TECHNICAL REVIEWERS' RATING SUMMARY

R009-H

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

Clean Republic LLC
Principal Investigator(s): Yong Hou, Jing Shi
Request for $186,000; Total Project Costs $372,653

		Technical Reviewer			
		3A	3B	3C	Average
Rating Category	Weighting Factor		Rating		Weighted Score
1. Objectives	9	4	3	2	27.00
2. Achievability	9	3	1	1	15.00
3. Methodology	7	3	2	1	14.00
4. Contribution	7	4	2	1	16.33
5. Awareness	5	4	2	1	11.67
6. Background	5	4	2	1	11.67
7. Project Management	2	3	2	3	5.33
8. Equipment Purchase	2	4	3	2	6.00
9. Facilities	2	4	2	2	5.33
10. Budget	2	5	3	1	6.00
Average Weighted Score		184	104	67	**118.33**
Maximum Weighted Score					**250.00**

OVERALL RECOMMENDATION

FUND	x		
FUNDING MAY BE CONSIDERED			
DO NOT FUND		x	x

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1. The objectives or goals of the proposed project with respect to clarity and consistency with North Dakota Industrial Commission/Renewable Energy Council goals are: 1 – very unclear; 2 – unclear; 3 – clear; 4 – very clear; or 5 – exceptionally clear.

Reviewer 3A (Rating: 4)

Reviewer 3B (Rating: 3)

Reviewer 3C (Rating:2)
The stated goal is to develop a low cost reliable small wind turbine in 2 years. This proposal addresses three issues, two that are within themselves more than could be accomplished in two years. The proposers don't know enough about small wind turbine technology to prepare a realistic proposal. Their main focus is on wind speed statistics and they added the other two components to make the proposal look as if it would meet the goals of the North Dakota Industrial Commission.

Response to Reviewer 3:
It is surprising that the reviewer didn't understand the wind resource analysis part is an integral part of the proposal. It should be reiterated that our proposal focuses on low-cost small wind turbines (SWT) with the introduction of a few new technologies: (1) Lower tower height introducing a level-based design; (2) To help with the lower tower design, we will develop wind modeling approaches to verify the wind resource at specific sites; (3) To reduce the cost, we introduce new designs of mechanical pitch-control system.

Our company has a proven track record on new product research and development. We believe that it is a niche for ultra-low cost SWTs in the areas with abundant wind resources such as North Dakota and South Dakota. To be fair, everyone understands what a "perfect" SWT would be. However, can the consumers accept the price tag for such SWT? Isn't the major reason that we only see few SWTs running in North Dakota?

2. With the approach suggested and time and budget available, the objectives are: 1 – not achievable; 2 – possibly achievable; 3 – likely achievable; 4 – most likely achievable; or 5 – certainly achievable.

Reviewer 3A (Rating: 3)
This is an aggressive agenda, but if they stay focused, they should be able to deliver.

Reviewer 3B (Rating: 1)

Time table and budget for prototyping, testing and validation are insufficient.

Response:
We believe that the time table and budget are sufficient with the collaboration from NDSU and UND.

Reviewer 3C (Rating: 1)
Task 1 is a different statistical approach for evaluating the wind speed in North Dakota. The Department of Energy and the Windpowering America Program have published wind resources maps for North Dakota. Correctly stated these maps give a general idea of the wind speed at a given location. However, small wind turbine siting is about the location and its unique features, not average wind speed. This proposed statistical procedure will not improve the individual siting of small wind machines.

Response:
The reviewer misunderstood the proposed modeling approach. With the proposed approach, the wind characteristics at unknown site can be inferred. This is not limited to wind speed, and provides higher resolution than the published map the reviewer mentioned. If the published map really can serve the purpose, why there are so many meteorological towers running in North Dakota to collect wind data before the wind turbines are installed on the sites?

Task 2 is a tower design and is related to the individual siting as well. Many people have designed tilting and folding towers. Some are on the market, but are not commonly used because of fatigue damage to hinge points.

Response:
The mechanical and material technologies are evolving every moment. On markets, tilting and folding towers used in 5kW turbine are actually common now.

Task 3 is a design of a new wind turbine and is total unrealistic in projection of time required and cost. To meet the new AWEA Small Wind Turbine Standards (2009) and Certification will require at least 6 years.

Response:
Our phase-one goal is to demonstrate that this system design and technology will work, and we will develop a prototype by incorporating the key features with common components. We are confident that we can achieve the objectives in 2 years.

