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 Ms. Fine at 328-3722, or Andrea Holl Pfennig at 328-2687.

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title:

Redesigning the Residential Wind Turbine (RWT) for Rural Areas with Abundant Wind Resources

Applicant:

Clean Republic LLC

Principal Investigator:

Yong Hou, Clean Republic LLC

Jing Shi, North Dakota State University

Date of Application:

May 1, 2010

Amount of Request:

$186,000

Total Amount of Proposed Project:

$372,653

Duration of Project:

2 Years

Point of Contact (POC):

Yong Hou

POC Telephone:

218-791-3746

POC Email:

hou@cleanrepublic.com

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ABSTRACT

Objective:

Wind power, which does not generate CO_2 emissions or consume water, is a highly attractive renewable energy option for the states with abundant wind resources like North Dakota. Both federal and state governments are establishing incentives for renewable energy production, especially for wind turbines, with an ambitious objective of producing 10% renewable energy in North Dakota by 2015. Large-scale wind energy production is still an elite game, struggling at present because of a lack of adequate power line transmission capacity and financing. As such, **the objective of this proposal is to develop small and reliable wind turbine systems that meet the circumstances of rural communities in terms of balancing technology and the costs of production, installation and maintenance.**

Expected Results:

The results expected from this project are (1) capability of accurately estimating North Dakota wind resources of any sites based on a novel method, and development of software code; (2) low-cost 5-10 KW Residential Wind Turbine (RWT) systems using technologies such as innovative mechanical pitch-control, lever-based tower system, and reliable permanent magnet generator; and (3) field test of the proposed RWT systems in North Dakota.

Duration:

Two years (Suggested: Nov. 1, 2010 – Oct. 30, 2012)

Total Project Cost:

$186,000 requested from NDIC

$372,653 for total project cost

Participants:

Clean Republic LLC

North Dakota State University

University of North Dakota

PROJECT DESCRIPTION

Objectives:

The ultimate objective of this project is to develop small and reliable residential wind turbine (RWT) systems that meet the circumstances of rural communities in terms of balancing technology and the costs. The current 5-10kW RWTs on the market have at least a 13-year payback period, with a front-end entry cost of at least $25,000 to $40,000. We strive to significantly reduce the unit cost as well as the operation and maintenance costs, and earn a payback of less than 10 years.

Methodology:

To achieve the objectives, we plan to conduct research and development on several key areas regarding small wind turbines. The key areas for improvement are identified to be (1) developing a new model to effectively estimate the wind potential of a potential site at various elevations above ground; (2) developing and comparing multiple pitch control mechanisms for small wind turbines; (3) simplifying the installation and maintenance of RWTs; and (4) effectively integrating components to improve the energy harvesting efficiency, preventing generator overloading, and thus further decrease the overall cost. The main project activities are described in details as follows.

1. Wind potential estimation

The large scale estimation of wind energy potential is based on the computation of complex physical models (such as the GEOS-5 system developed by NASA). However, the large scale estimation is usually rough and computational intensive due to two reasons. First, the computation resolution is not high enough to handle the assessment of a particular site of wind turbine installation [1]. Second, the accuracy of wind estimation is generally lower than that made based on the information from local weather or wind observation stations. As such, we propose to develop an innovative method for accurate wind speed estimation. This method applies Kriging statistical model [2,3] to map the spatial wind information based on the existing North Dakota weather observation networks (e.g., http://ndawn.ndsu.nodak.edu/), the wind observations made by the state and utility companies since mid 1990s, as well as other sources. Kriging model can efficiently and effectively infer the wind information of one unknown site at various elevations from the known wind information from its sounding sites. It provides the foundation for selection of installation site and tower height.

2. Tower height

In the United States, the business of RWT started in the Western and Southern states, most notably in California, Colorado, Oregon, and Texas, where density of population and electricity price are quite high but wind resources and intensity are moderate. Most RWT products in the U.S. design the tower height as high as 100 feet. In contrast, it is arguably true that the wind intensity in North Dakota or nearby region is too strong at this height to be controlled effectively for RWTs. According to a typical power curve of RWTs, over-speed wind does not produce any extra output. Instead, the power output may drop. Our research results [4, 5] indicate that the average wind speed at 33-ft above ground is around

5m/s or higher for all the North Dakota sites. This make us hypothesize a 30-40 ft tower will be suitable for the RWTs. It may lose 10-25% of its power output during gentle wind days compared with a 100 foot tower, but it only costs 1/3 to 1/5 as much as its larger competitor. For any particular site, the selection of tower height will be subject to the verification from the model in the first activity.

3. Lever Tower

Following the choice of the tower height, we propose to use a lever-based tower system for the ease of installation, operation, and maintenance. The schematics are shown in Fig. 1. The lever tower is galvanized by dipping and plastic coated for anticorrosion. We will also explore the possibility of replacing the steel frame with fiber-reinforced plastics. In this regard, we will work with a North Dakota composite manufacturer – Sioux Manufacturing. With this design, labor can be saved in both installation and maintenance, and no cranes will be needed. The lever tower provides an opportunity of saving not only 2/3 of the installment cost, but also reducing future costs as compared to a regular tower.

