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:

Innovative Lithium Battery Production for Renewable Energy Storage Systems

Applicant:

Clean Republic LLC, Grand Forks, ND

Principal Investigator:

Yong Hou, Clean Republic LLC

Michael Shope, Clean Republic LLC

Date of Application:

January 1, 2012

Amount of Request:

$185,000

Total Amount of Proposed Project:

$398,000

Duration of Project:

2 Years

Point of Contact (POC):

Yong Hou, Ph.D.

POC Telephone:

218-791-3746

POC Email:

hou@cleanrepublic.com

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ABSTRACT

Objective:

The production of wind and solar energy systems is often intermittent. This poses a major challenge to the utilization of renewable energy and its penetration into the electrical grid. Energy storage solutions, therefore, have been developed to address this challenge. In this regard, battery energy storage is gaining momentum in recent years. Lithium-ion/polymer cells have been the workhorse of small batteries for consumer products and are now starting to supplant lead-acid batteries and NiMH cells in large packs for applications such as land-based distributed energy storage. The objective of this project is to develop innovative packaging processes and thermal management solutions to increase the performance, reliability, and service life of lithium battery packs for energy storage of renewable energy conversion systems. With the success of this project, the ultimate goal is to set up a lithium battery production and packaging line at Clean Republic LLC, in Grand Forks, ND.

Expected Results:

The results expected from this project are (1) the development of battery management systems with cell balancing technologies; (2) the design of removable mechanical architecture for quick assembly and disassembly of battery cells; (3) the advanced thermal management capability of the packaged battery pack; and (4) the installation and field testing of the new battery packs for energy storage in a hybrid wind and solar energy system.

Duration:

Two years (Suggested: April 1, 2012 – March 31, 2014)

Total Project Cost:

$185,000 requested from NDIC

$398,000 for total project cost

Participants:

Clean Republic LLC

PROJECT DESCRIPTION

Objectives:

The objective of this project is to develop innovative battery packaging techniques and processes for large packs of lithium batteries used as the storage medium of renewable energy systems. Lithium-ion/polymer cells have been the workhorse of small batteries for consumer products (such as cell phones and laptop computers) and are now starting to supplant lead-acid batteries and NiMH cells in large packs for applications such as vehicle traction and land-based distributed energy storage.

Compared to consumer products, the current large packs of lithium batteries often suffer from premature failure or a reduced number of charging cycles due to improper battery cell balancing and thermal management, poor maintainability and high service cost due to the inflexible mounting of battery cells during packaging. We strive to overcome these major issues by developing not only newly effective battery management systems (BMS), thermal management solutions, and innovative mechanical design, but also new manufacturing processes, so that the barrier of renewable energy utilization due to its nature of intermittent generation can be removed, the cost of energy storage can be reduced, and the battery maintainability can be improved. With the technologies developed, we ultimately aim to establish a battery packaging production line at the North Dakota facility of Clean Republic LLC to contribute to the regional economic development.

Methodology:

To achieve these objectives, we plan to conduct research and development on the following key areas: (1) developing new battery management systems (BMS) for cell balancing to mitigate the mismatches of cells during operational life; (2) designing and developing a removable architecture for battery cell installation; (3) evaluating and investigating the use of phase change materials (PCMs) in thermal management of batteries, identifying the best possible solution; and (4) testing the battery products in a wind/solar hybrid generation system. These main activities are described in details as follows:

1. BMS for cell balancing

One advantage of a lithium battery pack is its flexibility in connecting multiple battery cells to provide various outputs. However, in the multi-cell battery packs, it is difficult or even impossible to find two cells with identical performance. The cells are always different, to some extent, in terms of the state of charge, capacity, impedance, and temperature characteristics. The differences will become more significant during the life span of the battery. In this regard, an effective battery management system (BMS) to balance the cells and mitigate the mismatches is of great importance. The benefits of BMS cell balancing include higher efficiency, overall

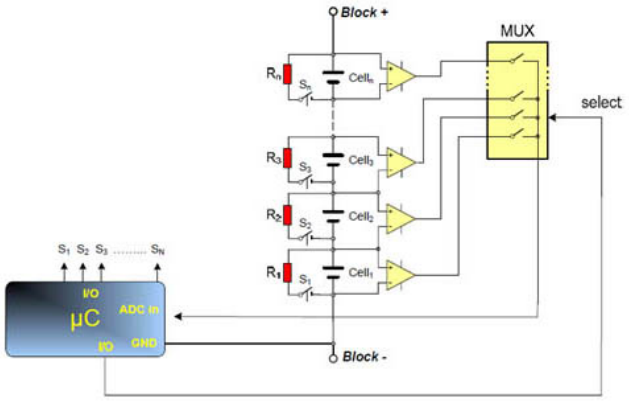


Figure 1: Schematic of passive cell balancing [1]

capacity, and longer lifetime of the battery.

In general, there are two types of cell balancing approaches – passive balancing that is built on using power resistors to dissipate energy by discharging the cells that need to be discharged, and active balancing that uses capacitive or inductive charge shuttling to transfer charge between battery cells. Passive balancing is inexpensive and widely used in applications where cost far outweighs the battery efficiency, while active balancing is more expensive but provides higher efficiency and longer run time.

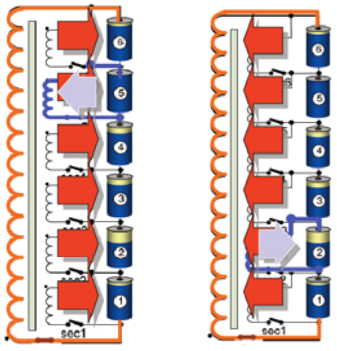
The general schematic of passive cell balancing is shown in Fig. 1. The main idea is to equalize cell voltages using the following procedure. The cell voltages are compared with the threshold value. If any cell reaches this particular value, charging will be stopped and the internal bypass to the power resistors is enabled. When the high-voltage cells hit the recovery limit, the cell balancing will stop.

Figure 2 shows an example of Clean Republic LLC passive cell balancing research for electric vehicles. A Clean Republic prototype electric bicycle battery containing eight cells is fully charged to the point where all cells are just above the referenced threshold voltage, indicated by eight lit red LED lights. At this point charging is stopped and the balancing resistors bleed off energy from each cell until all cells have come back down just a little to an exact threshold voltage. The right-hand picture below shows only two lit LEDs, indicating six of the eight cells have finished their passive balancing cycle, two cells are still bleeding down to the threshold voltage, and the pack of all eight cells will momentarily be balanced.

Figure 2: Passive cell balancing under development at Clean Republic

Passive cell balancing has been widely used in various applications for battery management. In this project, we plan to comprehensively evaluate the available solutions and research the ones with optimal performance for the batteries suitable wind and solar energy conversion systems.

On the other hand, active cell balancing is more advanced, in which the balancing technology using inductors is more promising compared with that using capacitors. As indicated by Fig. 3(a), top balancing can be realized by a balancing circuit, which connects the cell with higher voltage to its secondary winding. As a result, an induced voltage will be created on the primary winding. The cell's switch is then opened and the switch of a receiving cell is closed to send the primary's energy back into its secondary winding. Energy can be transferred between cells with high efficiencies using this balancing technique. Meanwhile, bottom balancing, shown in Fig. 3(b), can also be realized which allows weaker cells to take charges from stronger cells. The circuit first uses a pulse of the battery stack voltage to energize the primary winding with all secondary switches open. Thereafter, the secondary switch for the cell to be charged is



(a) (b)

Figure 3: Active cell balancing using inductors - (a) top balancing, and (b) bottom balancing [2]

closed, and this allows the stored energy to be transferred to the particular cell.

Although the principles of active cell balancing are not difficult, the development of active balancing solution is challenging [3, 4]. There are only a very limited number of integrated circuit (IC) chips that are suitable for this purpose. The costs of cell balancing circuits are still very high, and they add complexity to the battery systems. In this project, we plan to devote R&D effort to active cell balancing to find an effective and yet affordable solution.

