RESPONSE SUMMARY

Thank you kindly for your time and consideration in your preliminary review and feedback on our grant application. Below is a summary of the additional documentation and clarified communication we have included in our responses to the reviewers' comments.

Note on confidentiality: Though certain parts of the original formal grant application and process, including this summary page, may need to be released for the public record according to certain rules of the Commission, we ask that the sensitive information detailed in the Confidential Information Document attached to this Review Response be kept confidential. To help explain our research and demonstrate the commercial viability and value of our group's work, we have included sensitive information about price points, profit margins, and specific technical details from our product development history in the Confidential Information Document.

Viability of North Dakota as a lithium battery packaging location: Six key reasons North Dakota is an excellent spot for a lithium battery packaging business are the electricity price, climate, educated work force, UND & NDSU research facilities, the fact that ND companies are already looking for the type of solutions we propose, and proximity to parts suppliers. Battery assembly and testing requires heavy electricity usage, and the low costs of ND electricity are very attractive. Heat generation is a big problem in many battery assembly and testing facilities because excessive heat can damage the battery chemistry itself, but the natural ND climate offers simple solutions to this problem. The educated work force in the region and resources of the UND and NDSU research facilities allow for high-quality labor and solutions to many technical problems and questions. ND companies such as Solargy Lighting LLC are already looking to groups like ours for the battery solutions we propose, and the proximity to large parts suppliers like Digi-Key ads to the efficiency of the business model.

BMS designs we propose are not readily available today: Some BMS solutions for small battery packs and cells are indeed already available off-the-shelf, however effective, affordable BMS designs for the medium-large size batteries our proposal focuses on are *not* available. Details of features, cost points, and processes regarding this issue are provided.

We have a great deal of documented analysis and tests: Based on our previous engineering modeling, lab analysis, research and commercialization experience documented in our response, we show how our team does have a unique starting point do develop and launch these new technologies.

Demonstrated commercial viability of our research: Comparisons between our group and other industry groups show not only the clear commercial viability of our work but the additional advantages we have over competing businesses and research groups.

Awareness of published research: Due to the specific document length restrictions on our original application, only our work was included, not that of others. Detailed examples of other published work we have been referencing is included here.

Team's experience in lithium battery manufacturing: Our management team has extensive career and market experience in the lithium battery manufacturing industry, and the details of this experience are further documented here.

R015-C
Innovative Lithium Battery Production for Renewable Energy Storage Systems
Submitted by Clean Republic LLC
Principal Investigators: Yong Hou & Michael Shope
Request for $190,000; Total Project Costs $403,000

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 1A (Rating: 4)
The goals are clearly stated, which is to improve the thermal management, cell balancing, and serviceability of large battery packs suitable for storage of wind energy.

Reviewer 1B (Rating: 3)
This proposal discusses a potential manufacturing operation based in North Dakota, selling renewable energy-related energy storage products. Those products also are applicable to the wind and solar projects already existing in the state. As such, the objectives and goals of the proposed project are clear and consistent with the NDIC/REC goals, including efficient, economic and environmentally sound development of renewable energy resources; jobs creation; stability and growth of the renewable energy industry; and encouraging the use of new technologies.

However, it's not clear why ND should be a center of lithium ion battery manufacturing – an industry which has seen recent bankruptcies because it is highly cost-competitive and crowded.

Response: The lithium battery industry has changed substantially over the last few years. Small lithium batteries that are commonly used in cell phones, laptops, and other small electric devices are labor intensive to manufacture and, in addition, there is a considerable amount of competition in this field. The competition in this industry has made it unwise for new companies to venture in this direction; however, medium-large scale lithium batteries offer a far more promising market. With few competitors in this field the chances of success are far better. Customers of these medium-large scale batteries are likely to be far more concerned with reliability and technological features than cost. Unfortunately the cost to enter into this industry is steep considering the equipment resources needed and also the large amounts of electricity. We feel that North Dakota would be an ideal location to start such a company for the following reasons.

a) North Dakota has some of the cheapest electricity in the world.
b) The unique weather conditions in North Dakota are ideal for production of medium-large scale lithium batteries. Battery cells and packs need to be charged and discharged many times during the production and testing phases and this generates large amounts of heat. Ambient temperatures cannot exceed 50ºC without damage to the batteries. In warmer climates this amount of heat will require facilities to use more air conditioning to control climate; however, production in a typical North Dakota winter will actually reduce heating costs to a substantial degree.

