations in geothermal process and technology.

Stage I Task 1 *Quantification and delineation of the resource.*

The critical elements for quantifying the geothermal resource are formation temperature and fluid production capacity. UND has developed methods for accurate temperature determinations (Gosnold et al., 2012) in the Williston Basin and in task 2 we will apply these methods to better define the resource and to identify optimal targets for development. Fluid production capacity is a function of formation permeability, transmissivity, and pressure and will be assessed by the industry partners who have extensive knowledge of the geology of the Williston Basin. Identification of optimal geothermal sites through these analyses of critical parameters of temperature, fluid production capacity, in addition to well accessibility will be a team effort involving UND and the geothermal and oil and gas industries. We have learned from our most recent research that there are hotter and colder regions in the Basin, but they are yet to be clearly defined. Better knowledge of the resource temperatures is essential for economics and acquiring that knowledge is the goal of Stage 1.

Our prior research shows that heat flow, thermal conductivities and formations thicknesses vary laterally in the Basin and accurate application of our temperature determination method requires data from the well being evaluated rather than using data from wells tens of km distant or estimates from the literature. Thus, a major effort in Task 1 will be measurement of thermal conductivities on samples of core from our selected target wells or nearby wells and precision temperature vs. depth measurements in those wells or nearby wells.

The calculations, temperature, and thermal conductivity measurements are labor intensive and based on our experience will require at least two years to provide sufficient data to attain our goal of assessing the total amount of the geothermal resource. The work will be carried out by UND graduate and undergraduate students under supervision of PI Gosnold and Professor Crowell. The field work for measuring temperature gradients will take place during the summers and be coordinated with our industry partners.

Education in STEM and Industry Experience

The educational component in this project includes all stages with the aim of providing STEM graduates to carry geothermal development into the future. The educational elements will include undergraduate research projects and senior theses for geology students and senior design projects for electrical, petroleum, and geological engineering students. We also plan to develop internship opportunities for our students with our industry partners.

UND currently offers three graduate courses in Geothermics and we have been successful in attracting domestic and international students numbering eleven MS and eight PhD students. Geothermics has interested undergraduates also with twelve Geology Senior Theses and research projects and five Geological Engineering Senior Design projects completed during the past six years. Since the formation of the UND Geothermal Laboratory our students have participated with success in national competitions. In 2011 UND won a $10,000 award in an NREL National Geothermal Student Competition. In 2014 three UND student teams were selected as winters in NREL's OpenEI Geothermal Case Study Challenge. The students also have won awards for "best Papers" at Geothermal Resources Council meetings and have gained recognition as co-authors on 46 GRC publications. In 2020, the UND team, Dreamer Geothermophiles, was one of 15 teams to win a $32,000 award in the Ready Stage of a design challenge for additive manufacturing https://www.herox.com/GeothermalManufacturing/round/604/entry/32398.

On January 12, 2021, another team consisting of three students from the fall semester 2020 Geothermics II class received another award. This time for a Geothermal Design Challenge for promoting geothermal energy https://www.energy.gov/eere/articles/department-energy-announces-winners-fall-2020-geothermal-design-challenge.

Faculty involvement includes supervision and mentoring undergraduate and graduates' students and team teaching some of the Geothermics graduate courses in addition to leading the research activities.

Stage I Task 2 *Economic Analysis of Power Generation and Direct Use Geothermal Energy for Heating and Cooling*

In this task we will develop an economic plan for large-scale development of smart thermal grid distributed power plants and district heating systems that can supply communities and industry, academic, and military campuses in the Basin. The primary factors for the analysis are matching the quantity of energy that can be produced at a site with the cost of production. The energy from a geothermal well is calculated from $\boldsymbol{E = \rho c_v V \Delta T}$, where E is joules, ρ is fluid density in kg m^{-3}, Cv is fluid heat capacity in J kg^{-2} deg^{-1}, V is fluid volume, in m^{-3} and ΔT is the temperature difference drop achieved in the heat extraction process. A joule is a watt-second and conversion to kWh is straight forward where flow rate in volume per unit time, e.g. liters per second is known. Where the heat extraction process is for direct use, the energy equation is a good estimator of the resource. For power generation, the technology and efficiency of energy conversion are key factors. Resource temperatures between 70 °C and 150 °C require binary

power plants, usually organic Rankine Cycle (ORC) engines, and those systems vary in capacity with temperature and conversion technology.