2. Removable mechanical architecture and visual diagnostic indicators

We plan to develop a removable mechanical architecture and power contact per cell/module to allow quick replacement of defective or degraded cells/modules. Traditionally, lithium battery producers and distributors have met the service and maintenance needs of their customers by simply replacing entire battery packs that showed decreased performance, and discarding the entire original pack though many internal cells may still have been good. This traditional service model will not work for larger, more valuable battery packs in alternative energy storage and electric vehicles systems.

A removable cell architecture would be ideal for servicing and maintaining large-scale lithium packs. With individual internal cells of large battery packs accessible for customers and local service technicians, the waste of shipping entire packs back to the manufacturer and/or disposing of them because of a small internal problem is eliminated. Removing this waste and adding this flexibility to the supply chain of large scale lithium packs is necessary to practically and realistically grow a new industry of large-scale lithium battery service providers. With these options available, revolutionary and disruptive service and maintenance business models become possible for lithium battery distributors allowing vertical integration of supply chains at very low unit volume. Individual cell/module removal is possible in a safe, simple process allowing access to retail consumers on subscription power module plans or technical support personnel during troubleshooting and repair, creating options for “ever-lasting” pack usage and predictable performance.

Figure 4 shows the schematic of mechanically removable cells, in which A represents the BMS circuit board, B represents a support connector structure for all cells with visual indicators, C represents the mechanical power contacts, and D represents the battery cells/modules. The mechanical power contact concept has not been implemented in commercial lithium battery packs. The traditional approach is to permanently weld the cells on the terminals of support structure. Based on our extensive experience with lithium batteries, the failure of battery stacks can be often attributed to one or two cells/modules in the entire assembly, and the replacement of these failed cells/modules can bring the battery back to life. In this case, the traditional permanent type of contact makes the replacement of battery cells very difficult, if not impossible. The concept of removable cells/modules with mechanical power contact mechanism makes the maintenance and replacement jobs easier, cheaper, and faster.

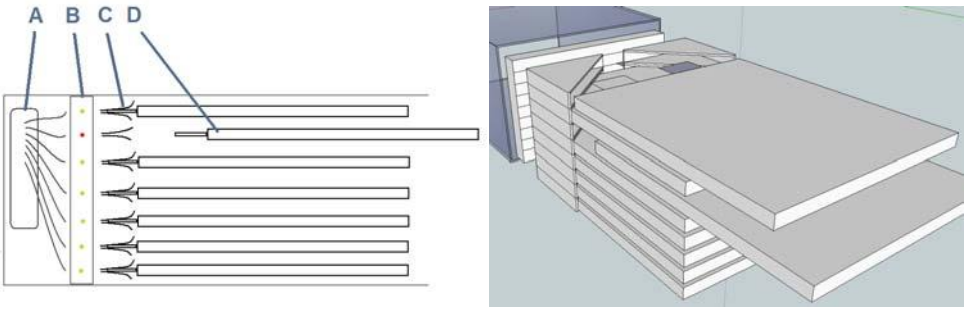


Figure 4. Removable battery cell architecture

Certainly, we will need to experiment with a variety of materials and configurations to test the reliability of mechanical power contacts. Moreover, we plan to include visual diagnostic indicators on the collection board (B) to facilitate easy monitoring of battery pack performance. Cell health status will be determined by the sensor signals of voltage, temperature, and others. In addition, a new production processing/technique of packaging large packs of lithium battery cells will be further developed, utilizing the advantages of our removable mechanical architecture itself.

3. Thermal management solutions

It is also well known that the temperature of a lithium battery needs to be controlled within the narrow optimum range. Otherwise, the electrochemical performance of lithium cell charge acceptance, power capability, reliability, life time, and safety will all be adversely affected. Most lithium battery cells are limited to an operating temperature of -20°C to 60°C, while their charging temperature ranges are often smaller [4]. To ensure charging at low temperatures, we can develop a simple BMS-based heating solution to keep the pack above the minimum temperature by drawing energy from the charging supply. On the other hand, overheating poses a challenge to most lithium battery packs in which the battery cells are closely packed and the center temperature is often significantly higher. Understandably, the failure of the center cells due to high temperature will cause the failure of the entire battery pack.

In this aspect, we plan to develop two solutions. One is to add space between the battery cells/modules as indicated in Fig. 5. We will experiment to test the effectiveness of the different techniques under a combination of conditions such as battery cell geometry and characteristics, as well as application-related charge and discharge requirements.

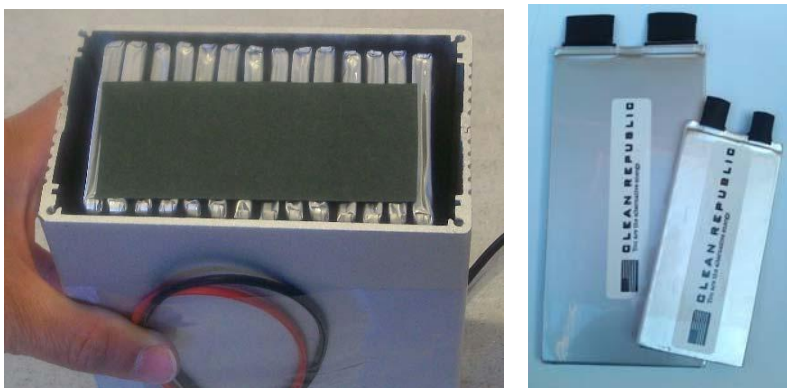


Figure 5. Added space between battery cells for thermal management

In parallel with the added space for air circulation to reduce the temperature of “hot spots” in battery packs, we also plan to conduct extensive experimentation using phase change materials (PCMs) to provide an alternative thermal management solution. PCMs are materials that ‘soak up heat.’ They depend on chemical bonds to store energy as they change from solid state to liquid and release latent heat changing from liquid to solid. The PCMs can absorb large quantities of heat due to their high latent heat of fusion [5,6]. The common PCMs in solar heating systems include sodium sulfate decahydrate, calcium chloride hexahydrate, and paraffin wax [7].

In this case, PCMs can be pre-formed into a cavity in which the battery cells can slide in. During discharge and charge, the heat generated could be absorbed by the PCM between the cells inside the battery pack. Basically, the PCM acts as a heat sink absorbing the heat generated by the battery. If the internal temperature exceeds the PCM melting point, the material starts to melt and the absorption of

heat can prevent the battery cell temperature from overheating. PCMs for thermal management eliminate the complicated design of traditional cooling systems. We regard this approach as a viable solution for battery packaging production to make advanced, reliable batteries for wind/solar energy systems. However, there are a number of PCMs available for thermal management applications. We need to carefully select the candidate materials, then conduct simulations and tests to determine the best possible solution based on PCMs.

Below, in Table 1, we provide a brief comparison between the new battery packaging process and the traditional processes used widely in the industry today.

Table 1. Comparison of traditional and proposed packaging processes:

	Old process	**Proposed new process**
Battery size and target market	Small, laptop, cell phone	Mid / bigger, E-vehicle and Electric energy storage
Complication of production	Complicated	Less complication
Flexibility	Low	High
Performance	Moderate	High
Cost per unit	Low	Moderate
Labor	Labor intensive	Tech intensive
Quality control	Moderate level	High level
Place of jobs creation	China, South Korea	U.S.A
End consumer experience	Standard	Increased value
After-sales maintenance	Impossible	Highly flexible

4. Testing the batteries produced by the new processes

We plan to conduct both lab and field tests for the prototype batteries produced using the proposed packaging technologies and processes. For lab tests, we will establish a set of apparatus to measure the charging and discharging curves of battery cells, as well as temperature profiles under a variety of loading conditions. In terms of the field tests, we will work with Solargy Lights to test the performances of the batteries on its hybrid wind/solar energy conversion systems. We have been providing consulting services to Solargy Lights, another North Dakota company, to develop street lighting solutions based on wind/solar energies (see Fig. 6). They have agreed to work with us on this project.