c) North Dakota has a good, well educated, workforce that possesses very good work ethics, yet is less expensive than many other parts of the country. Clean Republic has been benefiting from this workforce since 2008.
d) Placing this facility near Grand Forks, North Dakota allows easy access to resources at both the University of North Dakota and North Dakota State University. These research institutions present great opportunities for collaboration through their engineering and technology programs. This provides a mutually beneficial atmosphere for both company and institution and the industrial experience gained can be a tremendous advantage for faculty researchers and instructors who can share these experiences with their students. Additionally, the close relationship between these two institutions offers the potential for many rewarding Co-op and part-time job opportunities for students, which Clean Republic has been offering since they started operations in Grand Forks in 2008.
e) North Dakota is experiencing economic growth beyond any other state in the country. Numerous renewable energy businesses, such as Solargy Lights are currently operating in North Dakota, or looking to get started in this region. Whether you are looking at wind, solar, or hybrid systems, batteries play a major role in the success, or failure of these companies. Forward thinking companies, like Solargy Lights are always on the lookout for cutting edge technologies that allow their products to rise above the competition. Lithium battery technology offers numerous advantages over traditional lead acid styles; however, the huge cost difference between these systems makes them economically unviable at the moment. A company that can produce these medium-large scale lithium batteries with the capacity useful for intermittent energy sources such as wind and solar, yet capable of performing in the frigid conditions of the Midwest will have a considerable advantage in the market.
f) North Dakota benefits from well-established electronic component suppliers such as Dig-Key located nearby.
g) Also, this project will be further strengthened by the effective combination of Clean Republic's experience and resources in terms of lithium battery R&D, outsourcing, selling and servicing which have occurred over the past four years. In addition, the Principal Investigator's career in the lithium battery industry provides valuable insights into the current field and intimate understanding of current techniques, know-how, and insights into low cost suppliers for basic components necessary for the construction of medium-large scale lithium batteries.

Reviewer 1C (Rating:4)
The key objectives of the proposal are identified. Specifically, the proposed research seeks to overcome barriers to the greater use of renewable energy by providing more cost effective energy storage options. These objectives are well aligned with the Council's goals.

Reviewer 1D (Rating:5)
The proposal aims to develop battery management system through designing novel electrical circuits, design battery pack frameworks with removable architectures, and investigate the use of phase change materials for thermal management of batteries. The study and investigations will be tested in field with wind/solar hybrid generation system.

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 1A (Rating: 2)
None of the approaches proposed is unique or novel. In some cases, not concrete plan is described. For example, it is unclear what phase change material will be tested. Without the specifics, it is not clear

whether the material can be configured to the desired form, or whether there is any environmental issue in their use. Although they have a reasonable chance to achieve the technical goals, the proposer has not provided a reasonable justification of commercial potential. For example, cell balancing is practiced in many commercial applications of Li-ion batteries. How is the proposed work superior in performance and in cost?

Reviewer 1B (Rating: 2)
What is proposed is a 3-part research and development program over 2 years. In order to complete these objectives, a team of 3-4 employees will need to investigate and solve disparate mechanical, electrical, and design-for-manufacturing challenges.

In addition, in these 3 primary research tasks, there is already a rich body of other research and development in what is a crowded sector (lithium ion cell and battery manufacturing), and it's unclear from the materials provided that this team has an advantaged starting point for developing solutions that the broader research community hasn't been able to produce. It is entirely possible that this team's approach could be successful, but it also seems unlikely that they will have breakthrough advantages in all 3 areas.

And if the objective is to develop an economically viable North Dakota-based lithium ion battery manufacturing operation based upon this team's efforts, it's notable that there is little mention in this proposal of likely cost points versus competitive offerings, in a market (lithium ion batteries) that has seen very significant price-based competition over the past decade.

Reviewer 1C (Rating: 2)
The areas identified (improved battery management systems, better thermal management, and more modular battery system design) are important. However, these areas are being aggressively pursued by many organizations. It would seem that developing competitive solutions within the time and budget proposed is a difficult challenge.

Reviewer 1D (Rating:4)
The team has facility to fabricate battery pack and test battery pack. This makes the objective achievable with the time and budget framework. The team also has experience in the battery engineering.

Response: By far the largest proportion of off-the-shelf battery management systems (BMS) consists of simple protectors for small batteries from Chinese companies. They are not appropriate for medium-large scale lithium battery packs which must economically manage hundreds of individual cells, or blocks if cells, in terms of state of charge (SOC), state of health (SOH), and depth of discharge (DOD); in addition to safety and communication. Very few commercially available BMS's are from large, well-known companies. Clean Republic has learned through several years of corporate experience in the purchase and sale of lithium batteries that the most advanced, most practical, yet most economical BMS's available today are sold by small scale U.S. and European companies. The opportunity to observe the processes of these companies has provided insights into how their approaches might transfer to the production of medium-large scale lithium batteries in an economically viable fashion. These observations have so far resulted in the production of several successful mid-range size battery packs using lithium polymer cells, which have resulted in a better understanding of the requirements, challenges, and solutions necessary for the development of a successful medium-large scale lithium battery production operation.