Power Generation

In the early 2000s, the efficiency of ORCs was 6 percent or less for conversion of thermal energy to electricity, but innovations since then by companies such as Ormat, Calnetix, ElectraTherm, and Climeon have raised efficiencies up to 14 percent. Corresponding with machine efficiency, developments in the way the geothermal fluid is handled have increased the power capacity even more. For example, the power production capacity from the UND-CLR binary geothermal power plant was 250 kW with two Calnetix 125-kW ORCs (Gosnold, Mann, and Salehfar (2017). The fluid temperature and flow rate were 100 °C at 51 l s^{-1} and the one-pass flow through the ORCs took all of the heat (ΔT). The ElectraTherm and Climeon systems can cascade the ORCs in a flow chain that removes only a portion of the heat over a greater range in each ORC thereby increasing capacity up to 4x over single pass configuration. According to Ruben Havsed of Climeon (personal communication, 2017) their system could yield 1 MWe with the100 °C at 51 l s^{-1} resource available at the UND-CLR site. They have a new system coming online that will deliver power at $2,000 per kW (Laure Mora).

Cost of development includes many factors and the analysis of those factors will be the task of our industry partners who can transfer oil field technology to geothermal production. The amount of electric power generation that can ultimately be obtained from the geothermal resource is yet to be determined precisely, but our estimates indicate that it is four-orders of magnitude greater than the energy contained in fossil fuels in the basin.

Direct Use and Space Heating

Given the extreme continental climate of the north central United States, there are high demands for heating year-round. The mean annual temperature in central North Dakota is 4.3ºC and temperatures in the winter (December – March) average -12.4 ºC. Annual heating degree-days average approximately 4000ºC (8600 ºF). Average summer temperatures (June-September) are less than the base temperature, thus cooling degree-days are negative. The potential for meeting these heating needs with direct-use geothermal energy is excellent in North Dakota. Development of the thermal energy in the mid-depth (1,000 m to 2,000 m) moderate-temperature (50°C to 80°C)

formations in the Williston Basin and the upper few hundred meters of rocks throughout the state for direct use with district heating systems and ground source heat pumps could supply most of the heating and cooling demand in North Dakota. Current development in Europe creating high-efficiency smart grid heating systems will be a model for our analyses (Lund et al., 2014; Lund et al., 2018; Averfalk and Werner, 2020).

Our tasks in direct use are to quantify energy usage by amount and source and to assess the potential for developing geothermal heat for electric power production and district heating systems. We expect the results of our analysis to have national impact. Approximately 46 percent of the energy usage in the northern tier of US states comes from burning fossil fuels for heating and cooling of living and workspaces (Tester, et. al., 2020). Pivoting from fossil fuels to geothermal heating and cooling would be an immediate and effective response to the challenge of anthropogenic global warming (AGW).

Stage II *Planning conversion of a non-economic oil well to a geothermal well*

Stage II will lead to our ultimate goal, establishment of a geothermal industry in North Dakota by demonstrating conversion of a non-economic oil well to a geothermal well. This Stage utilizes the capabilities of our geothermal, oil and gas, and electrical power industry partners in direct roles. All have contributed to preparation of this proposal. Conversion of existing infrastructure using the capabilities of the oil industry is the most economic route for development of the resource. We are currently negotiating with Hess Corp. for use of a deep (4.5 km) well that is scheduled to be plugged and abandoned. Neset's analysis of prospects for developing the well as a turnkey project follow. "The well penetrates formations with temperatures of 140 °C to 155 °C and if flow tests are promising could yield 5 MW of electricity. Once an agreement has been reached with Hess existing plugs will need to be removed and a mechanical integrity test will need to be performed. Existing perforations may need to be cemented, if so, this is a simple procedure that is performed regularly. There are intervals in the Black Island formation of the Ordovician period that may be sufficient for geothermal electric power production. These intervals will need to be tested for fluid production. If these intervals do not meet the requirements of the project the well can be drilled deeper into the Cambrian Deadwood formation to access intervals that will meet the production requirements of this project." At this stage of the project we will link oil and geothermal technologies by bringing in the geothermal experts from GeothermEx who will use wellbore simulation techniques to assess water production rate and flowing wellhead

temperature after the well has been re-completed. GeothermEx will review the completion details of the target well, the plans for perforating and/or deepening the well (potentially including production from the Deadwood Formation, and evaluate available information about 1) historical production rates (hydrocarbons and water cut), 2) static and flowing temperature and pressure data (ideally profiles of these parameters vs. depth), 3) permeability and porosity as indicated by well logs or test data. This review will enable GeothermEx to simulate the impact of different re-completion options to maximize the flow rate of hot water from depth.