Figure 6: Hybrid wind/solar system (courtesy of Solargy Lights)

Anticipated Results:

The major goal of this project is to develop adaptive lithium battery packaging technologies that can produce large packs of lithium batteries with improved quality, lifetime, and reliability, and reduced costs for the applications in wind/solar energy conversion systems (small or large). The same set of technologies should be suitable for the production of battery packs for other applications such as electric vehicles. To be more specific, the project will be able to develop a complete understanding of passive cell balancing BMSs available on the market, and economical solutions for active cell balancing. The project will also help invent completely new removable mechanical architecture and its production

processing/ techniques for battery cell installations in large packs of lithium batteries. Also, the project will be able to develop a comprehensive knowledge about the applicability of existing PCMs for lithium battery packaging. Based on simulation and testing, the spacing between the battery cells with or without PCMs will be determined. More importantly, at the end of the project, we expect to set up a low-medium volume production line that uses the developed technologies to produce high quality large lithium batteries for customers in the United States and worldwide.

Facilities & Resources:

The following facilities and resources are available to Clean Republic LLC for the proposed project.

1. Clean Republic LLC has a shop space of 5,000 square feet located at 5515 University Avenue, Grand Forks, ND, for the project. The facility has PCs, measuring devices, test instruments, work benches, hand tools, and other tools for design, assembly, and test of the lithium batteries.
2. The project team has a broad spectrum of knowledge in mechanical design, electrical circuit design and testing, and battery packaging and testing. If necessary, it will receive assistance from leading technological companies such as AllCell Technologies of Chicago.
3. The company has an excellent collaboration history with NDSU and UND. It has the access to the talents and the necessary equipment at these two research universities.
4. Solargy Lights of North Dakota will provide wind/solar systems for field testing of out batteries.
5. The machine shop at Dr. Alex Johnson's residence will also be available for the project to make necessary components using machining operations for the prototyping phase of this project.

Techniques to Be Used, Their Availability and Capability:

A critical component of these new packaging techniques is the battery management system (BMS) circuit board. The principles of passive cell balancing and active cell balancing are not new. However, even for passive cell balancing, the development of a sound engineering solution with considerations on thermal management and cost requires significant effort; while for active cell balancing, the suitable solutions are scarce and this requires a major R&D effort.

There are a number of PCMs available for thermal energy storage. Certainly, these materials have different melting points and heat of fusion. As such, they may not be all suitable for thermal management in lithium battery packaging. This will require the scientific process of material selection and verification. The measurement of temperature history and the simulation of temperature field in battery packs are also considered as the techniques available for the company or the universities that will provide services to the company on this project.

The removable mechanical architecture is a completely new idea being developed by Clean Republic LLC. To the best of our knowledge, no other similar products can be found on the market. The realization of this idea will require rigorous engineering and testing. For instance, the material selection of terminal clips is a non-trivial task which requires excellent contact at all times, and ease of disassembly during maintenance. However, the adoption of removable battery cell structure may not work with the use of PCM material for thermal management directly.

Environmental and Economic Impacts while Project is Underway:

We do not anticipate any environmental impacts when the project is underway. This is because the project does not directly involve the manufacture of individual battery cells, and furthermore we are dealing with the environmentally friendly lithium batteries instead of other types of batteries. The

possible adoption of PCM materials in the battery packs does not have environmental concerns since the materials are safe and environmentally friendly.

With the success of this project, we will establish a battery packaging production line at the Grand Forks facility of Clean Republic LLC, which will provide job opportunities to this region and hire at least four additional employees in two years after the project completes. During the project certain local sub-contracting services will be employed to conduct specialized testing and consultation. 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 utilization of renewable energy in North Dakota, and the country by launching new, valuable products.

Ultimate Technological and Economic Impacts:

1. The battery packs manufactured using the proposed concepts will have significantly higher reliability, increased number of charging cycles, and improved maintainability.
2. The lithium battery for energy storage of wind and/or solar energy systems will stimulate the further utilization of renewable energy to protect the environment and reduce CO_2 emissions.
3. The technologies developed from this project can be scaled up to the manufacture of battery storage solutions for renewable energy generators, and applied to the manufacture of batteries used on electric vehicles.
4. The technologies developed will be promptly commercialized and this will contribute to the state economic development by adding jobs and tax revenue.
5. The project will also enhance local manufacturing businesses. Local manufacturing companies will have the opportunity to fabricate components for the battery packs.

Why the Project is Needed:

One pillar of North Dakota development is the energy industry. Besides the oil reserve in west part of the state, North Dakota is also a state with abundant wind energy potential and bio-mass resources. Wind and solar generations, which do not generate carbon emissions or consume water, are environmentally-friendly forms of electrical generation. In particular, wind power could provide 20% of U.S. electricity needs by 2030, according to a U.S. DOE report of 2008 [8]. North Dakota has the most abundant wind resources among all the states in the country, according to another U.S. DOE report [9].

The biggest obstacle that keeps wind or solar energy forms from the electricity grid is their intermittent nature of electricity generation. Therefore, energy storage technologies, which are developed to smooth the intermittence, play a pivotal role in more effectively utilizing wind and solar energy. Meanwhile, the other major advantage of energy storage is that generators can manage when to sell the electricity to maximize their profit. The available storage technologies include hydrogen production, which is a process of electrical electrolysis of water using the renewable energy generation; pumped storage, which uses the renewable energy generation to pump water to an elevated reservoir and release the water to drive hydraulic turbine when the renewable generation is not available; flywheel energy storage, which uses fast rotating flywheels to store excessive energy; compressed air storage, which compresses air into underground cavities and release it to drive air motors; thermal storage, which heats substances and allow them to release latent heat if returned to their initial state; and battery storage, which allows charge and discharge batteries to smooth the generation [10]. Among these storage technologies, battery storage has the best flexibility and scalability because the other technologies usually need huge investment, are developed for large scale renewable energy generation, and have various constraints. Battery storage can work well with not only the large scale generation, but

also the small renewable energy conversion systems. Just last year the U.S. passed the mark of 100,000 solar installations directly tied to the national grid (resource: NREL), and the rate of new installations is going off the charts. Battery storage has been common for solar energy generation, but in recent years, it has also gained momentum for wind generation [11,12,13].

Lithium batteries, compared with other batteries such as metal-acid type, have the advantages of high energy density, deep cycle, low maintenance, good low-temperature performance, light weight, environmental friendliness, flexible battery voltages and sizes, etc. In light of the promising potential of lithium battery storage for renewable energy generation, new technologies need to be developed to accommodate a broad range of charging and discharging rates, increase the number of charge/discharge cycles, enhance the reliability, improve the maintainability, and reduce the production cost. These are reflected by the proposed project activities in BMS, thermal management, and battery architecture.

STANDARDS OF SUCCESS

Built on the success of its electric bike business, Clean Republic LLC has expanded to a company with five full time employees within two years. Battery packaging has been a key component of this business. The company has also been developing other green energy technologies, such as their newly-launched home solar water heating kit. The development of reliable battery storage systems for intermittent renewable energy sources such as wind and solar matches the strengths and focus of this company and its proven track record in the area of developing and commercializing practical alternative energy products.

Technology wise, the success of this project will be evaluated based on three key areas: (1) the removable mechanical architecture for production of large lithium batteries, which should improve the maintainability, reliability, and overall service life of the batteries; (2) the customized cost-effective cell balancing BMSs with the capability of temperature regulation, which include one BMS based on passive balancing for low cost systems and one BMS based on active balancing for medium-high end applications, and (3) the comprehensive evaluation of thermal management solutions in battery packaging, which should lead to the adaptive selection of optimal thermal management solutions depending on applications and service environment characteristics. Moreover, the batteries packaged using the new technologies will be benchmarked against the offerings available on the market to demonstrate the effectiveness of these technologies. Although the project is targeted at battery storage solutions for wind/solar energy conversion systems, the three key technological developments should be applicable for the battery systems in other products such as electric vehicles.

As for economic development for the region and the state of North Dakota, the project will provide the precious seed R&D fund for Clean Republic LLC to develop a core business with huge potential. We have a track record of successful entrepreneurship, and we expect to continue it with this project. In this aspect, the project should be reflected and measured by the successful delivery of new battery packs (based on the innovative packaging technologies developed) to commercial customers at the end of the second project year. After the project period, we expect to establish a battery packaging production line, and we strive to grow the revenue of battery packaging business to $1 million and add four FTEs to the company for this business in two years after the project completes.