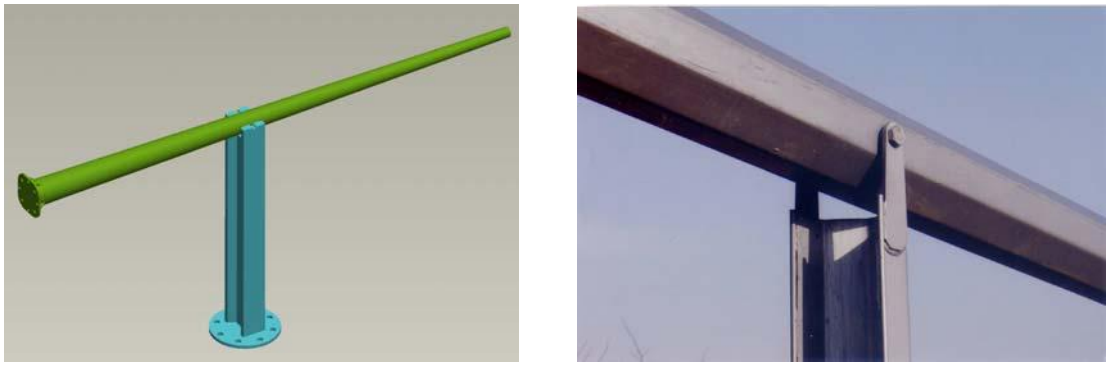

Fig. 1: Lever tower concept

4. Pitch-Controlled Blades

In cases of high wind speeds (>rated wind speed), it is desirable to keep the wind turbine at constant speed. In other words, to prevent overloading, the excess power available at the higher wind speeds should be discarded. This can be realized by pitch control. When the wind speed is low, the pitch angle is kept small; when the wind speed becomes larger, the angle increases to shed the aerodynamic power. Generally, the pitch-controlled blade is employed in 20 kW or larger turbines. Considering frequent strong winds and blizzards that occur regionally, we seek to exploit a pitch-controlled blade system in 5-10 kW turbines. Typically, there are two ways to realize the pitch control mechanism. For larger turbines, it is usually realized by a complicated closed-loop electrical control system. The controlled electrical motors adjust the pitch angle. Nevertheless, the electrical control system is not suitable for small wind turbines because it adds significant cost, and complicates the maintenance for home owners. As such, a simple mechanical feed-back system is more desirable.

Here we have two options for reliable pitch control for the 5-10 kW RWTs, and both use the centrifugal force to achieve variable pitching. The first option (Fig. 2) uses a bearing-based connector to adjust the pitch angle, and a spring restore mechanism to reduce the pitch angle when the wind speed reduces.

The second option is even simpler – it eliminates the use of spring restore and bearing connector. As shown in Fig. 3, it is built on the support of several metal beams. The centrifugal force due to the flyweight will twist the beams and adjust the pitch angle. Its benefits are reduced noise and vibration from the rotor, and the quick adjusting and restore of pitch. We plan to build and test both pitch control options in the 5-10 kW RWTs. In addition, we plan to employ a mechanical brake to further reduce turbine damage and system malfunction caused by extremely high winds.