Anticipated Results

The results of this project will have positive impacts on the energy future of North Dakota by launching a new industry that will boost employment and provide long-term stability for the state's economy. It will lead to new jobs for new workers and a no-gap job transition for oil field workers and oil-field support industries. The transference of oil and gas extraction skills and technology to geothermal well development will yield technological advances in both energy sectors. It also will have a positive impact on the energy future of the nation by demonstrating how to develop the enormous energy resource in sedimentary basins for both power and district heating. It will add to our growing list of sustainable and climate friendly energy resources as a forward-looking path for reducing carbon emissions.

Facilities and Techniques to Be Used, Their Availability and Capability

UND has excellent facilities and support staff for hosting the project, managing the budget, and coordinating all elements of the project. Online remote meetings will be held with Microsoft® Teams will be used for consortium meetings. The UND Geothermal Laboratory has high precision thermal conductivity and temperature logging equipment. The thermal conductivity equipment needs upgrades due to age of some of the components.

STANDARDS OF SUCCESS

Deliverables for Stages I and II

- An active consortium of industry partners that will provide leadership for formation of a geothermal industry in North Dakota
- A quantitative report on potential for both geothermal power and direct use for all permeable formations in the Williston Basin.
- A database of geothermal characteristics of Williston Basin formations. i.e., temperature, depth, and thermal conductivity. This will be available to everyone through UND HHSGGE.
- A tabulation of existing P & A and non-productive wells and their characteristics relevant to geothermal development. The format will be developed by the board to make it most useful to potential users

Deliverables for Stage II

- A plan for an operating geothermal power plant using a converted oil well.

Value to North Dakota:

- Initiation of a new high-employment industry.
- New jobs and a no gap job transition for oil field workers
- Long term energy stability and security
- Education and outreach through meetings with communities

Value to the Environment

- Pivoting from fossil fuels for direct use space heating will directly address AGW.

BACKGROUND/QUALIFICIATIONS (see also Appendix I)

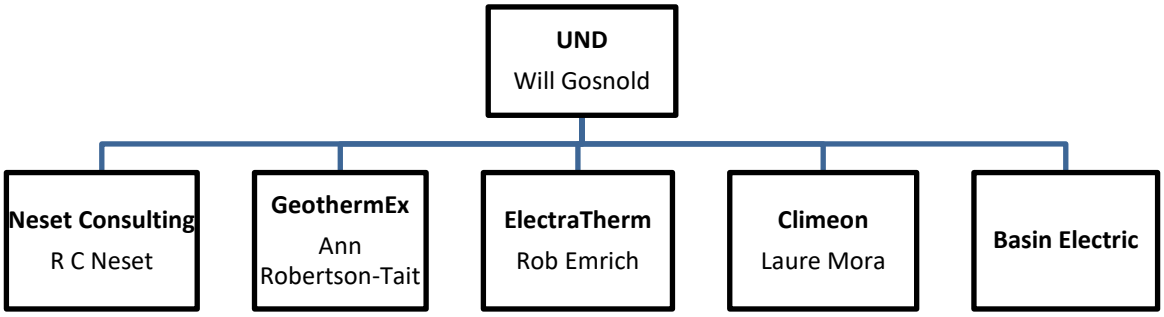
Principal Investigator: Dr. William Gosnold is Chester Fritz Distinguished Professor in the Harold Hamm School of Geology and Geological Engineering at the University of North Dakota. Dr. Gosnold's career spans forty-two years of research in heat flow, geothermal energy, tectonics, and climate change. He was a member of the team that developed the United States National Geothermal Data System for the US Department of Energy. He served as chair of the Department of Geology and Geological Engineering (2006-2010), interim chair of the Department of Petroleum Engineering (2015-2016) and is currently Graduate Director for the Harold Hamm School of Geology and Geological Engineering. He was PI or Co-PI on nine different geothermal and energy resource projects during the past decade totaling $7,869,503.