We will work closely with the two research universities in North Dakota – NDSU and UND, and provide work and training experience to the students from both universities. By working with our university collaborators, we will provide direct R&D training experience to graduate students, and provide 1-2 seminars each year to NDSU/UND engineering/technology students. These outreach activities will help the students to consider staying in the state and developing a career in renewable energy industry.

BACKGROUND/QUALIFICIATIONS

Dr. Yong Hou of Clean Republic LLC will serve as the Principle Investigator for this project. His main 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 Seattle, Washington. The company focuses on developing personal alternative energy products such as rechargeable battery packs, electric bike conversion kits, and small wind turbines. Dr. Hou has a BS and an MS in Electrical Engineering, and a PhD in Management Science. He has not only published many papers in academic journals, but has personally invested and been involved in many other renewable energy projects. Before he returned to the graduate school for PhD, 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 and Department of Management on the subjects of renewable.

Mr. Michael Shope will serve as the Co-Investigator for this project. Mr. Shope has extensive experience in product design and development, retail advertising and marketing, business management, and renewable energy research. Mr. Shope graduated from UND with a BS in Aeronautics, and a track in the Entrepreneurship program. He co-founded Clean Republic LLC to focus his combined interests of product development and practical alternative energy products. He and Dr. Hou have quickly grown the successful new venture and created new jobs in North Dakota by combining a disciplined practicality-based approach to their alternative energy product research. Mr. Shope was the recipient of the SBA Region 8 Young Entrepreneur Of The Year 2011, and the Clean Republic team is the proud winner of the Innovate ND Venture Competition.

Dr. Jing Shi will provide necessary consulting to Clean Republic LLC on this project. He is an Associate Professor in the Department of Industrial and Manufacturing Engineering at NDSU. He earned two Ph.D. degrees, one in Materials Engineering and the other in Industrial Engineering. Dr. Shi is teaches automation/control, and manufacturing courses at NDSU. His current research interests include advanced energy materials, battery packaging, energy economics, wind forecasting, and design of new wind turbine systems. Dr. Shi serves on the editorial boards on several energy related technical journals as well as the international advisory committees of various energy conferences. He has authored and co-authored 47 refereed journal papers, 35 refereed conference papers, and 5 book chapters.

Dr. Alex Johnson will also provide necessary consulting to Clean Republic LLC on this project. He is an Assistant Professor in the Department of Technology at the University of North Dakota and also a Project Manager at Solargy Lights. He has a PhD in Education and a Master of Science in Industrial Technology from the University of North Dakota. His current research interests include metallurgy, site assessment techniques for small wind turbines, and the development of small wind turbines. He has presented extensively on these topics at national conferences.

MANAGEMENT

Dr. Yong Hou of Clean Republic LLC will be the point of contact and principal investigator for the project, and he oversees the entire project progress. He will lead a team of 3-4 employees with various expertises in electrical circuit analysis, mechanical design, battery assembly and testing, from Clean Republic LLC. The team's major responsibilities include packaging process design, design and manufacturing of components, assembly, field tests, and report writing. Dr. Hou will also coordinate with the Department of Technology of UND to expand the participation of UND students in the related design and renewable energy courses that they offer.

Within the company, the team is expected to meet every week to discuss about the progress and the plan for next week. For the potential collaboration with NDSU/UND, the company will have frequent information exchange by email and phone calls. In particular, a telephone conference will be scheduled every month between the collaborating universities and the company to check against the milestones, and address the outstanding issues, and a face-to-face meeting happens once every 3 months.

Project reports will be periodically prepared by the PI(s) and submitted to NDIC for record. The PI(s) and the collaborators 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

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Task 1: Development of BMS for cell balancing								
Evaluate active/passive balancing solutions								
Develop cost-effective BMS								
Task 2: Removable mechanical architecture								
Design of removable mechanical architecture								
Develop visual diagnostic indicators								
Task 3: Thermal management solutions								
PCM material selection and comparison								
Develop PCM based thermal management solutions								
Task 4: Battery testing								
Lab testing								
Field testing								
Quarterly reports								
Write and submit reports to NDIC quarterly								

BUDGET

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
Personnel				
Project management		$20,000 (Company)	$25,000 (Company)	
BMS development	$40,000	$40,000 (Company)		
Removable battery packaging structure	$20,000			
Thermal management	$20,000	$20,000 (Company)		
System integration	$20,000			
Labor (manufacturing)		$27,000 (Company)		
Consulting subcontract	$50,000 (NDSU/UND)		$40,000 (Other)	
Materials/components				
Components to develop lab testing apparatus	$10,000	$20,000 (Company)		
Cells and materials for 5 prototype batteries	$25,000			
Others		$3,000 (Solargy Lights)		
Field installation/testing				
Property and equipment			$13,000 (Solargy Lights)	
Labor (testing)		$3,000 (Company)	$2,000 (Solargy Lights)	
Total	$185,000	$133,000	$80,000	

Budget Justification:

Clean Republic LLC (i.e., the company) requests a total amount of $185,000 for this project. The total cash matches from the company and other sources add up to $133,000, while the in-kind matches from the company, NDSU/UND professors(s), and Solargy Lights add up to $80,000. Note all match funds are pending upon the approval of the project by NDIC.

Among the $185,000 requested from NDIC, the material cost will be $35,000, in which the company will use $10,000 to purchase the necessary components to develop additional apparatus to test the batteries, and the company will also use $25,000 to purchase the battery cells, BMS boards, and other components for making 5 prototype batteries to be tested with the hybrid wind/solar energy system. Meanwhile, the personnel cost on technology development from NDIC will be $100,000, in which the company will hire an engineer paid at $40,000/year to develop the technologies, integrates components and equipment, and conduct lab testing. The total cost of this position in two years will be $80,000. The remaining $20,000 from NDIC will be spent on a current company employee for the R&D efforts. In addition, the company will issue a subcontract to NDSU and/or UND for the amount of $50,000 on key issues of active balancing BMS development and PCM-based thermal management.

Clean Republic will invest significant resources on the project, which include $110,000 in cash for personnel salaries for project management and labor, and $20,000 for equipment and components needed for battery performance testing in lab environment. Solargy Lights of North Dakota will provide $3,000 in cash to support this project. Also, Clean Republic will provide $25,000 for in-kind salary due to the hours contributed from its VP, Dr. Yong Hou and its CEO, Mr. Michael Shope.

The project will receive in-kind consulting service from Dr. Jing Shi of North Dakota State University during the summer time for both project years. Dr. Shi is expected to invest 300 hours on this project without charge to the company, which is worth $30,000. Dr. Alex Johnson is expected to invest 150 hours on this project without charge to the company, which is worth $10,000. He is also providing the use of his fully equipped machine shop for use. As a project manager of Solargy Lights he will work closely with Clean Republic during the testing phase of this project. Meanwhile, Solargy Lights will provide two sets of wind/solar hybrid systems to test the prototype batteries developed under this project. The in-kind value is estimated to be worth $15,000.

CONFIDENTIAL INFORMATION

No confidential information is involved with this grant application.

PATENTS/RIGHTS TO TECHNICAL DATA

Clean Republic LLC reserves the right to all intellectual property developed under this project.

TAX LIABILITY STATEMENT

December 31, 2011

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

Yong Hou, Vice President and Director of Product Development

CLEAN REPUBLIC
You are the alternative energy.

December 30, 2011

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

Transmittal Letter
Lithium Battery Research Grant

Dear Ms. Karlene:

This letter is an indication of commitment from Clean Republic LLC to proceed with the proposed project – "Innovative Lithium Battery Production for Renewable Energy Storage Systems". As outlined in the proposal, there is growing demand in the renewable energy industry for lithium batteries as a medium of energy storage. However, to truly capitalize on the greatest advantages that lithium batteries can bring to this industry, key solutions must still be developed for specific challenges in troubleshooting and servicing lithium battery packs, controlling the temperature of batteries, accessing a local and reliable supply of individual battery cells, and integrating lithium batteries in small off-grid systems like remote lighting applications in simple, affordable ways.