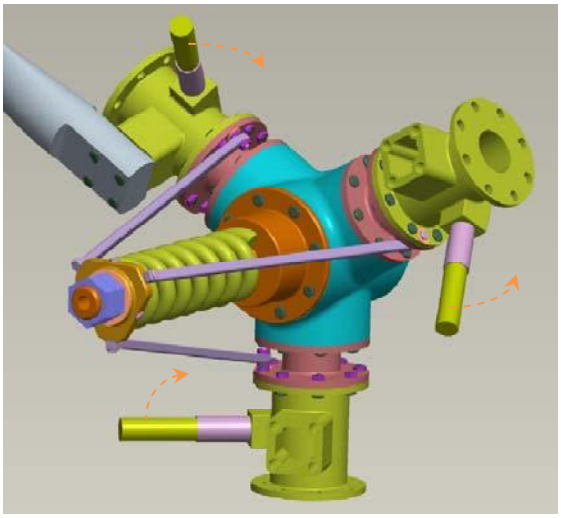

Fig 2: Pitch control concept – I

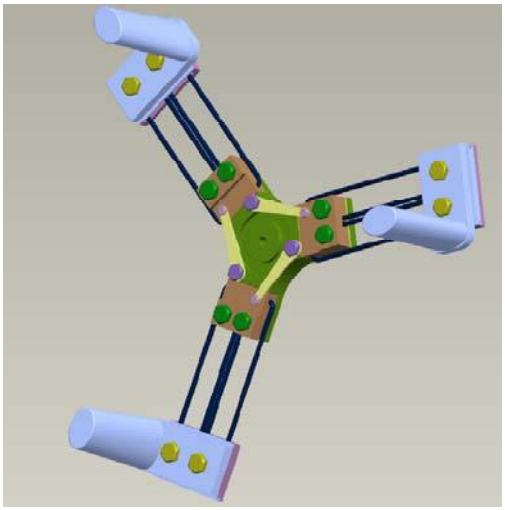

Fig 3: Pitch control concept – II

5. Permanent Magnet Generator

There are essentially two types of generators used in the RWT systems, namely, (a) Synchronous Generator + Hypoid Gear (SHG), and (b) Permanent Magnet (PM) Generator. We will employ the PM generator system, in that the outdoor installed gear is likely to develop possible malfunction under inclement winter conditions in North Dakota. However, the PM generator requires complicated electrical equipment including a turbine-specific controller and inverter, which are easily moved to a residential building to avoid the effects of cold weather. On the other hand, turbine-specific inverters should be used with PM generators. To prevent overloading and fluctuation of power generation, the selection criterion for inverters is typically 30% - 50% higher than the rated power of wind turbines. This would significantly increase the cost of the wind turbine systems – the typical prices are around $3,000, $6,000, and $14,000 for the 5kW, 10kW, and 10kW inverters, respectively. However, this problem should be effectively mitigated by adopting the reliable pitch control mechanisms introduced above. Moreover, we plan to introduce an overloading/speeding protection design to the PM generator such that the output current will not increase with the increase of rotor speed after reaching a threshold value of RPM.

6. Other Considerations

To achieve the goal of developing low-cost and reliable RWTs, other components (e.g. the inverters) also need to be considered besides the technological improvements discussed above. The RWT inverter is

capable of feeding power to the grid converting the power generated by a small turbine. When the wind turbine is not generating enough energy, the power required by the connected users is provided by the public power grid. If the energy produced by the RWT exceeds the quantity required by the user's load, the extra power is directly fed to the grid. According to ND regulations, the power produced can be credited to the user against future consumption, and thus it provides financial saving. Note that we don't plan to do in-house innovation for all these components in this project due to the time and budget constraints. Instead, we plan to focus on the selection of components, as well as system integration.

7. Testing the RWTs

Field test is the most appropriate way to test the performance of a wind turbine. There are two commonly accepted protocols for small wind turbines, namely, the testing standard from the American Wind Energy Association (AWEA), and the European standard. In our case, we plan to adopt the AWEA protocol (www.awea.org), which was first introduced in 1988. It should be noted that up to date, there are few small wind turbines on the market that comply with the standard, and we will strive to meet these provisions.

The AWEA standard urges the manufacturers to measure the performance and operating characteristics of their wind turbines so that the consumers will have adequate information to compare different products. The core of the AWEA standard is to measure the power curves. We plan to follow the standard to continuously collect wind speed, direction, and temperature, pressure. Note that the wind turbines will be interconnected with a utility network, and the power generation will be measured by a watt transducer as recommended by the standard. A test report will be prepared (and be made available upon request), and the power curves and other test results will be included.

Anticipated Results:

Overall, there will be two major outcomes from the execution of the proposed activities. One is the development of a statistical methodology (and correspondingly a software code) for accurate estimation of wind potential at various elevations above ground, based on the wind record from a limited number of observation sites. This will not only be useful for this project, but also benefit the general development of wind power. The other is the re-designed RWTs with advanced features and balanced selection of components. It will be expected that some R&D results developed from this project will be patented. The RWTs are expected to have a startup wind speed around 2m/s, and a working wind speed range of 3-30m/s, and it should be able to survive at the gust of 60 m/s.

Facilities & Resources:

The following facilities and resources are available at Clean Republic LLC, NDSU, UND, and field test sites. They will be used to carry out the proposed project.

1. At Clean Republic LLC, a shop space of 5,000 square feet located at 5515 University Avenue, Grand Forks, ND, will be used for the project. The facility has multiple PCs, measuring devices,

electronic test instruments, work benches, small drilling machine, hand tools, and other necessary tools available for design, assembly, and test of the residential wind turbines.

2. The machine shop hosted in the Department of Technology at UND will be available for Dr. Hou to make necessary components using machining operations. The equipment includes CNC lathe, CNC milling machine, grinding machine, etc. Staff will provide help if needed. Please see the attached support letter from the department chair, Dr. Yearwood.
3. To evaluate the performance of the proposed RWTs, it will be critical to conduct field tests and data collection in the land property of one or two families. After installations, the field tests will be conducted to monitor of wind speed, direction, and power generation. In this regards, we have secured support from two families to deploy RWTs in their properties, located in Grand Forks and Nelson County respectively.
4. At NDSU, Dr. Shi has the full access to the Manufacturing Lab and Automation & Control Lab, both of which are hosted in the Department of Industrial and Manufacturing Engineering. In the Manufacturing Lab, multiple CNC and manual machines are available for the fabrication of components if needed. Two research specialists employed by the department in the lab may also provide assistance. In the Automation & Control Lab, electronic devices, such as sensors, microcontrollers, oscilloscopes, signal generators, are available for this project.
5. To perform the wind resource assessment using a new methodology at NDSU, two high-end desktop PCs with quad-core Intel i7 CPU and 9G RAM in the Automation & Control Lab will be dedicated to the project. For data analysis, coding, and visualization, a number of software packages such as LabView and MatLab are available. Laptops are also available for field installation and data collection.