3. The quality of the methodology displayed in the proposal is: 1 – well below average; 2 – below average; 3 – average; 4 – above average; or 5 – well above average.

Reviewer 3A (Rating: 3)

Reviewer 3B (Rating: 2)
Lack of information.

Response:
Due to the page limit, this is the most information we can put in the proposal.

Reviewer 3C (Rating: 1)
It is clear from their statements about tower height that they do not understand wind flow near the surface and the effects of wind shear on wind turbines. Most small wind machines will be placed near a usable load which means that they will be near houses, barns, businesses, etc. all of these structures effect the wind flow for small wind turbines. A Rule of Thumb is to place the lower tip of the rotor at twice the height of the nearest object (building, trees, etc.). They did not include a single reference for the tower or wind turbine design.

Response:
Again, we are surprised about this judgment. The wind shear effect is a common knowledge for everyone, in particular, for the proposer with numerous publications on wind modeling. To be fair, whether the rule of thumb holds or not really depends upon the real wind resource at the particular site.

4. The scientific and/or technical contribution of the proposed work to specifically address North Dakota Industrial Commission/Renewable Energy Council goals will likely be: 1 – extremely small; 2 – small; 3 – significant; 4 – very significant; or 5 – extremely significant.

Reviewer 3A (Rating: 4)
The concept of a speed controlled rotor in the 5kW to 10kW range of turbines is currently an open niche in the US marketplace. There is a great need for a turbine of this size with a speed controlled rotor.

However, I have a concern about the 30-40 foot towers that they are proposing. I understand the justification for this based on the economics and the wind resource in North Dakota, but there is also a downside to moving in this direction. First of all, the towers will need to be carefully sited on properties in North Dakota so that they are upwind of the homestead and any fencerows present, as these will create considerable turbulence as well as reduced annual energy output. More significantly, short tower wind systems can only succeed is states such as North Dakota, wide open spaces on the Great Plains. This platform is not transferable to more populated states east of the Mississippi River or west of the Rocky Mountains, due to the more complex terrain and tall tree cover prevalent beyond the Great Plains states. If transferability outside of North Dakota or the Great Plains is not of concern, then this platform will be successful.

Response:
Point well taken. This should be considered in the next phase of this project.

Reviewer 3B (Rating: 2)
There is little to be gained by developing a method to harvest the small amount of wind energy available at the low hub heights and low wind speeds being proposed.

Response:
Why?

There is also little to be gained by mapping wind speeds across the state at these low elevations from a wind energy point of view, because of the low energy content available at the low wind speeds.

Response:
Mapping the wind speed/resource at higher resolution using a new methodology itself is a major contribution.

Reviewer 3C (Rating: 1)
This proposal is basically to support graduate students doing statistical analysis and model development to further the Kriging Method. I see no benefit to the North Dakota Industrial Commission/Renewable Energy Council.

Response:
Mapping the wind speed/resource at higher resolution using a new methodology is a major contribution. If the developed method becomes commercialized, this will definitely benefit NDIC.

Tasks 2 and 3 could benefit the North Dakota Industrial Commission/Renewable Energy Council; however, this team does not understand what they are attempting to do or how to do it. They show no previous experience with small wind turbines or constructing towers.

Response:
Our company has a proven track record on new product development. In fact, we just won the "Innovate ND" competition in May 2010 for a product which was believed to have no future, but are selling well now.

Granted. Previous experience is important, but SWT technology is not a secret or rocket science. We have good ideas about SWT to fit a niche, we have engineering development experience, and we have learnt the related SWT technologies. Why not give us the opportunity?

5. The principal investigator's awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research related to the proposal is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.

Reviewer 3A (Rating: 4)
However, there is a reference to the 1988 AWEA Standard for wind turbines. The applicants need to be aware of the new AWEA Small Wind Turbine Performance and Safety Standard, which was approved and adopted in December, 2009.

Reviewer 3B (Rating: 2)
The wind resource estimation methods being proposed do not appear to take into consideration the differences in topography, surface roughness effects or obstacles between the measurement sites and the prediction sites. At the low elevations being proposed for turbine hub heights, the effects of these surface elements will significantly influence the wind speeds.

Also, the energy available for capture at these low elevations is much less than at hub heights of 30 meters or higher. Due to the nighttime cooling and more stable air mass that exists at these low levels during nighttime hours, the wind turbines would be missing much of the energy available many nights because the winds would likely be calm at the low hub heights being proposed while at a higher elevation, the wind would still be blowing. With the lower wind energy content at these low hub heights, I am doubtful that any wind turbine would be financially viable with paybacks less than 10 years.