Clean Republic has identified specific solutions (outlined in the proposal) to these challenges that will enable commercialization of new technologies and job creation if detailed testing can be performed. By collaborating with key partners in UND and NDSU and combining the resources of our research team, the academic community, and the support of the NDIC, we can a) develop a system to remove individual cells/modules from battery packs for fast servicing and troubleshooting, and a battery management systems with new cell balancing technologies b) control the internal temperature of batteries to prolong their usable life time, c) create a battery production facility in North Dakota which will create new jobs, and d) further promote the integration of lithium batteries with wind and solar systems by collaborating with ND alternative energy companies for real-world testing and product development.

Our group has a proven track record of researching and commercializing new alternative energy technologies. We are requesting $185,000 from NDIC to support this new 2-year project with testing equipment and contracted design services detailed in the proposal, which will yield more cutting-edge lithium battery solutions and accelerate alternative energy development in North Dakota. Thank you for your time and consideration in reviewing our proposal.

Sincerely,

Yong Hou

Yong Hou, PhD
Vice President and Director of Product Development

4200 James Ray Drive #204, Grand Forks, ND 58203
Email: info@cleanrepublic.com Phone: 218 791 3746

APPENDICES

A1- References:

[1] Goldberg, L., Battery Cell Balancing for Improved Performance in EVs - Part I: Passive Balancing Technologies, Electronic Products, http://www.digikey.com/ca/en/techzone/energy-harvesting/resources/articles/battery-cell-balancing.html

[2] Goldberg, L., Battery Cell Balancing for Improved Performance in EVs - Part II: Active Balancing Technologies, http://www.digikey.com/ca/en/techzone/energy-harvesting/resources/articles/battery-cell-balancing-part-2.html

[3] Altemose, G. Achieving cell balancing for lithium-ion batteries, Electronic Products, DECEMBER 2008, pp. 21-22.

[4] Davide Andrea, Battery Management Systems for Large Lithium-ion Battery Pack, ARTECH HOUSE, ISBN-13 978-1-60807-104-3, 2010

[5] Duan, X., Naterer, G. Heat transfer in phase change materials for thermal management of electric vehicle battery modules, International Journal of Heat and Mass Transfer, 2010, 53 (23-24), pp. 5176-5182

[6] Al-Hallaj S., Selman J.R. A novel thermal management system for electric vehicle batteries using phase-change material, Journal of Electrochemical Society, 2000, 147 (9), pp. 3231-3236.

[7] Demirbas, F. Thermal energy storage and phase change materials: An overview, Energy Sources, Part B, 2006, 1, pp. 85–95.

[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.

[10] Della, R., Randb, D., Energy storage — A key technology for global energy sustainability. Journal of Power Sources, 2001, 100(1-2), pp. 2-17.

[11] Bayar, T. Batteries for energy storage: New developments promise grid flexibility and stability, Renewable Energy World magazine, August 30, 2011, http://www.renewableenergyworld.com/rea/news/article/2011/08/batteries-for-energy-storage-new-developments-promise-grid-flexibility-and-stability

[12] Wald, M. L., Batteries at a wind farm help control power output, The New York Times, http://www.nytimes.com/2011/10/29/science/earth/batteries-on-a-wind-farm-help-control-power-output.html

[13] John, J. A mega wind farm, needs lots of batteries, http://gigaom.com/cleantech/a-mega-wind-farm-needs-lots-of-batteries/

A2 - Support Letters:

Please see attached pages.

James DeSeyn

Subject: FW: Letter

From: James DeSeyn [mailto:jdes@designercare.com]
Sent: Friday, December 30, 2011 2:59 PM
To: 'yong@innovators.net'
Subject: Letter

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

RE: Clean Republic Application: Innovative Lithium Battery Production for Renewable Energy Storage Systems

Dear Ms. Fine:

Our company, Solargy Lights, LLC, is involved with providing alternative outdoor lighting solutions for various industries. These include municipalities, construction sites, sports facilities, and RV/mobile home parks.

Our hybrid street lighting system requires battery storage capacity to store the energy created by the wind turbine and the solar panel.

The Innovative Lithium Battery for Renewable Energy Storage Systems would be a nice fit to use for our battery storage pack. Dr. Yong Hou, owner of Clean Republic, is developing a battery with superior lifetime and increased reliability. Clean Republic is also engineering the batteries for optimum efficiency in cold weather conditions.

This letter is written in support of Clean Republic, and Dr. Yong Hou's efforts in developing and manufacturing the Innovative Lithium Battery Production for Renewal Storage Systems. We would like to provide two sets of wind/solar hybrid systems for Clean Republic to test as a battery prototype pilot project. Solargy Lights is willing to commit up to $3,000.00 in good faith for the purchase of Innovative Lithium Batteries for our project.

I have personally worked on a pilot street light project with Dr. Yong Hou. I have found his engineering expertise to be very valuable, along with personal qualities of ethics and honesty in our business dealings. I would highly recommend his project moving forward. Please be free to contact me at (701) 886-7684 for any reference considerations.

Warm regards,

Jim DeSeyn

Jim DeSeyn
President
Solargy Lights
474 Main Avenue
Neche ND 58265

PH: (701) 886-7684
FX: (701) 886-7797
www.solargylights.com

ALLCELL TECHNOLOGIES
cool by design

2321 West 41st Street
Chicago, IL 60609

January 4, 2012

North Dakota Industrial Commission
State Capitol 14th Floor
600 E. Boulevard Ave. Dept. 405
Bismarck, ND 58505

To whom this may apply:

Having heard that Clean Republic is applying for a research grant, I wanted to share a few words about them.

At AllCell Technologies, we work in this same industry. From our experience with them, it is evident that the folks at Clean Republic stand out at identifying a particular need, researching a solution, and commercializing a real product to create jobs.

Their knowledge and technical experience enables them to excel at an often overlooked art form in the Light Electric Vehicle industry. Clean Republic understands how technological advances and continuous research can improve even the newest industries and products.

I'm sure if you extended this grant to help them build a superior Battery Management System, their partners and the industry would be better off for your support.

Sincerely,

Said Al-Hallaj
CEO
AllCell Technologies, Inc.

December 29, 2010

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

RE: Clean Republic Application: Innovative Lithium Battery Production for Renewable Energy Storage Systems

Dear Ms. Fine,

The development of wind and solar energy systems depends on generation technology, transmission, and increasingly storage technology to solve the intermittent nature of their electrical generation. We have confidence the Clean Republic team has the know-how and ability to develop adaptive lithium battery packaging technologies. They have a proposal to develop a workable solution to the storage problem with lithium batteries of improved quality, longer lifetime and additional reliability (thus lower costs) for wind and solar energy applications as well as other energy storage applications. Solar and wind energy systems are still growing briskly, and the 100,000 solar installation on the grid was just achieved. Successful results would include an innovative lithium battery pack factory in North Dakota as well as enhanced opportunities for wind and solar energy projects. Batteries with these characteristics offer the best storage flexibility and scalability to allow their users to decide when to sell their electricity to maximize profit.

We know the Clean Republic team (Dr. Hou & Mr. Shope) well as they have been clients of the Center for four years, they were to winners in the statewide InnovateND venture competition in 2010, and in 2011 co-founder Michael Shope was the SBA Young Entrepreneur of the Year for North Dakota and the six states in SBA Region VIII which includes states like Utah and Colorado. Dr. Yong Hou is an experienced entrepreneur founding and growing his first company into a wholesaler of Compaq Computers with annual revenue of $13 M. He has worked on lithium battery technologies for several years. This team has a history of innovating and venturing well.

The UND Center for Innovation Foundation provides assistance to innovators, entrepreneurs, students, and researchers to launch new ventures, commercialize new technologies, and secure access to capital from private and public sources. The Center has helped launch more than 540 ventures that employ over 5000 people and raised over $130 M in capital. We support Dr. Hou Yong's proposal to NDIC on developing Innovative Lithium Battery Production for Renewable Energy Storage Systems. The technologies developed from this grant will promote innovation, entrepreneurship and economic development in North Dakota.

Respectfully yours,

Bruce Gjovig
CEO & Entrepreneur Coach
Bruce@Innovators.net
701-777-3134 O

NDSU NORTH DAKOTA STATE UNIVERSITY

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

Tel: 701-231-7119
Fax: 701-231-7195

January 12, 2012

Re: Support for NDIC grant proposal by Dr. Yong Hou

To Whom It May Concern:

I am writing this letter to support the grant application titled "Innovative Lithium Battery Production for Renewable Energy Storage Systems", an effort led by Dr. Yong Hou of Clean Republic LLC.