Techniques to Be Used, Their Availability and Capability:

Kriging method is a special statistical technique used to estimate the function value at an unobserved position. It was developed by Danie G. Krige, a mining engineer in South Africa [6]. The literature shows that Kriging has wide applications [3, 7] due to its interpolation accuracy, and the Kriging models widely adopted are Ordinary Kriging (OK). Liu and Maghsoodloo [2] recently developed a novel Kriging model based on Taylor expansion, named Taylor Kriging (TK), where Taylor expansion is used to identify the base functions of Kriging. Taylor expansion has the excellent nonlinear approximation capability, thus enhancing the interpolation accuracy of Kriging. The methods, especially, the newer TK approach, are very promising. We will be one of the first who apply either the OK or TK approach to spatial wind resource estimation.

Other proposed improvements for re-designing RWTs are innovative. They include the mechanical pitch control mechanisms, overloading protection for PM generator, and construction of lever tower. These improvements may not be necessarily regarded as the state-of-art research because the physical concepts are clear and straightforward. However, the designs and products coming out of these innovative concepts will still need to be tested and verified, and the results are expected to be patentable. Similarly, the selection of other components and the optimal integration of the technologies

will also be a challenge during the execution of the project, but we are confident that these are feasible and we will be able to deliver a viable technical solution.

Environmental and Economic Impacts while Project is Underway:

We do not anticipate any major environmental impacts when the project is underway. The minor negative side is the volatile emission problem in the manufacturing of wind turbine blades with our contracted industrial partners. This problem is almost universal for the molding of any fiber reinforced plastic (FRP)-based blades. Low styrene emission resins and all necessary protective means will be employed to minimize the impact on environment and human beings.

The direct economic impacts during the execution of the project will be the business activities at Clean Republic LL, NDSU, and UND – workers and students will be hired. Meanwhile, we expect to expand our connection with local and regional manufacturers, utility companies, as well as the investors. With the help of this grant, we intend to spur the exploitation and effective utilization of abundant wind energy in North Dakota. In addition, the proposed Kriging method to assess wind resources (with the focus on low elevations above ground level) based on meteorology/wind observation network will be developed into a software code. The commercialization of this software code alone may carry economic impacts such as bringing extra revenue to the company and NDSU.

Ultimate Technological and Economic Impacts:

1. Protect the environment, stimulate the renewable energy industry in North Dakota, and reduce CO_2 emissions.
2. By obtaining federal and state financing incentives for wind energy, such as tax breaks (30% credit), low interest loans, and federal grants, rural families and businesses have the opportunity to use our unique wind resources.
3. Enhance local manufacturing businesses. Local manufacturing companies will have the opportunity to fabricate components, electric facilities, and assemble the residential wind turbines, which will in turn dramatically reduce the cost of the small RWT product and respond promptly to the demand of our rural customers.
4. Activate local service businesses, from installation to operations to maintenance.

Why the Project is Needed:

Wind generation, which does not generate carbon emissions or consume water, is an environmentally-friendly form of electrical generation. Wind power could provide 20% of U.S. electricity needs by 2030, according to a DOE report of 2008 [8]. Currently, most installed wind turbine systems in the U.S. are large-scale units. The front-end acquisition, installation, and transmission costs are also quite large, averaging $2 – 6 million per unit. On the other hand, approximately 24% of the U.S. population lives in rural areas, which is important because a small wind turbine with enough power output to provide a substantial portion of the electricity needed by the average U.S. home generally requires at least one

acre of property. North Dakota has the most abundant wind resources of any state in the country, according to a U.S. Department of Energy report [9], yet it is also one of the least populated. Considering the ambitious objective of producing 10% renewable energy in North Dakota by 2015, wind power, and in particular Residential Wind Turbines (RWTs), will play a significant role.

Although North Dakota has unique wind resources in this country, as well as strong interests in developing this exciting green industry, the wind turbine business looks like an elite game far from a rural community's day-to-day life except for a few giant towers built by the companies with deep pockets. However, the lack of adequate power line transmission capacity in North Dakota, South Dakota, and Northwestern Minnesota has limited the growth of the burgeoning wind energy industry in this region. The transmission expansion would require $5-10 billion over a span of 10 years. To break this bottleneck and achieve our 2015 goal in time, a surge of distributed, small wind turbine systems – which require significantly less investment – can be installed promptly with no extra transmission capacity required. In spite of the incredible growth of the small wind turbine business in some states like California and Oregon during the last decade, not many small wind turbines can be found on the North Dakota countryside. We believe that the gap between low electricity price and high-cost, small-wind turbine facilities should be bridged for rural North Dakotans.

STANDARDS OF SUCCESS

This project is mainly a joint effort between a private company, Clean Republic LLC, and a higher education institution, NDSU. Meanwhile, faculty and students in the Department of Technology at UND will be actively involved in the project. The deliverables are clear – the new wind estimation technology and the innovative small wind turbines that are efficient, reliable, and easy-to-maintain.