Factors the group is researching concerning BMS operations are:

a) Balancing leaves room for more charge, which brings all the cells/blocks to the same SOC without overcharging the most charged cell/block. Balancing can be performed by the BMS, or by a distributed charger. If it uses the BMS, balancing can be passive (energy is wasted in heat) or active (energy is transferred between cells/blocks). We propose passive balancing based on our own experiences and research over the past several years. This goes against a lot of those in industry who would suggest the active approach. The fundamental reason for us to make this choice are: (1) the small portion of energy waste (less than 10%) is not a big deal with large capacity of the medium-large scale lithium battery packs that we propose. This system is more concerned with issues of reliability, long life cycle, and ease of field replacement. In addition, (2) huge cost savings of $1-2USD per cell/blocks (depending on the algorithm) compared to $10-20USD per cell/block for the active balancing BMS.

b) [See confidential response document]

c) Redistribution is a technique that shuffles energy in a battery in such way that all of its energy can be used. It allows for cell balancing during discharging. It's similar to active balancing, except that it uses either complex or expensive DC-DC converters, capacitors or transformers. Its battery energy utilization is 100%, but it is too expensive. This is not a major concern for our renewable energy storage battery system.

d) Distributed charging is a feature of the charger, not BMS. It's an alternative to a BMS's balancing function. It is a number of small chargers which charge their own cell/block, up to the full voltage, and no further. This approach will inherently result in a pack that is top balanced without any risk of overcharge.

   Instead of the normally electronic distributed charging system, which is very complex and expensive (up to $17-50USD per cell/block), we are conducting research of a disruptive, low-cost mechanical solution for these functions for batteries of middle and large size that would advance the technology in this area. It should be feasible for a wide variety of energy storage systems; in addition to light vehicle battery systems.

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 1A (Rating: 2)
Much can be done with good engineering analysis. For example, removable mechanical architecture will make sense only for packs larger than a certain size. What preliminary analysis has been done to determine this? What is the cost/benefit analysis of using phase change materials, and what are the competing technologies? Is there any effort for bench marking?

Much can be done with engineering modeling without performing experiments to minimize the cost of development. Very little is done by the proposer.

Reviewer 1B (Rating: 3)
The proposal seems well considered and acknowledges the need to evaluate available options before determining a best design to be commercialized.
However, there is also little discussion of competitive efforts being pursued or even already commercialized. This is a critical consideration if one objective is the eventual formation of a

commercially-viable ND-based battery manufacturing operation. For example, there is extensive discussion of the investigation of various phase-change materials for thermal management in the assembled battery. This is an approach that has already been pursued in the marketplace and in fact there are patents published on the subject.
Again, this team may be able to improve upon work done previously in these other efforts, and to surpass the competitors already in the marketplace. But existing IP may preclude commercialization even if this is possible.

Reviewer 1C (Rating: 2)
The one caveat is that I am reviewing just this proposal. This fact notwithstanding, there are few details in the proposed research that demonstrate novel approaches to a better BMS or a superior thermal management system. It is well-known that a good battery management system is needed to equalize charge on individual cells, and a BMS is part of any lithium ion battery system. There is no indication that the proposed work will advance the technology in this area. The second thrust is in thermal management, with the key concept to use phase change material. The use of phase change material has been around for a while. The most serious drawback is that there is only a limited amount of heat that can be removed before the material has to be solidified again. For renewable energy applications where charging and discharging are nearly continuous, the limited heat removal ability is a major obstacle. This challenge is not addressed in the proposal.
Within the modular design concept, integration with the thermal management system and accounting for the axial load that is typically used with prismatic cells is not discussed. Here, the concept is not novel but ok, yet the challenges are not clearly identified and solutions proposed.

Reviewer 1D (Rating: 2)
The methodology for some of objectives is not convincing. For example, the phase change material (PCM) is an important component for investigating thermal management of battery pack. The study on the phase change materials is not clearly illustrated how the PCM will affect temperature distribution in the battery pack. It is also important to mention how to manage the hot spots of battery cell for thermal management.

[Response contains confidential business information. Please see confidential response document.]

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 1A (Rating: 1)
It is unclear what the commercial viability of the proposed technology. Without a clear performance target that is also cost competitive, the chance of success in job creation or generation of new business is low.