Wind and solar energy has been growing at an unprecedented pace in the United States and other countries. North Dakota is estimated to have the largest wind energy potential among the lower 48 states of the United States. However, the production of wind and solar energy is intermittent by nature, which affects the continuous supply of power. To explore the full potential of these renewable energy forms, energy storage is widely regarded as a viable approach, in which battery storage has been gaining popularity. With key R&D efforts, the proposed project is aimed at enhancing lithium battery packaging technologies to improve reliability and service performance, and reduce cost. I am impressed by the proposed technologies and the well-thought plan. What's more, this project will help establish a battery packaging line to deliver the battery products and help the economic development.

I am regarded as an established researcher in the areas of renewable energy and energy-efficient manufacturing. I have served on a number of professional leadership committees and technical journal editorial boards, and I have published many papers in these areas. By Clean Republic's invitation, I am committed to providing complimentary consulting service to the company for 300 hours, which will take place in summer time only.

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

Sincerely,

Jing Shi, PhD
Associate Professor
Industrial & Manufacturing Engineering, NDSU
Tel: 1-701-231-7119
Email: jing.shi@ndsu.edu

December 30, 2011

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

RE: Clean Republic Application: Innovative Lithium Battery Production for Renewable Energy Storage Systems

Dear Ms. Fine,

I am writing this letter in support of Clean Republic's research into lithium battery packaging technologies. I have had the opportunity to work closely with Dr. Yong Hou in numerous research projects over the last three years. I have full confidence in Dr. Hou's abilities as an engineer and businessman and feel he has the necessary qualifications to pursue research in lithium battery packaging technology, as well as the, business experience to produce a viable manufacturing plant here in North Dakota.

As a Project Manager of Solargy Lights I am able to assist Dr. Hou for up to 150 hours per summer for the next two years on this research project with no pay. In addition, I have a fully equipped machine shop complete with both manual and CNC machine tools at my home that will be available for the prototype development phase of this project. I will make my time and expertise in machining available to Dr. Hou as needed throughout this project. Also, as a faculty member in the Department of Technology at the University of North Dakota and I am ready and able to assist Dr. Hou with whatever resources are available to me throughout this project.

Respectfully yours,

Dr. Alex Johnson
Assistant Professor
Department of Technology
University of North Dakota
10 Cornell Street Stop 7118
Grand Forks, ND 58202

A3 – Resumes of Key Participants:

Please see attached pages.

Yong Hou, Ph.D.

4200 James Ray Drive, Grand Forks, ND 58203 **Phone: 701-738-4805, Cell phone: 218-791-3746**

Email: hou@cleanrepublic.com

BUSINESS AND WORKING EXPERIENCE

Aug. 2008- Co-founder, Vice President and Director of Product Development
Clean Republic LLC, Grand Forks, North Dakota

Aug. 2008- Assistant Professor Temporary
College of Business and Public Administration, University of North Dakota

Jan-Aug 2008 Vice President of Product Development
Neosonic Li-Polymer Energy (Zhuhai) Corporation

2002-2007 Founder/President
Shanghai Wuling Information Technology Ltd.

1995-2002 Founder/General Manager
Shanghai Zhongdian International Trade Company

1992-1995 Systems Design Engineer, Department Manager
Shanghai Branch Company of Chinese Electronics Group

1983-1989 Electronics Engineer
Hunan Puyuan Engineering Machinery Company

EDUCATION BACKGROUND

- 2002-2007 Ph. D., Management Science
  University of Shanghai for Science and Technology
- 1989- 992 Masters of Science, Systems Engineering
  University of Shanghai for Science and Technology
- 1979-1983 Bachelors of Science, Electronics Engineering
  Hunan University of Art and Science

OTHER EDUCATION

Oct. 2004 – May. 2005 **University of North Dakota**
Visiting Scholar Program

Research Topic: Renewable Energy -- Technologies and Economics

RESEARCH EXPERIENCE

Ph. D. Dissertation

- Optimal dynamic process of investing in renewable energy as substitute for fossil energy

Master Program

- Delaminating and systems analyzing of corporation cost by his historic data.

Other research projects participated

- Technical Feasibility Analysis of Distilling Biodiesel from Cultivated Microalgae
- Our China Biofuels—An Economic Analysis of Producing Biofuels from Corn in China
- Systemic Analysis of Optimized Reduction of Greenhouse Gases with Renewable Energy
- Development of a Site Assessment Instrument for Small Wind Turbine Development in North Dakota

AWARDS

- InnovateND Venture Competition, 2010

PUBLICATIONS

1 .Yong Hou and Luke Huang, **The Present State of and a Suggested Inserting Point for Biodiesel Production Industrialization in China**: 2006 IEEE International Conference on Service Operations and Logistics, and Informatics Proceedings, June, 2006. Page 679-683, ISBN: 1-4244-0318-9 (EI Accession Number: 074610921148)

2. Yong Hou and Fuyan Xu, **The Development of Biodiesel Industrialization** (in Chinese): Commercial Research, October, 2006. ISSN: 1001-148X

3. Yong Hou, **Research on an Evaluation Model of Technique Innovation**: 2006 IEEE International Conference on Service Operations and Logistics, and Informatics Proceedings, June, 2006. Page 187-191, ISBN: 1-4244-0318-9

4. Luke Huang and Yong Hou, **Manufacturing information recognition, analysis, and simulation using Windows based programs**: The 5th Wuhan International Conference on e-Business: Integration and Innovation through Management, May, 2006, Vol. 3, pp1931-1937

5. Yong Hou, Fuyuan Xu and Wei Cheng, **A Sustainable Growth Model with the Utilization of Renewable Energy**: 2007 IEEE International Conference on Communications, Services, Knowledge and Engineering, September 2007. Page 5012-5015, ISBN: 1-4244-1311-7

COURSES TAUGHT

1. TECH 590 – Renewable Energy Economics
2. TECH 497 – Energy Systems and Sustainability
3. TECH/ENTR 405 – Product Research and Development (with Dr. Alex Johnson)
4. BADM 395 – Technology and Innovation Management
5. MGMT 301 – Operations Management

Michael Shope

4200 James Ray Drive, Grand Forks ND 58203
1222 20TH Avenue East, Seattle WA 98112
Phone: (218) 779 3136 Email: mike@cleanrepublic.com

Education

- Bachelor of Science Degree in Aeronautics with an emphasis in Commercial Aviation from the University of North Dakota, Track in Entrepreneurship.
  Enrolled: September, 2000. Graduated: December, 2004.
- Cumulative GPA: 3.83
- Semester Abroad: American College of Thessaloniki, Greece. 12 credits completed.
  Enrolled: January, 2002 – June, 2002

Experience

- Business founding, marketing and communication. 2004-Present
  - Founded Clean Republic LLC with Dr. Yong Hou. See CleanRepublic.com 2008
  - Travel, production, sourcing experience in Guandong, Shanghai, Jilin, and Beijing.
  - Authored and edited two business and marketing plan documents with financials.
  - Edited and compiled: LLC registrations, bylaws, and management contracts.
- Commercial Pilot, AMEL, CFII.
- Founded Pilot Friendly Products, LLC in 2003.
  - Negotiated $15,000 seed funding from Center for Innovation.
  - Developed marketing and sales systems, and prepared invoices.
  - Created and administered company e-commerce website.
  - Sold customer base and entire inventory to an industry leader.
- Presentation and instruction experience.
  - Delivered business plan and marketing presentations for clients and customers.
  - Commercial flight instructor, JDO School of Aerospace Sciences 2004-2005
  - Prepared lesson plans and instructed single and multiple students.

Employment Experience

- Product Specialist, Aviation Supplies & Academics, Bellevue, WA
  - Invent, source production for new products. Google "ASA Tri-Lite, Hoodwink."
  - Collect market feedback for product development cycle (over 300 products).
  - Prepare reports on customer service systems for management.