One pillar of North Dakota development is the energy industry. Besides the abundant oil reserve in west part of the state, North Dakota is also the state with largest wind energy potential but far from sufficient wind turbine installation. Wind energy has the potential to be a driving force for the development of state economics. Some technologies developed from the project are expected to be patentable and will be commercialized. This helps the incubation of new companies and the growth of existing companies in North Dakota. The RWTs developed from this project will greatly help the home owners in the areas with abundant wind resource to afford reliable and low-cost RWTs and utilize the wind energy.

This project will have a direct impact on the education of students at NDSU and UND. There is a sizable demand for student training in renewable energy. At NDSU, there will be two graduate students directly involved with this project, and more undergraduate students will be also given opportunity to develop experience with wind energy. Two seminars regarding the R&D issues of this project will be given to NDSU students. At UND, there are two courses that will benefit from this project, one is TECH 590 - Renewable Energy Economics, and the other is TECH 403 – Product Research and Development. The courses have been well received, and they can be further improved by incorporating the experience gained from the project. The research results will also be disseminated to both academia and industry people by presenting at the annual WINDPOWER conference.

BACKGROUND/QUALIFICIATIONS

Dr. Yong Hou of Clean Republic LLC and Dr. Jing Shi of NDSU will serve as the Principle Investigators for this project. This is a collaborative effort between a company and higher education institutions. By closely working together, Drs. Hou and Shi will jointly lead the team.

Dr. Hou's expertise is in the field of renewable energy technologies. He is the co-founder of Clean Republic LLC, with offices in Grand Forks, North Dakota and Settle, Washington. The company focuses on developing personal alternative energy products such as electric bike conversion kits and residential products such as small wind turbines. Dr. Hou has not only published many papers in academic journals, but has personally invested and been involved in many other renewable energy projects such as the development of advanced Li-Ion rechargeable batteries. Before he returned to the graduate school for PhD in the area of renewable energy, he founded and grew his first company into a wholesaler of Compaq Computers with annual revenue of $13 million USD. Currently, he also works as a part-time professor for the Department of Technology on renewable energy topics. In addition, Dr. Hou has a B.S. and M.S. in electrical engineering, and several years' experience with electrical power industry.

Dr. Shi is an Associate Professor in the Department of Industrial and Manufacturing Engineering on 9-month contract at NDSU. He received his Ph.D. in Industrial Engineering from Purdue University. Dr. Shi is in charge of the Automation & Control Lab and teaches automation related courses at NDSU. His current research interests for renewable energy are about wind resource evaluation, wind forecasting, reliable penetration of wind/renewable energies into the power grid, design of new wind turbine systems, and manufacturing of renewable energy materials. Dr. Shi has authored and co-authored 43 refereed journal papers (8 papers are under review), 24 refereed conference papers, and 3 book chapters. In the period of 2009 – 2010 alone, Dr. Shi has published more than 10 technical papers on wind modeling, and he is regarded as a leading researcher in this area in the world. His papers appear in reputable journals such as *Wind Engineering*, *Renewable Energy*, *Energy Conversion and Management*. In addition, he is a reviewer for more than 10 prestigious technical journals, 6 conferences, and 2 books.

Mr. Alex Johnson, an Assistant Professor in the Technology Department on 9-month contract at the University of North Dakota, will also be actively involved in the project – in particular, on the product design and system integration of the RWT components. His focus in the department is on manufacturing and technical design. He teaches courses ranging from production processes to computer-aided design and drafting. Mr. Johnson spent several years working for companies such as Bobcat, Cirrus Design Corp, EAPC Architects Engineers, and Concrete, Inc., which provided him with valuable experience that he brings to the classroom. Mr. Johnson has a special interest in practical and hands-on learning and includes service learning in his courses to broaden the students' learning experiences. He has established a partnership with Turtle Mountain Community College to involve his students in and has presented at workshops regarding service learning. Mr. Johnson is currently pursuing a Ph.D. in Teaching and Learning with a focus on the use of technology in education.

MANAGEMENT

The principal investigators of this project are Dr. Yong Hou from Clean Republic LLC, and Dr. Jing Shi from NDSU. This will be an excellent opportunity for collaboration between industry and university, and to contribute to the economical development of North Dakota. A good management plan will be the key to the success of the project.

Dr. Hou will be the point of contact for the project, and he oversees the entire project progress. It is expected that he will lead a team of 3-4 people from Clean Republic LLC, and the major responsibilities will be the integration of technologies, the design and manufacturing of components, assembly, field tests, and report writing. Dr. Hou will also coordinate with Prof. Johnson at UND to expand the participation of UND students in the related courses that they offer. Dr. Shi also oversees all the aspects of the project. He will supervise 2 graduate students from NDSU for this project, and the major responsibilities include the evaluation of wind potential at reduced elevations in North Dakota, assisting the development of technologies, the field tests, data analysis, and report writing.

The project will be executed based on frequent communication and coordination between the company, NDSU, and UND. Within the company or NDSU, the individual team is expected to meet every week to discuss about the progress and the plan for next week. Between the company, NDSU, and UND, the timely information exchange by email and phone calls is kept open. Meanwhile, a telephone conference will be scheduled every month for all team members to check against the milestones set for the project, and address all the outstanding issues. Physically, the team is expected to meet once every 3 months, and the meeting place will be alternated between Grand Forks and Fargo.