Reviewer 1B (Rating: 3)
There is a significant research and development component to this proposal, and the objectives of this work are clearly in alignment with the NDIC/REC goals.

Above, I have suggested that it may be difficult for this team to ultimately develop a commercially competitive lithium ion battery offering given the scope of the technical challenges faced and the fact that there is already a crowded market of competitive solutions and researchers.

That said, even if that should be the eventual result, the scientific and technical work done in pursuit of this proposal could result in either a) the identification of emerging energy storage technologies that could be valuable for ND-based renewable energy project developers and owners; and/or b) the identification of alternative configurations and applications of lithium ion technologies so that existing manufacturers may be able to better bring to ND project developers and owners products that meet their needs.

Reviewer 1C (Rating: 3)
In spite of the concerns raised above, it is likely that the proposed work would help to achieve the council's goals.

Reviewer 1D (Rating: 3)
The low cost Li-ion battery with good cycling stability and safety is an emerging energy storage technique for stationary energy storage application. The energy storage system is also important to efficiently use intermittent energy source such as solar and wind energy. The proposal work will address three key issues of current Li-ion battery packs for the stationary applications paired with solar/wind energy conversion devices. The proposed work significantly addresses the goals of North Dakota Industrial Commission/Renewable Energy Council.

[See confidential response document]

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 1A (Rating: 2)
The description of competing technologies is minimal, certainly inadequate.

Reviewer 1B (Rating: 2)
There is little mention in the proposal of the deep body of existing research into cell balancing and thermal management. Also, modular-based energy storage is well-known and commercialized in other energy storage technologies (notably fuel cells and flow batteries), but that is not mentioned. The major existing commercialized lithium ion efforts aimed at stationary renewable energy project applications isn't explored.

It would be good to request that the Principal Investigator make contact with leading researchers in lithium ion (such as Gerd Cedar at MIT) to discuss this proposal, and make revisions if such discussions show that existing research efforts have already pushed the state of play beyond that described in this proposal.

Reviewer 1C (Rating: 3)
The PIs have demonstrated a good awareness of the present importance of the bms and thermal management. Again, more information showing that there proposed research would advance the state of the art is needed. There is a wealth of recent literature on algorithms for charge equalization, it is not clear what novelty is proposed here.

Reviewer 1D (Rating:2)
The use of phase change materials have been reported in literature for managing thermal runaway and thermal distribution issue in battery pack.

Response: Thank you for the comments. We had performed an extensive literature review on battery development before the submission of this proposal. Due to the page limit of the proposal, we omitted much background knowledge and only made statements such as "The removable mechanical architecture is a completely new idea being developed by Clean Republic LLC" in the section of "Techniques to Be Used, Their Availability and Capability" in the original proposal. We thought that the proposed three key areas of applied research are unique and these statements are able to show our understanding. In response to the comments, we hereby provide more details to support our statements and justify the proposed work below.

In terms of battery management systems (BMS), the most efficient way to fabricate your own BMS, with a minimum amount of risk, is to begin with a reference design. There are a number of BMS designs, in which many utilize standard ICs, while others rely on complete BMS chip sets. The existing solutions of BMS with passive balancing functions include: Atmel (ATA6870, ATA6871), Elithion (EL01/EL02), Perkins (V series), Linear Technology (TLC 6802), Texas Instruments (bp78PL114, bp77PL900), National Semiconductor's complete BMS and Intersil (ISL9208). We decided to focus on Atmel's and Linear Technology's solution, after conducting a survey through various resources of published literature in terms of the comparison of its accuracy, total cost and availability. The following references [1-4] were particularly important in making this decision.

[1] Barsukov, Y., Battery Balancing: What to Balance and How, Texas Instruments.
[2] Dubarry, M., et al., Capacity and Power Fading Mechanism Identification from a Commercial Cell Evaluation, Journal of Power Source, Vol. 165, 2007
[3] Dubarry, M., and B.Y. Liaw, Development of a Universal Modeling Tool for Rechargeable Lithium Batteries, Journal of Power Source, Vol. 174, 2007
[4] Beauregard, Garrett, Report of investigation, Hybrids Plus Plug in Hybrid Electric Vehicle, National Rural Electron Cooperative Association, Inc. and U.S. Department of Energy, Idaho National Laboratory, ETEC, June 26, 2008

Regarding the thermal management, we are also aware of the state-of-the-art developments. Again, no removable architecture for lithium batteries has been proposed and studied in literature – Clean Republic LLC is filing a Disclosure of Invention for the idea. We will not only conduct experimental tests to determine the optimal architecture, but also work with NDSU/UND partners to develop the simulation analysis tool for heat generation and transfer in the proposed architectures. In the mean time, the literature of thermal management can be briefly summarized in the following aspects.