Co-PI, Dr. Hossein Salehfar has been with the UND School of Electrical Engineering and Computer Science (SEECS) since 1995 and has over thirty years of research and teaching experiences in electrical power and other related energy systems. Dr. Salehfar's research work has been supported and funded by DOE, NSF, and other agencies throughout his career. Specifically, Dr. Salehfar has worked and collaborated with the PI, Dr. William Gosnold, and his research team on geothermal energy related projects DOE-EE0002731 and DOE-EE0002854. The results of these collaborations have been published in various conferences and journal publications. Dr. Salehfar expertise and contribution will be focused on the geothermal heat to electrical power conversion activities of the proposed work.

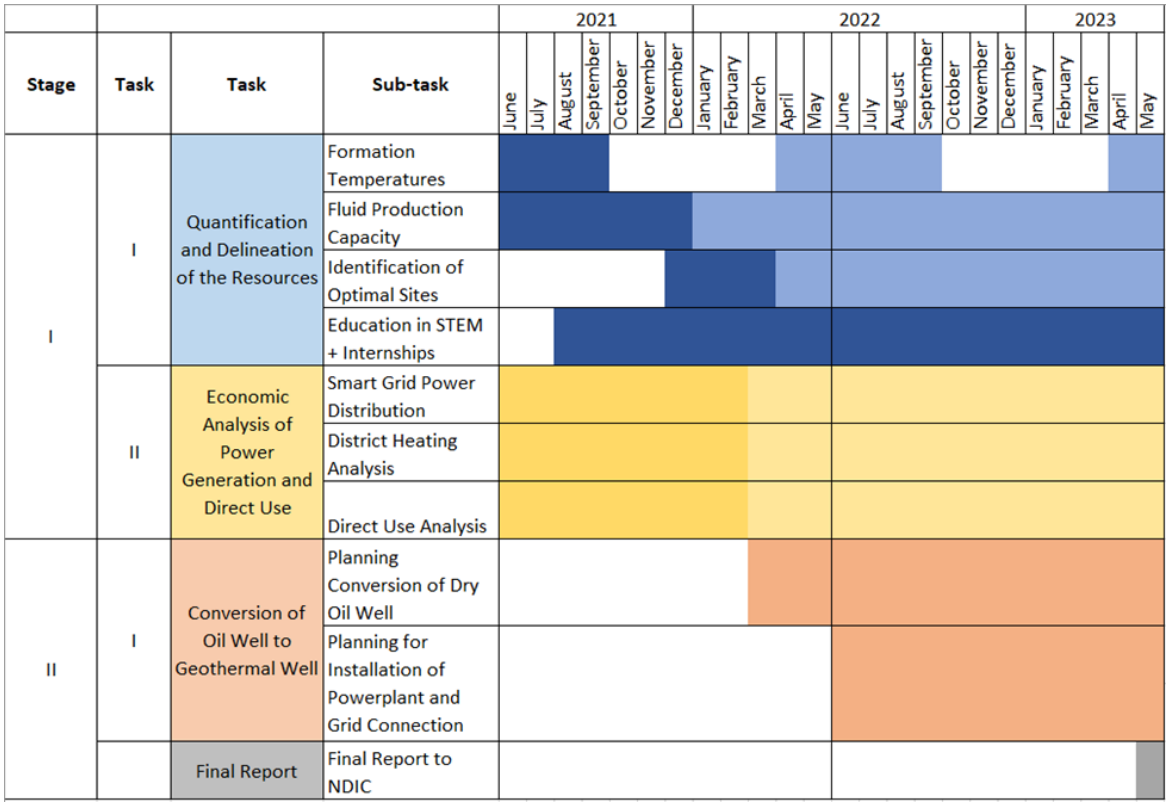
MANAGEMENT

The project will be based at the University of North Dakota and will be managed by a Board of Directors with PI Gosnold as chair. The founding board comprises the partners in the consortium at startup including the UND faculty and we will continue to seek and add members as the project develops. Board meetings will be held monthly via Microsoft® Teams and special meetings may occur more or less frequently as needed. Board meeting agendas will be set and circulated one week prior to the meeting. Written reports on all activities will be submitted all board members one week prior to each monthly meeting. The report structure will include an Executive Summary and details of activities in each task. The budget will be handled by staff in the UND College of Engineering and Mines and the UND Grants and Contracts Office. Budget expenditures and actions relative to the project will be discussed at Board meetings and approved by a majority of the Board.