Project reports will be periodically prepared by the PIs and submitted to NDIC for record. The PIs are also expected to prepare manuscripts based on the research results from this project, and submit them for publication with technical journals and conferences. A final report will be prepared and submitted at the end of the project period.

TIMETABLE

November 1, 2010: Project starts.

November 1, 2010 – May 31, 2011: Development of a Kriging-based model for accurate wind resource estimation in North Dakota. A software code will be developed for the general purpose of wind estimation. Also, we are expected to demonstrate the high wind potential for RWTs at the low elevations of 30-40 ft above ground. This work will be mainly performed at NDSU. An interim report will be submitted.

November 1, 2010 – May 31, 2011: Development of two pitch control mechanisms, and lever tower structure. Design and manufacture of these key components will be accomplished during this period. Meanwhile, the initial re-design of prototype RWTs will be finished.

March 1, 2011 – October 31, 2011: Development of overloading protection mechanism for the PM generator. The initial plan is to purchase a PM generator, and modify it by adding the overloading protection mechanism. An interim report will be submitted.

November 1, 2011 – March 31, 2012: Design and selection of other turbine components. For instance, the procurement of a set of wind blades, and the selection of proper inverters should be accomplished. Two prototype RWTs will be assembled during this period. An interim report will be submitted.

April 1, 2012 – October 31, 2012: Installation and field tests of prototype RWTs. Data will be collected from the tests. A final report will be prepared and submitted to NDIC. The project ends.

BUDGET

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
Personnel				
Project management		$15,000 (Company) $22,653 (NDSU)	$32,000 (Company)	
Wind resource assessment	$20,000			
Development of pitch control, lever tower	$20,000	$10,000 (Company)		
Circuit/software development	$30,000	$20,000 (Company)	$15,000 (Company)	
System integration	$30,000	$10,000 (Company)		
Labor (manufacturing)	$10,000	$10,000 (Company)	$20,000 (Company) $5,000 (Sioux Mfg)	
Materials/components				
Blade subcontract	$8,000			
Two generators (5kW and 10kW)	$8,000			
Two inverters	$15,000			
Mechanical components	$5,000			
Electrical hardware	$8,000			
Power monitoring device	$7,000			
Others	$2,000	$3,000 (cash, UND)	$1,000 (Sioux Mfg)	
Travel				
Team meeting	$4,000			
Field testing	$3,000			
Conference	$3,000	$3,000 (NDSU)		
Field installation/testing				
Truck rental	$3,000			
Use of property			$20,000 (in-kind, use of property land for installation and tests)	Mr. Tom Kenville and Mr. Craig Silvernagel (pending)
Labor (testing)	$10,000			
Total	$186,000	$93,653	$93,000	

Budget Justification:

Clean Republic LLC (i.e., the company) requests a total amount of $186,000 for this project. The company will issue a subcontract to NDSU for the amount of $80,885. The total cash matches from the company, NDSU, and UND add up to $93,653, while the in-kind matches from the company, Sioux Manufacturing, and two property owners add up to $93,000. Note the cash matches from NDSU and UND are not state funds, and all match funds are pending upon the approval of the project by NDIC.

Clean Republic LLC will use $52,000 for purchase of materials and components that are necessary for developing two RWTs. Meanwhile, the company will use the remaining $53,115 to cover the expenses of staff salary, field testing, and travel. On the other hand, the company will invest significant resources on the project, which include $65,000 in cash for personnel salaries, and $67,000 for in-kind salary due to the direct hours from Dr. Yong Hou (620 hrs at $50/hr), and the consulting services in summer from Dr. Jing Shi and Mr. Alex Johnson (300 hrs per person at $60/hr).

At NDSU, the total direct cost will be $56,366, and the indirect cost will be $24,519 (43.5% of the direct cost according to NDSU Policy Manual Section 813). The direct cost will be used to support two graduate students for two years and one temporary staff for 3 months. Meanwhile, the IME department at NDSU plans to provide a cash match of $25,653 for Dr. Shi's summer salary and travel in the two project years.

CONFIDENTIAL INFORMATION

No confidential information is involved with this grant application.

PATENTS/RIGHTS TO TECHNICAL DATA

Clean Republic LLC and NDSU jointly reserve the right to all intellectual property developed under this project.

TAX LIABILITY STATEMENT

April 30, 2010

Clean Republic LLC has no unpaid outstanding taxes to the State of North Dakota or its political subdivisions.

Yong Hou

Yong Hou, PhD
Vice President and Director of Product Development

Transmittal Letter

This letter is an indication of commitment from Clean Republic LLC to proceed with the proposed project – "Redesigning the Residential Wind Turbine (RWT) for Rural Areas with Abundant Wind Resources". As outlined in the proposal, large industrial wind turbines require significant amount of capital investment on the units as well as infrastructure. This is not feasible in many rural areas. Meanwhile, the current RWTs with advanced pitch control and overloading protection are deemed as out-of-reach for many families due to the high upfront price tag and long pay-back period.