The turbulence induced by the surface roughness elements, topography and local obstacles is much higher at these lower elevations than would be experienced at higher hub heights. The effect of the higher turbulence will be increased fatigue loading on the blades, compared to putting the wind turbine at a higher hub height.

While it is true that ND law does require that electrical utilities provide net-metering, so that a wind turbine owner is credited against future consumption for wind energy generated, this only applies to the regulated utilities which mainly serve the metropolitan areas in the state. The rural areas where the wind turbines would likely be installed are served by the Rural Electric Cooperatives which do not offer net metering. The inability to take advantage of net metering will have a significant impact on the financial feasibility and payback period for small wind turbines.

Response:
We appreciate this comment. Based on our knowledge about the wind resource of North Dakota and some wind-rich areas, the height of 30-40 feet should be able to provide sufficient power generation.

Reviewer 3C (Rating: 1)
Only references are for the statistical procedure for the analysis of varying data. Windpowering America has already published wind distribution maps for North Dakota. Other private companies offer more detailed analysis of wind resources for a fee. There are no references listed for types of towers, height of towers, requirements for tower design, etc. The same is true for wind turbine design. The Department of Energy funded the design of several small wind turbines and this information is available for many sources. There are a number of wind turbine design books available. None of these are listed. Suggested reading:

"Wind Power for Home & Business" by Paul Gipe, Celsea Green Publishing Co.
"Wind Turbine Technology" Edited by David Spera, ASME Press
"Wind Energy, Renewable energy and the Environment" by Vaughn Nelson, CRC Press.

Response:
Instead of the common books and references everyone knows, we list references resourced to our innovative system solution only.

6. The background of the investigator(s) as related to the proposed work is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.

Reviewer 3A (Rating: 4)

Reviewer 3B (Rating: 2)
While the authors demonstrate knowledge related to estimating and fitting of wind distribution curves based on fitting measured data, they have not discussed how they intend to incorporate the surface effects and resulting wind shear into a predictive model.

Response:
Actually, there are some empirical models regarding the surface effect, and we will try them. More importantly, this effect will also be addressed by the proposed Kriging approach, which works well in all dimensions of space.

Technology being proposed is not new or innovative regarding speed control, hinged tower, or permanent magnet generator. Rotor diameter has not been identified, but could easily end up being too close to the ground, based on a 30 to 40 foot hub height. A typical rotor diameter for a 5 to 10 kW machine would be in the range of 20 to 30 feet. For a low wind regime such as that proposed, it may require a larger rotor to extract more wind energy in order to achieve better economics. A larger rotor combined with higher fatigue loading would be a difficult design challenge.

Response:
The tower we plan to make will have at least close strength and fatigue performance the regular, tower. It will save big money for consumers in terms of installation and maintenance.

In the first prototype, we plan to use level tower for 5kw machine only.

Yes, speed control, permanent generator, even industrial level inverter are existing technologies. However, this does not undermine the significance of innovative system integration. The team's goals are to (1) select the right components and technology from current market; (2) review or redesign the components and make it matching our regional weather environment, such as minus 60 degree temperature and strong wind; (3) demonstrate the redesigned SWT system to local community.

We propose 16 feet rotor diameter and 24 feet level tower for 5kw machine; 21 feet rotor diameter and 36 feet regular tower for 10kw machine.

Reviewer 3C (Rating: 1)
They are experienced in statistics and wind modeling; however this does not mean they can build and construct a new tower, new wind turbine, or know where to site a wind turbine for optimum

energy production. The critical issue for the small wind turbine owner and installer is the placement of the wind turbine with respect of buildings and objects near the wind turbine. Tower height is also a critical issue. For the small wind turbine, it is about matching the energy produced against the energy load. We purchase and sell energy, not wind speed.

Response:
We are afraid that this is a contradictory statement from the reviewer. The reviewer stressed the common knowledge regarding the relationship between energy and speed in Section C, and questioned whether the proposers understand the relationship. Here the reviewer talks as if the energy output has nothing to do with wind speed.

There might not be any breakthroughs for SWT technology in the past several decades. However, this does not stop us from improving and renovating the existing products. The critical issue here is to if your SWTs can save money and become really affordable for consumers.

7. The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – very good; or 5 – exceptionally good.

Reviewer 3A (Rating: 3)

Reviewer 3B (Rating: 2)
Insufficient level of detail.

Response:
Due to the page limit, this is the most information we can put in the proposal.

Reviewer 3C (Rating: 3)
The management plan is adequate. The technical plan is so weak that at some point it is going to collapse the management plan because of the technical failures and delays.