Organizational Chart



Timetable



Budget

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
UND Faculty support	$73,748			
UND Student support	$55,593			
UND F & A	$78,450			
Field Work	$4,000			
Laboratory upgrade	$7,104			
UND CEM		$15,000		
Neset	$190,000		$410,000	
ElectraTherm			$10.000	
GeothermEx	$24,000		$6000	
Well Conversion				$8,200,000

Faculty support is for five faculty researchers covering the academic disciplines in the project: geothermal energy, petroleum engineering, and electrical engineering. Student support is for graduate and undergraduate students work in the laboratory and in the field. Field work is for travel for temperature logging. UND F&A is 41% of Total Direct Cost. The student field and laboratory work will include several thousand thermal conductivity measurements on core samples and borehole temperature measurements on 20 to 50 depending on access. Neset estimates that their work will require $600,000 and they are donating $410,000 (62%) for the project. We estimate the value of the well to be donated following Stage II at $8,200,000 and list it as under Other Project Sponsor. That donation is in negotiation.

UNIVERSITY OF NORTH DAKOTA

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February 5, 2021

Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Avenue
Bismarck, ND 58505-0840

Subject: Tax liability pertaining to UND's proposal, "Geothermal Development Consortium"

Dear Ms. Fine:

I am writing to you regarding the Tax Liability Statement which is a requirement for the University of North Dakota's proposal to the NDIC Renewable Energy Council. Dr. Will Gosnold is the UND Principal Investigator for this proposal entitled "Geothermal Development Consortium." As an Authorized Official of the University of North Dakota, I affirm that the University of North Dakota is a State entity and has no tax liability.

Please feel free to contact me at (701) 777-2505 or Karen.katrinak@und.edu with any questions.

Thank you for the opportunity to propose this project to the Renewable Energy Council.

Sincerely yours,

Karen Katrinak

Karen Katrinak, Ph.D.
Proposal Development Officer
Research and Sponsored Program Development

NESET

6844 Highway 40, Tioga, ND 58852 701-664-1492

7 February 2021

Dr. William Gosnold
Leonard Hall Room 114
81 Cornell Street Stop 8358
Grand Forks, ND 58202-8358

Dear Dr. Gosnold:

At Neset Consulting Services Inc. we feel privileged to be involved with this Geothermal Development Consortium and its possibilities. In the past 70 years it has been proven that the Williston Basin possesses a vast amount of energy potential. The petroleum resource of the Williston Basin continue to provide our society with energy needed to fuel our economy. The work of intelligent ambitious people are proving that the Williston Basin has more energy potential than has been proven thus far.

NESET Consulting Service Inc. is an engineering and geology consulting firm which provides services in the Williston Basin and Rocky Mountain region. NESET offers a range of services including design and project planning from our headquarters in Tioga ND. From there NESET deploys crews which manage the execution of highly technical subsurface projects related to oil & gas, CO2 sequestration, geothermal energy production and subsurface injection. Through its 40 year history NESET has provided expert services on over 6,125 wells.

NESET believes that the geothermal energy of the Williston Basin could be the next great energy resource in North Dakota. As with the development of any great resource, great effort must be applied by those who want to see its success. NESET has estimated that our services for development of the subsurface portion of the project will cost $660,000, of which NESET is willing to contribute $410,000.

Sincerely

Roy Neset Jr

RC Neset | VP Geology & Instrumentation

40 NESET YEARS

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Dr. William Gosnold
University of North Dakota
Harold Hamm School of Geology and Geological Engineering
Leonard Hall, Room 202
81 Cornell Street, Stop 8358
Grand Forks, ND 58202-8358
sent via email: william.gosnold@und.edu

2 February 2021

Ref: Williston Basin Geothermal Energy Research Project

Dear Dr. Gosnold,

Thank you for your efforts to advance geothermal energy in the Williston Basin, and specifically for preparing the above-referenced proposal to the North Dakota Industrial Commission (NDIC). GeothermEx has been involved in a geothermal project on the Saskatchewan side of the Basin, and we can expect that the operator of that project (Deep Earth Energy Production, "DEEP") envies the higher temperatures that are present on the US side, where your project will be located! We also have recent experience on the North Dakota side of the Basin, providing well designs, drilling management and well testing services for a CCS project.

As long-term geothermal practitioners, GeothermEx has witnessed remarkable progress in technologies that enable power production from low-to-moderate-temperature geothermal resources. The Williston Basin is an obvious choice for deploying such technologies. Your work will set the stage for geothermal developments in many deep sedimentary basins, the traditional domain of oil & gas operators. As the energy transition continues, your proposed project will inspire those operators to adapt their significant skills to develop geothermal projects, bringing employment opportunities and clean energy to North Dakota.