  Employed: October, 2006-Jun 2008
- Non-Profit Manager, Outdoor Education Post, Garfield High School, Seattle, WA
  - Advise over 50 student staff, chair and facilitate community meetings.
  - Provide organizational and leadership reports and advice to the Board of Directors.
  - Oversee $90,000 annual budget.

  Employed: August, 2007- June 2009
- Founder and CEO – Clean Republic LLC
  - Developed new practical retail products for alternative energy industry
  - Invented solutions for universal electric bike throttle/motor control
  - Manage sales, advertising, and accounting.

  Managing: 2008 - Present

Personal Information and Honors

- Vice President of Delta Tau Delta Fraternity: 50 members, $200,000 annual budget.
  National Top 10 Awarded Chapter. November, 2002 – November, 2003
- Outward Bound leadership academy graduate July, 2003
- President's Honor Roll: University of North Dakota Spring/Fall, 2003
- Dean's List: College of Aerospace Sciences Spring/Fall 2002/2003
- Jack Wright Entrepreneurship Award
- Certified keel boat skipper
- InnovateND Venture Competition 2010
- SBA Regional Young Entrepreneur of the Year 2011

References: Available upon request.

JING SHI, Ph.D.

Associate Professor
Industrial & Manufacturing Engineering
North Dakota State University
Fargo, ND 58108, USA

Tel: 1-701-231-7119
Fax: 1-701-231-7195
Email: jing.shi@ndsu.edu

Education

2004	Ph.D., Industrial Engineering	Purdue University (West Lafayette), Indiana, USA
1998	Ph.D., Materials Engineering	University of Science and Technology Beijing, China
1992	B.E. Materials Engineering	University of Science and Technology Beijing, China

Professional Experience

2010-present	Associate Professor	Dept of Industrial & Manufacturing Engineering, North Dakota State University, Fargo, ND, USA
2004-2010	Assistant Professor	Dept of Industrial & Manufacturing Engineering, North Dakota State University, Fargo, ND, USA
2003-2003	Graduate Instructor	School of Industrial Engineering, Purdue University, Indiana, USA
1998-2002	Research Assistant/ Graduate Instructor	School of Industrial Engineering, Purdue University, Indiana, USA
1996-1997	Co-op Research Engineer	Iron and Steel Research Institute of Baosteel, Shanghai, China

Research Interests

Wind energy systems
Energy economics
Renewable energy storage technologies
Advanced energy materials and manufacturing
RFID and wireless sensor network technologies

Professional Societies

Member, Institute of Industrial Engineers (IIE)
Member, Institute of Electrical and Electronics Engineers (IEEE)
Member, American Society of Mechanical Engineers (ASME)
Member, Institute for Operations Research and the Management Sciences (INFORMS)

Honors and Awards

Alpha Pi Mu Excellence in Teaching Award, 2007
Nominated for FAG Innovation Award, 2006
Nominated for SME Young Manufacturing Engineer Award, 2006
Purdue Research Foundation Fellowship, West Lafayette, IN, 2003
Excellent Graduate/Undergraduate Scholarship, 1989-1998
Best College Graduate of Beijing City, 1992
Baosteel Fellowship, 1991

Professional Leadership Committees
Wind Energy Committee, American Society of Mechanical Engineers (ASME)
Micro/Nano Manufacturing Technical Committee, American Society of Mechanical Engineers (ASME)
International Scientific Advisory Committee, International Green Energy Conference
Symposium Organizer for ASME International Conference of Manufacturing Science and Engineering

Journal Editorial Boards
International Journal of Green Energy (to start in 2012)
International Journal of Manufacturing, Materials and Mechanical Engineering
Energy Science and Technology
The Open Renewable Energy Journal

Journal Reviews (30+ journals)
Atmospheric Research, International Journal of Green Energy, Energy, Applied Energy, Wind Energy, International Journal of Energy Research, International Journal of Electrical Power and Energy Systems, Journal of Wind Engineering & Industrial Aerodynamics, IEEE Transactions on Sustainable Energy

IEEE Transactions on Electronics Packaging Manufacturing, International Journal of Modelling and Simulation, International Journal of Applied Logistics, International Journal of Machine Tools and Manufacture, Journal of Intelligent Manufacturing, International Journal of Advanced Manufacturing Technology, Materials and Manufacturing Processes, Journal of Engineering Manufacture, Nanoscience and Nanotechnology Letters, Vacuum, International Journal of Manufacturing, Materials and Mechanical Engineering, Measurement, Scientific Research and Essays

European Journal of Operational Research, International Journal of Production Economics, IEEE Transactions on Automaton Science and Engineering, IEEE Transactions on Parallel and Distributed Systems, International Journal of RF Technologies, Advanced Engineering Informatics, Sensors, Majlesi Journal of Electrical Engineering, Knowledge-Based Systems, Current Pharmaceutical Design, Neurocomputing, IEEE Transactions on Industrial Electronics

Selected Journal Publications
[1] Liu, H., Erdem, E., and **Shi, J.** "An integrated wind power forecasting methodology: Interval estimation of wind speed, operation probability of wind turbine, and conditional expected wind power output of wind farm," *International Journal of Green Energy*, accepted.
[2] Li, G., **Shi, J.**, and Qu, X. "Modeling methods for GenCo bidding strategy optimization in the liberated electricity spot market – A state-of-art review," *Energy*, 2011, 36 (8), pp. 4686-4700.
[3] Zhou, J., **Shi, J.**, and Li, G., "Fine tuning support vector machines for short-term wind speed forecasting," *Energy Conversion and Management*, 2011, 52(4), pp. 1990-1998.
[4] Li, G., and **Shi, J.**, "Applications of Bayesian methods in wind energy conversion systems," *Renewable Energy*, 2010, accepted.
[5] Erdem, E., and **Shi, J.**, "ARMA based approaches for forecasting the tuple of wind speed and direction," *Applied Energy*, 2011, 88(4), pp. 1405-1414.
[6] Liu, H., Erdem, E., and **Shi, J.**, "Comprehensive evaluation of ARMA-GARCH(-M) approaches for modeling the mean and volatility of wind speed," *Applied Energy*, 2011, 88, pp. 724–732.
[7] **Shi, J.**, Qu, X., and Zeng, S., "Short-term wind power generation forecasting: Direct versus indirect ARIMA-based approaches," *International Journal of Green Energy,* 2011, 8(1), pp. 100-112.
[8] Liu, H., **Shi, J.**, and Erdem, E., "Prediction of wind speed time series using modified Taylor Kriging method," *Energy*, 2010, 35 (12), pp. 4870-4879.
[9] **Shi, J.**, Shi, Y., and Liu, C.R., "Evaluation of three dimensional single point turning at atomistic level by molecular dynamics simulation," *International Journal of Advanced Manufacturing Technology*, 2011, 54 (1-4) pp. 161-171.