By partnering with NDSU and UND, we aim to develop the low-cost and reliable RWTs for rural areas. New designs and technologies will be developed and integrated into the RWTs. For instance, we will re-design the pitch control systems based on two innovative concepts, and certainly they will be verified in the prototype products. Also, the feasibility of 30-40 ft high lever tower in North Dakota will be verified by a new methodology/software code which in fact can be used to provide tailored installation height information for any other areas. This project will carry significant economical and educational impact on the renewable energy development in the state of North Dakota. With the success of the project, we expect regional manufacturing industry to join force to commercialize the re-designed RWTs. Meanwhile, the project will greatly benefit the learning experience of college students at both NDSU and UND, and prepare them for a career in renewable energy.

We are requesting $186,000 from NDIC to support this project, and the project duration will be 2 years. Also, Clean Republic LLC is committed to providing match funds of $65,000 in cash for personnel salaries, and $67,000 for in-kind salary due to the direct hours from Dr. Yong Hou, and the consulting service in summer from Dr. Jing Shi and Mr. Mr. Alex Johnson. By the end of 17 months, we expect to have the prototype RWTs assembled. We plan to use the remaining 7 months for field installation and tests.

Yong Hou

Yong Hou, PhD

Vice President and Director of Product Development

APPENDICES

A1- References:

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[2] Liu, H., and Maghsoodloo, S. Taylor Kriging for simulation metamodeling. VDM Verlag Press, 2009.

[3] Liu, H., Shi, J., and Erdem, E. Prediction of wind speed time series using modified Taylor Kriging method. Energy, 2010, under review

[4] Zhou, J., Erdem, E., Shi, J., and Li, G. Comprehensive evaluation of wind speed distribution models: A case study for North Dakota sites. Energy Conversion and Management, 2010, 51(7), 1449 – 1458.

[5] Qu, X., and Shi, J. Bivariate modeling of wind speed and air density distribution for long-term wind energy estimation. International Journal of Green Energy, 2010, 7(1), 21-37.

[6] Krige, D.G. A statistical approach to some basic mine valuation problems on the Witwatersrand. Journal of the Chemical, Metallurgical and Mining Society of South Africa 1951; 52: 119-39.

[7] Kleijnen, J.P.C,. and van Beers, W.C.M. Robustness of Kriging when interpolating in random simulation with heterogeneous variances: some experiments. European Journal of Operational Research 2005; 165(3): 826-34.

[8] U.S. Department of Energy. Energy efficiency and renewable energy, 20% wind energy by 2030 – increasing wind energy's contribution to U.S. electricity supply. DOE/GO-102008-2567, May 2008.

[9] U. S. Department of Energy. Small wind electric system – a North Dakota consumer's guide. DOE/GO-102007-2406, April 2007.

A2 - Support Letters:

Please see attached pages.

April 30, 2010

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

Dear Ms. Fine and Proposal Review Team,

Please accept this letter as Tglobal's intent to support the *Redesigning Residential Wind Turbine (RWT) for Rural Areas with Abundant Wind Resources* project proposal from Dr. Hou at CleanRepublic, LLC and Dr. Shi from North Dakota State University.

As the property owner of the Tglobal logistics center and long-time supporter of North Dakota entrepreneurship and new venture development, I would be pleased to offer our warehouse and facilities as a trial location for Dr. Hou's wind research and development project. Clean Republic LLC already rents space in our logistics center. I believe our facility offers a unique combination of advantages for the development of this project as there is space for tower installation, testing, and technical analysis of wind turbine performance all at a single location.

We have had a strong working relationship with Dr. Hou and his group for many years and I look forward to more collaboration and supporting this rural wind development project.

Sincerely,

Tom K. Kenville
President, Tglobal
5515 University Avenue
Grand Forks, ND 58203

April 30, 2010

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

Dear Ms. Fine and Proposal Review Team,

I am pleased to submit the following letter of support for the *Redesigning the Residential Wind Turbine (RWT) for Rural Areas with Abundant Wind Resources* project proposal from Dr. Hou at CleanRepublic, LLC and Dr. Shi from North Dakota State University.

As a property owner in Rural Nelson County, ND in the "wind belt" region, I have pledged my support to Dr. Hou and his team in allowing access to my personal property for the installation and testing of the small-scale wind turbine system described in the proposal. The 10 acre property I currently own and reside on is 100% electricity powered. The electric-based system includes basic household items such as lights, kitchen and other appliances, water heater, etc. In addition, the home heating system is electric baseboard with no furnace or related forced-air ducting. This setup provides the ideal setting to test the efficacy of the small-scale wind turbine system described in the aforementioned proposal. The wind turbine testing on my home site would include both technical feasibility and economic viability in terms of payback period, both important measures to move small-scale wind power systems into the mainstream marketplace.

I strongly support the continued testing and development of wind power systems with the potential to provide positive economic and environmental impacts for commercial and non-commercial applications in rural areas. I am a strong supporter of rural communities and the rural lifestyle and believe a wind power system like the one prosed by Dr. Hou and his team has the potential to make a measurable and positive impact on the energy generation and distribution for the real, practical needs of homeowners, farm operators and others in rural America.