Within your project, GeothermEx proposes to use its skills in wellbore simulation to assess the likely productivity of an existing well that will be re-purposed for geothermal fluid production. This is only one small element of a big project; nevertheless, we strongly support your overall concept and therefore offer an in-kind cost share of $6,000.

Please do not hesitate to let us know if you require any additional information about GeothermEx's role in the Williston Basin Geothermal Energy Research Project. We wish you every success with your proposal, and hope to work with you to advance the development of geothermal projects in sedimentary basins.

Yours sincerely,

Ann Robertson-Tait, President, GeothermEx, Inc. (a Schlumberger company)
ann1@slb.com

UNIVERSITY OF UND NORTH DAKOTA

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PHONE (701) 777-3411 FAX (701) 777-4838
www.engineering.und.edu

February 3, 2021

Dr. Will Gosnold
Harold Hamm School of Geology and Geological Engineering
University of North Dakota

RE: Cost share support for NDIC Renewable Energy Council Proposal

The College of Engineering and Mines is happy to support your proposal "Geothermal Development Consortium" submitted to the North Dakota Industrial Commission Renewable Energy Council. This proposal is in close alignment with the goals of the college, and supports the University's One UND Strategic Plan by targeting UND's Grand Challenge Energy and Environmental Sustainability research area.

The College will specifically support your proposed effort by providing $15,000 in cash to be used as cost share. These funds will be provided from a local fund, independent from our appropriated and tuition revenues. As your contribution to the proposed effort, we will expect the PIs/Co-PIs to waive their share of any indirect costs associated with this project that would normally be distributed under CEM's current F&A distribution model.

I wish you the best of luck with your proposed efforts.

Sincerely

Michael D. Mann

Michael D. Mann
Associate Dean for Research
College of Engineering and Mines

ElectraTherm
BY BITZER GROUP

4080 Enterprise Way
Flowery Branch, GA 30542
www.electratherm.com

January 29, 2021

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81 Cornell St Stop 8358
Grand Forks, ND 58202-8358

Re: Williston Basin Geothermal Energy Research Project

Dear Dr. Gosnold,

We are pleased to support your work and to participate in the Williston Basin Geothermal Energy research and development project for renewable, sustainable, and ecologically sound energy for the future. Additionally, ElectraTherm is willing to help the project with in-kind labor and service contributions. Specifically, we will contribute with in-kind services up to a total value of $10,000 consisting of:

- Labor to perform modeling for output, performance, and heat balance
- Engineering labor for modeling of alternative working fluids and/or blends
- Operations and testing of project heat values and performance within the specification of our equipment on our test cell
- Technical assistance relating to ORC performance, parameters, and optimization

Feel free to contact me with questions by email or by telephone at 678-267-7700.

Sincerely,

ElectraTherm, Inc.
Rob Emrich
Managing Director
remrich@electratherm.com

CLIMEON

LAURE MORA
Head of Sales – North America
Climeon

08 FEBRUARY 2021

To: Dr. William Gosnold
Leonard Hall Room 114
81 Cornell Street Stop 8358
Grand Forks, ND 58202-8358

Dear Dr. Gosnold,

Climeon AB is pleased to support the Geothermal Development Consortium project submitted to the North Dakota Industrial Commission's Renewable Energy Program.

Climeon is a heatpower technology company that has successfully managed to convert low temperature geothermal waters (70 to 120degC) into clean baseload electricity at a unique efficiency rate in the ORC market. Climeon will deliver the modular powerplant on successful completion of the drilling and testing programme.

Climeon supports this initiative to develop a sustainable power industry in North Dakota with all the benefits that it generates: carbon emission reduction, flight against climate change, economic stability, employment and secure supply of baseload electricity.
We at Climeon are looking forward to cooperating with Dr Gosnold and his team on this project and to deploy our technology to deliver a new type of energy out of ageing oil and gas wells.

Best regards,

Laure Mora

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Appendix A

UND student support is for three graduate research assistants and three undergraduate research assistants.