[10] **Shi, J.**, and Verma, M., "Comparing atomistic machining of monocrystalline and polycrystalline copper structures," *Materials and Manufacturing Processes*, 2011, 26, pp. 1004–1010.
[11] Li, G., and **Shi, J.**, "Bayesian adaptive combination of short-term wind speed forecasts from neural network models," *Renewable Energy*, 2011, 36(1), pp. 352-359.
[12] Zhou, J., and **Shi, J.**, "A comprehensive multi-factor analysis on RFID localization capability," *Advanced Engineering Informatics*, 2010, 25(11), pp. 32-40.
[13] Zhou, J., **Shi, J.**, and Qu, X. "Landmark placement for wireless localization in rectangular-shaped industrial facilities," *IEEE Transactions on Vehicular Technology*, 2010, 59(6), pp. 3081 – 3090.
[14] Zhou, J., and **Shi, J.**, "Error analysis of non-collaborative wireless localization in circular-shaped regions," *Computer Networks*, 2010, 54(14), pp. 2439 – 2452.
[15] Erdem, E., and **Shi, J.**, "Comparison of bivariate distribution construction approaches for analyzing wind speed and direction data," *Wind Energy*, 2011, 14(1), pp. 27 – 41.
[16] Li, G., and **Shi, J.**, "On comparing three artificial neural networks for wind speed forecasting," *Applied Energy*, 2010, 87(7), pp. 2313–2320.
[17] 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), pp. 21-37.
[18] Li, G., and **Shi, J.**, "Application of Bayesian model averaging in modeling long-term wind speed distributions," *Renewable Energy*, 2010, 35(6), pp. 1192-2002.
[19] **Shi, J.**, Xu, X., Wang, J., and Li, G., "Beam damage detection using computer vision technology," *Nondestructive Testing and Evaluation*, 2010, 25(3), pp. 189-204.
[20] Zhou, J., **Shi, J.**, and Qu, X., "Statistical characteristics of landmark-based localization performance," *International Journal of Advanced Manufacturing Technology*, 2010, 46(9), pp. 1215-1227.
[21] **Shi, J.***, and Liu, C.R., "Two-step cutting as a tool for improving surface integrity and rolling contact fatigue performance of hard machined surfaces," *Materials and Manufacturing Processes*, 2010, 25(6), pp. 495 - 502.
[22] Zhou, J. and **Shi, J.** "Performance evaluation of object localization based on active radio frequency identification technology," *Computers in Industry*, 2009, 60(9), pp. 669-676.
[23] Zhou, J. and **Shi, J.** "RFID localization algorithms and applications – A review," *Journal of Intelligent Manufacturing*, 2009, 20(6), pp. 695-707.
[24] Zhou, J. and **Shi, J.** "Localisation of stationary objects using passive RFID technology," *International Journal of Computer Integrated Manufacturing*, 2009, 22 (7), pp. 717-726.
[25] **Shi, J.** and Grow, D. "Effect of double constraints on the optimization of two-component armor systems," *Composite Structures*, 2007, 79, pp. 445-453.
[26] **Shi, J.**, Wang, J.Y., and Liu, C.R. "Modelling white layer thickness based on the cutting parameters of hard machining," *Journal of Engineering Manufacture*, 2006, 220(2), pp.119-128.
[27] **Shi, J.** and Liu, C.R., "On predicting chip morphology and phase transformation in hard machining," *International Journal of Advanced Manufacturing Technology*, 2006, 27, pp. 645-654.
[28] **Shi, J.** and Liu, C.R., "On predicting softening effects in hard turned surfaces –Part I Construction of material softening model," *Journal of Manufacturing Science and Engineering*, 2005, 127(3), pp.476-483.
[29] **Shi, J.** and Liu, C.R., "On predicting softening effects in hard turned surfaces –Part II Finite element modeling and verification," *Journal of Manufacturing Science and Engineering*, 2005, 127(3), pp. 484-491.
[30] **Shi, J.** and Liu, C.R., "Flow stress property of a hardened steel at elevated temperatures with tempering effect," *International Journal of Mechanical Sciences*, 2004, 46(6), pp.891-906.
[31] **Shi, J.** and Liu, C.R., "Decomposition of thermal and mechanical effects on microstructure and hardness of hard turned surfaces," *Journal of Manufacturing Science and Engineering*, 2004, 126(3), pp.264-273.
[32] **Shi, J.** and Liu, C.R., "The influence of material models on finite element simulation of machining," *Journal of Manufacturing Science and Engineering*, 2004, 126(4), pp. 849-857.

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Educational Background

University of North Dakota, Grand Forks, ND **5/2010**
Ph.D. in Teaching & Learning
Dissertation Topic "Suitability of Bench Top Metal Lathes in Education"

University of North Dakota, Grand Forks, ND **5/2010**
M.S., Industrial Technology
Independent Study "Development of an Introductory Course on Stirling Engines for the Industrial Technology Department at the University of North Dakota"

University of North Dakota, Grand Forks, ND **12/2000**
B.S., Industrial Technology
Emphasis in manufacturing processes

Association Memberships

Association of Technology Management and Applied Engineering (ATMAE) Academic Membership

American Society for Engineering Education (ASEE) Academic Membership

Professional Experience

Solargy Lights, Grand Forks, ND **2011 – Present**
Consultant/Project Manager Part-Time

University of North Dakota, ND **2007 –Present**
Assistant Professor Department of Technology

Concrete Inc. Grand Forks, ND **2003 – 2007**
Quality Control Technician

EAPC Architects Engineers, Grand Forks, ND **2002-2003**
Mechanical Technician (Drafter)

Cirrus Design, Grand Forks, ND **1999-2000**
Manufacturing Engineer Intern

Bobcat, Gwinner, ND **1999**
Tooling Department Intern

Publications, Presentations, Abstracts

Publications in Process:

I am currently working on the following publications:

A collaborative effort with Turtle Mountain Community College involving a solar powered mosquito trap that was designed and built in conjunction with students from both TMCC and UND in the summer of 2011. This article will be submitted to Tech Directions in the fall of 2011 and is a collaborative effort between Dr. Yong Hou, Dr. Scott Hanson, and myself. I will be taking lead author on this article.

A study of mosquitoes collected with the solar powered mosquito trap in the Turtle Mountains during the summer of 2011. This article will be submitted to the American Mosquito Control Association in the fall of 2011 and is a collaborative effort involving Dr. Scott Hanson, Dr. Yong Hou, and myself. Dr. Scott Hanson will be the lead author.

A study of a solar wind hybrid street light prototype. This study was conducted during the summer of 2011 by Dr. Yong Hou and myself with the assistance of two undergraduate and one graduate student from the Department of Technology. The results of this study will be submitted to the Journal of Technology Education in the fall of 2011. I will be taking the role of lead author in this publication.

Development of a site assessment instrument for small wind turbine developers. Dr. Yong Hou and myself have been working on a mathematical model to predict wind speeds for purpose of site assessment. We have finished our calculations and are in the process of writing an article that will be submitted to the Journal of Renewable and Sustainable Energy in the fall of 2011. Dr. Hou will assume the role of lead author in this article.

I am currently finishing up a manuscript concerning the results of a study that was conducted on the use of bench top metal lathes in educational settings. This article will be submitted to the American Technical Education Association journal in the fall of 2011. This article will be a joint effort between Dr. David Yearwood and myself. I will be taking the role as lead author.

Presentations

June 2011 Cleantech, Grand Forks, ND
Presentation Topic: Development of a Site Assessment Instrument for Small Wind Turbine Development in North Dakota
Presented with: Dr. Yong Hou-Clean Republic

May 2008 Community College National Center for Community Engagement (CCNCCE) National Conference, Scottsdale, Arizona
Presentation Topic: Service Learning Saving Children Initiative: Recipes for student retention
Presented with: Turtle Mountain Community College

March 2008 American Indian Higher Education Consortium (AIHEC) National Conference
Location: Bismarck, North Dakota
Presentation Topic: Interdisciplinary approach to service learning
Presented with: Turtle Mountain Community College

Conferences Attended

Association of Technology Management & Applied Engineering Annual Conference
Panama City, Fl
October 2007

Association of Technology Management & Applied Engineering Annual Conference
Panama City, Fl
October 2010

Abstracts

Abstract for Assets Project Year Two
Title: *Fighting Diabetes through a Service Learning Partnership*
between Turtle Mountain Community College
and the University of North Dakota
Co-authored with Peggy Johnson, Turtle Mountain Community College
Abstract Published by: CCNCCE
http://www.mc.maricopa.edu/other/engagement/ASSETSAbstracts/Y2Abstracts/TurtleMountain.pdf

Collaboration

I have worked with faculty from Turtle Mountain Community College on several research projects in the past few years and am working on pursuing a department of energy grant with them in the near future. In addition to Turtle Mountain I have developed excellent relationships with local businesses that have helped with my research agenda in the past year. Two of the companies that I have worked extensive with are Clean Republic and Solargy Lights. In addition, I have started working with a colleague at EERC on a research project involving metallurgical samples that could prove to be important in the oil fields in North Dakota.

Research Interests

My latest research has been in the area of small wind turbine site development and assessment. I am currently working on two manuscripts in this area and have been awarded a grant for the development of a site assessment tool for North Dakota sites. I am also interested in the use of solar energy and have worked extensively with faculty from UND and also Turtle Mountain Community College faculty on these areas.

Other areas that I am interested in and have presented on in the past are service learning and the use of bench top machine tools to replace full size industrial equipment in educational settings.