I have known Dr. Hou for more than 3 years through my work as the entrepreneurship director in the University of North Dakota College of Business and Public Administration and can attest to the seriousness of his commitment to this project and sustainable small-scale wind power development in general. I look forward to providing Dr. Hou and his team access to my personal property and home to build and test their small-scale wind turbine system.

Regards,

Craig Silvernagel
11257 29th Street NE, McVille, ND 58254

UNIVERSITY OF UND NORTH DAKOTA

DEPARTMENT OF TECHNOLOGY
STARCHER HALL ROOM 135
10 CORNELL STREET STOP 7118
GRAND FORKS ND 58202-7118
(701) 777-2249
FAX (701) 777-4320

April 30, 2010

Yong Hou

Clean Republic

5515 University Avenue

Grand Forks, ND 58203

Dear Dr. Hou,

I am writing in support of the work being pursued by Dr. Hou and Alex Johnson. The Technology Department at UND is willing to provide assistance that would advance this project—the 'Residential Wind Turbine (RWT)' project in North Dakota. I am optimistic about this new potential source of clean power and hopeful your project will meet the rural residential demand in North Dakota in terms of balancing technology and cost.

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Sincerely,

Dr. David Yearwood, Chairman

Technology Department, University of North Dakota

May 21, 2010

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

Dear Ms. Fine,

The Center for Innovation at University of North Dakota is an entity that provides assistance to innovators, entrepreneurs, and researchers to launch new ventures, commercialize new technologies, and secure access to capital from private and public sources. We endorse Dr. Yong Hou's proposal to NDIC on re-designing the small wind turbines for residential homes in locations with abundant wind. Dr. Hou has a proven record as a researcher, professor and high tech entrepreneur. There are good reason to believe technologies developed from this grant will enhance entrepreneurship and economical development in North Dakota.

To support this project, the UND Center for Innovation Foundation has committed support of $3,000. This cash support does not come from any state funding sources.

Sincerely yours

Bruce Gjovig, Director
Bruce@innovators.net
701-777-3134

NDSU NORTH DAKOTA STATE UNIVERSITY

701.231.7287
Fax 701.231.7195

Department of Industrial and Manufacturing Engineering
NDSU Dept. 2485
202 Civil and Industrial Engineering Building
P.O. Box 6050
Fargo, ND 58108-6050

May 20, 2010

Re: Support for NDIC grant proposal by Drs Yong Hou and Jing Shi

To Whom It May Concern:

I am writing this letter to support Dr. Shi's participation in the wind energy project, co-led by Dr. Yong Hou of Clean Republic LLC.

Wind energy has been growing in unprecedented pace in the United States and other countries in recent years, and it is becoming a leading renewable energy source. North Dakota is estimated to have the largest wind energy potential among the lower 48 states of the United States. The proposed project will be of great importance to the effective utilization of wind energy for residential homes. I am very impressed by the proposed technologies and the optimized system integration plan.

As such, I endorse the proposed research. If the project is funded, the Industrial and Manufacturing Engineering (IME) Department at NDSU is willing to provide match funds in cash to support Dr. Shi and this project. The cash match will be made available from the project savings from federal grants and contracts, and it will pay for Dr. Shi's one-month summer salary and travel support in two years. The total amount of cash match is estimated to be $25,653. Meanwhile, the IME Department is willing to support this project by providing the access to the equipment and devices in IME Manufacturing Lab and Automation and Control Lab.

If you have any questions, please do not hesitate to contact me.

Kambiz Farahmand, Ph.D. P.E.

Professor and Chair

SIOUX MANUFACTURING CORPORATION

P.O. BOX 400 FORT TOTTEN, NORTH DAKOTA 58335 USA 701/766-4211 (FAX) 701/766-4359 (FAX) 701/766-4228

April 28, 2010

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

Subject: NDIC Proposal on Redesigning the Residential Wind Turbine

Dear Ms. Fine:

Sioux Manufacturing Corporation (SMC) is pleased to provide this letter of support to the NDIC proposal being submitted by Dr. Hou, Clean Republic LLC and Dr. Shi, North Dakota State University for Redesigning Residential Wind Turbine (RWT) for Rural Areas with Abundant Wind Resources.

Our interest is in bringing value to this project by evaluating and potentially manufacturing wind energy components from composite materials. SMC has been in business since 1973 and in the advanced composite business for thirty of those years. The investigator's interest in including an advanced composite manufacturer in this project is insightful; significant life cycle and performance gains can be realized when using corrosion resistant and weight saving materials such as composites.

Sioux Manufacturing Corporation would be very much interested in evaluating the opportunity to bring value to residential wind turbines. We appreciate this opportunity to offer our support of this very unique and timely proposal and we look forward to being of assistance.

Respectfully,

David P. Steffen
Business Development Director
Sioux Manufacturing Corporation

C.c. Mr. Carl R. McKay, President & CEO, Sioux Manufacturing Corporation