Response:
We have responded to all your questions on the technical plan.

8. The proposed purchase of equipment is: 1 – extremely poorly justified; 2 – poorly justified; 3 – justified; 4 – well justified; or 5 – extremely well justified. (Circle 5 if no equipment is to be purchased.)

Reviewer 3A (Rating: 4)

Reviewer 3B (Rating: 3)

Reviewer 3C (Rating: 2)

There is so little detail given for Tasks 2 and 3 that it is hard to determine what is going to be purchased. Task 2 only mentions considering using composite materials. It looks like they want to build all of the tower components. For Task 3, much of the discussion is about using a pitch control rotor system. The two pitching systems mentioned were tested in the 1970's and 80's by the National Wind Test Center (NREL) and were found unreliable for small wind systems. Many people forget that wind turbine designs have been around for years and forget to look for references older than 10 years. In this case, they did not include any references and show no experience from staff.

Response:
Yes, we are to build most of the tower components. It will not cost too much in the project.

Indeed, during the period of 1970-80, NREL mentioned that mechanical pitch control system was unreliable for small turbine. As time passed by, various mechanical pitch control systems are now widely used in other countries.

All in all, we are going to redesign a SWT system with the same quality and reliability as the products on the market at much lower cost.

9. The facilities and equipment available and to be purchased for the proposed research are: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – notably good; or 5 – exceptionally good.

Reviewer 3A (Rating: 4)

Reviewer 3B (Rating: 2)
Insufficient testing equipment for power curve measurement and verification and wind turbine testing.

Reviewer 3C (Rating: 2)
Task 1 takes few facilities, mostly computers and people. Task 2 requires a machine shop if using steel, but more extensive facilities if using composites. Task 3 requires considerable specialized testing equipment and skilled labor. University facilities may be adequate for Tasks 2 and 3.

Response:
We don't understand why the rating is only 2 here based on your comment!

10. The proposed budget "value"[1] relative to the outlined work and the financial commitment from other sources is of: 1 – very low value; 2 – low value; 3 – average value; 4 – high value; or 5 – very high value. (See below)

Reviewer 3A (Rating: 5)

Reviewer 3B (Rating: 3)

Reviewer 3C (Rating: 1)
This project will mainly support graduate students and cover non-teaching salaries. I believe that they will only accomplish Task 1. Task 1 has no value to North Dakota.

Response:
This comment is not responsible. Task 1 does carry value, and the company is committed to the project.

[1] "Value" – The value of the projected work and technical outcome for the budgeted amount of the project, based on your estimate of what the work might cost in research settings with which you are familiar.

10a. Financial commitment from other sources – A minimum of 50% of the total project must come from other sources to meet the program guidelines. Higher priority is to be given if the application has private industry investment equal to or at least 50% or more of total cost.

The minimum 50% cash match is demonstrated.

Section C. Overall Comments and Recommendations:

Please comment in a general way about the merits and flaws of the proposed project and make a recommendation whether or not to fund.

Reviewer 3A ***(Fund)***
The concept of meeting North Dakota's renewable energy requirements with distributed wind is a very clever idea. While North Dakota is noted for its exceptional wind resources, it is also known for it's electrical transmission constraints. Relative to providing renewably generated electricity far and wide with wind farms, North Dakota may as well be on another continent—it simply does not have the utility infrastructure to transmit bulk electricity across the state. However, tapping into the existing distribution system which services every residence in the state, circumvents that problem.

Reviewer 3B ***(Do Not Fund)***
Recommend do not fund. While a lower cost small wind turbine in the size range being proposed would be beneficial to the wind industry and would have a market, the low wind speed regime that is being targeted in this proposal is, in my opinion, not financially viable to exploit. In order to be cost-competitive, the wind turbine would need to be designed to withstand the higher wind speeds that current small wind turbines are designed to operate in.

Response:

Please consider the fact that at 30-foot height, the average wind speed at a number of North Dakota sites is over 6m/s with the standard deviation of more than 3m/s. As such, the proposal is financially viable.

Reviewer 3C ***(Do Not Fund)***

There are several statements in the proposal that lead me to believe that this team is new to small wind energy technology. Their statement about using a 33 ft (10 m) tower and experiencing a minimum loss of power is one example (page 3). Another example is on page 5, where they plan to design a turbine to begin producing power at a wind speed of 2 m/s.