The Federal UND Indirect Costs rate is 41% for research. Links to the UND research office web page and to the table of Indirect Cost Rates are below
https://med.und.edu/grants-management/fa-rates.html
https://med.und.edu/grants-management/_files/docs/fa-rate-agreement-04162020.pdf

We will use state rates and state vehicles for field work.
We estimate that we will need 60 temperature vs. depth log to fill in gaps in the existing database. Those field operations will be planned after contact with cooperating operators. We can log two wells per day.

Funding for the laboratory upgrade for replacement of two circulating baths used for thermal conductivity measurements. The bath units are13 years old and their electronics have shorted out. Each bath circulates a high heat capacity fluid through the heat source and heat sink maintaining temperatures with a 0.01 C precision needed for accurate measurements. The thermal conductivity measurements are used in accurate determinations of subsurface temperatures and are critical for our project. We last used the instruments in 2013- 2015 in a geothermal resource assessment of Minnesota for the U.S. Department of Energy.

The circulating baths cost $4,524 each.

The $15,000 cost share from the College of Engineering and Mines at the University of North Dakota is cash for undergraduate student support for work in the laboratory during the academic year. It was calculated from the time required to measure thermal conductivities on core samples for 60 wells. Then the request for matching funds was made to CEM.

Here is the statement from **ElectraTherm** on their cost share.
For our in-kind contributions, we will be providing:

1. Engineering time/labor ($200/hr) for output and heat balance calculations using ElectraTherm proprietary modeling software “Smarter Tool”. This will provide electrical production based on several variables including:
    - Input hot water temperature and flow rate (as provided by geothermal to hot water heat exchanger)
    - Available thermal energy from the geothermal resource
    - Condensing / cooling water temperature and flow rates, provided by either:
        - Dry cooler (liquid loop radiator)
        - Onsite cooling source
    - Smarter Tool calculations also include heat balance
        - Used kWth / BTUs
        - Hot water exit temperature

        - kWth / BTU rejected to the cooling source
        - Condensing / cooling water return temperature
2. Engineering labor ($200/hr) for modeling of alternative working fluids and/or blends
    - Alternative working fluids/blends will be evaluated for performance, output, and heat balance as described in item #1 above
3. Operations and testing of project heat values and performance within the specification of our equipment on our test cell ($400/hr.)
    - Test cell operation requires engineer and test cell operations personnel.
    - Test cell operations require considerable natural gas use for heating water to temperatures to meet specified test conditions (temperature, flow rate, thermal energy); and electrical consumption for condensing/cooling
4. Engineering labor/time ($200/hr) to provide technical assistance relating to ORC performance, parameters, and optimization based on input variables and alternative configurations, such as expander selection, heat exchangers, cooling sources, etc.

NESET

6844 Highway 40, Tioga, ND 58852 701-664-1492

16 February 2021

Preliminary cost estimate for well design and execution management for development of geothermal energy resource of the Deadwood Formation McKenzie County North Dakota.

Dear Dr. Gosnold:

Our team has completed a preliminary review of the scope of this project. NESET Consulting Service Inc has the resources, knowledge and experience to deliver the product required for this project. NESET can also address the challenges and offer a variety of solutions that meet both project requirements and budget.

This letter is addressing 3 parts of the development of the geothermal resource.

Geologic analysis. Assist UND with identifying the geographic location to explore and identify the best reservoir for this project. NESET feels that UND and its resources is capable of doing the majority of this work. NESET's portion of this phase is estimated at $160,000, of which NESET is willing to contribute 100%.

Wellbore design. Once a location and reservoir are identified NESET can design the subsurface facilities and secure the required permits. The anticipated facilities will be 1 well producing approximately 150 degree Celsius formation water. 1 injector well that will inject the formation water into the same reservoir that it was produced from. This well is expected to be within 1 mile of the producing well. 1 pipeline installed to transfer produced formation water to the injection well. NESET estimates the engineering and design of these facilities to be $300,000, of which NESET is willing to contribute 50% to the project. 50% will be needed to cover wages, benefits, transportation and housing for staff.

Wellbore plan execution. NESET can execute the designed plan which will include procuring materials, personnel, services and machinery. NESET will ensure successful execution of the wellbores, production testing, equipment installation and installation of the pipeline. NESET estimates this to cost $200,000 of which NESET is willing to contribute 50% to the project. 50% will be needed to cover wages, benefits, transportation and housing for staff.

Sincerely

Roy Neset Jr

RC Neset | VP Geology & Instrumentation

6844 Hwy 40

Tioga, ND 58852

O: 701-664-1492 | F: 701-664-1491