Response:

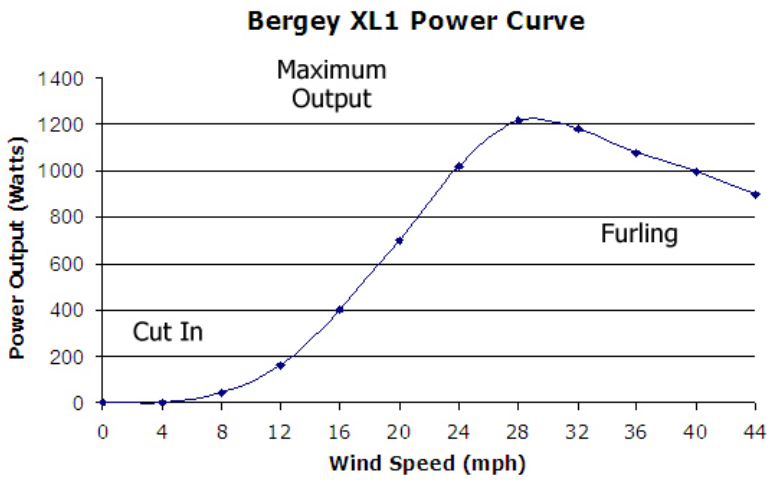
The reviewer may not know the fact that at 30-foot height for many places in North Dakota, the average wind speed is already more than 6m/s with the standard deviation of more than 3m/s.

I am not sure they understand the basic wind power equation of $P=1/2\ d\ A\ V^3$, where P is the power produced, d is the air density, A is the area of zone intercepted by the rotor, and V is the wind speed. The cubic relation of the wind speed means that at a wind speed of 2 you have a wind factor of 8 and if you double the wind speed to 4, the wind factor becomes 64. By slightly increasing the wind speed, you can greatly increase the power. This also means that we can build a smaller wind turbine and place it on a taller tower to achieve the same level of energy produced. The extra cost of a tower is much less that the cost of a larger wind turbine.

Wind shear is another function that I am not sure that they clearly understand. This is extremely critical for small machines placed near homes, barns, and other objects found near the loads for small wind turbines. By increasing a tower from 80 ft to 100 ft, a 50 kW wind turbine's annual energy output was increased from 85,000 kWh to 125,000 kWh, or an increase of 47%. The increase in tower costs was less than 9%. Other similar data can easily be found in the literature.

Response:

The basic wind power equation is true – this is an indication of mechanical energy potential. However, it is not a reflection of power output with respect to wind speed. For this, a power curve (such as the one shown below) should be used. Typically, there is a cut-in and a cut-out region for electrical power output – in other words, the electrical power generation can't increase with V^3 for most of the time.



(Source: http://www.kidwind.org/PDFs/LESSON_windpowercurves.pdf)

Again, it is a fact that at 30-feet height for many places in North Dakota, the average wind speed is already more than 6m/s (13mph). We are surprised by the statement that "the increase in tower costs was less than 9%" – the reviewer needs to consider two scenarios: One is the SWT system to be developed that does not require crane and many professionals for installation and maintenance. The other is the SWT systems that every time needs at least $2,000 – 4,000 for establishing or taking down the unit using cranes and other special equipment. This amount alone is not small compared with the overall unit cost of $15,000 – 20,000.

The use of the wind data from the North Dakota Weather Network (http://ndawn.ndsu.nodak.edu) is also questionable because the wind speed data is collected at a height of 3 m. Trying to correct data from this low height is difficult, because the variation in wind shear from day to day and from site to site can not be predicted. Everyone in the wind industry recommends that wind data be collected as near hub height as possible to avoid the issues of correcting data for wind shear.

Response:
The network information will serve one source of wind speed. We have wind data of 10-50 m from numerous metrological towers in the state as well. Combining both, we can infer the wind speed in all directions (including height).

Finally, the proposers don't understand the work, time, and money to develop a new wind turbine. Discussions with current manufacturers indicate that it takes at least 5 years and 5-7 million dollars to bring a small wind turbine to market.

This project should not be funded. Not one part of the proposal is well planned and they have not studied the technology enough to be current with what is happening in the industry. If it is important to build an educated base at the university, then I would suggest that you purchase a small wind turbine for the group and have them operate it for two to three years and learn about how a wind turbine operates in the North Dakota environment. Use some funds to train a teaching staff.

Response:
We have to repeat that this proposal is to re-design the SWT system by adopting some key technologies and mature components. The final project will be a prototype. This comment is misleading – this project has no intension to re-design every single component and part. Also, the prototype developed will clearly require extra effort and money for commercialization and mass production.