- Liquid for battery thermal management: Some studies indicate that conventional natural air convection or forced convection cooling method is not capable of alleviating heat accumulation, especially for large-scale batteries in electric vehicles and bulky energy storage systems [5]. Based on this concern, attention has been focused on using liquids for battery thermal management. Different methods could be used for liquid thermal management, including: 1) discrete tubing around each battery module, 2) submerging modules in fluid for direct contact, 3) place the modules on liquid cooled plate (heat sink).The heat transfer medium could be water, glycol, oil, acetone, etc. [6] Researchers reviewed a systematic approach for designing and evaluating battery pack thermal management systems in [7], and the performances of liquid cooling versus air cooling, cooling and heating versus cooling only were compared. It was concluded that thermal management systems using air as heat transfer are less complicated than using liquid. But liquid thermal management can achieve better thermal performance. As

suggested by Gaugler in 1942, heat pipes made the first use of change-of-phase heat transfer. It uses a sealed container whose inner surface has capillary wicking material to drive the condensate back to the evaporator. In order to simulate the temperature distribution in Li-ion battery, Wu et al. developed a two-dimensional, transient model for different heat dissipation methods [8]. In this study, two heat pipes with aluminum fins were attached to the battery for the purpose of reducing temperature rise. The results indicated that the heat pipes played an important role in heat dissipation.

- PCM for battery thermal management: This is a relatively new idea. Various thermal management techniques, especially the PCM (phase change material) battery thermal management system are discussed in Rao &Wang's work [9], and the novel idea of using of PCM for battery thermal energy management was proposed for electric and hybrid vehicles. The thermal energy is stored in the PCM, in which the major proportion is latent heat due to high latent heat storage capacity. The latent energy storage acts as heat absorption to maintain constant temperature when the PCM changes its phase from solid to liquid or from liquid to gas. It has been confirmed a better performance not only for heat dissipation but also for heating in cold environment. There are many PCMs available in a vast variety of temperature range. Generally, the PCM can be categorized into organic, inorganic and eutectic. A mathematical model based on the first law and second law has been created to simulate the heat-transfer process involving PCM [10]. A passive thermal management system using PCM for Li-ion batteries for electric car and scoter applications was proposed by researchers from the Illinois Institute of Technology [11]. It was found that the amount of PCM and its melting temperature had a significant effect on keeping the battery pack within a safe temperature range. About 90% of nominal battery capacity was utilized even at extreme conditions with high discharge rate and high ambient temperature. Test results again demonstrated the advantage of using the novel PCM thermal management systems over conventional cooling systems. This led to the founding of a start-up company, AllCell, which has been working with our company since 2011.

Since there are a number of PCMs available as shown in the table below, and there are also a number of additive materials which can be mixed in the PCMs to regulate the thermal conduction, no ideal solution has been proposed for the battery system designed for renewable energy storage. In this regard, we will work with AllCell and NDSU/UND partners to start from the AllCell PCM composition and extend to other viable solutions.

Table: Common phase change materials [12]

Paraffins	Inorganic compounds	Inorganic eutectics	Organic compounds
Paraffin C_{14}	H_2O	58.7% $Mg(NO_3)\cdot 6H_2O$ + 41.3% $MgCl_2\cdot 6H_2O$	Polyglycol E 400
Paraffin C_{15}–C_{16}	$LiClO_3\cdot 3H_2O$	66.6% $CaCl_2\cdot 6H_2O$ + 33.3% $MgCl_2\cdot 6H_2O$	Polyglycol E 600
Paraffin C_{16}–C_{18}	$KF\cdot 4H_2O$	48% $CaCl_2$ + 4.3% NaCl + 0.4% KCl + 47.3% H_2O	Polyglycol E 6000
Paraffin C_{13}–C_{24}	$Mn(NO_3)_2\cdot 6H_2O$	47% $Ca(NO_3)_2\cdot 4H_2O$ + 33% Mg $(NO_3)_2\cdot 6H_2O$	Dodecanol
Paraffin C_{16}–C_{28}	$CaCl_2\cdot 6H_2O$	60% $Na(CH_3COO)\cdot 3H_2O$ + 40% $CO(NH_2)_2$	Tetradecanol
Paraffin C_{18}	$LiNO_3\cdot 3H_2O$	66.6% Urea + 33.4% NH_4Br	Biphenyl
Paraffin C_{20}–C_{33}	$Na_2SO_4\cdot 10H_2O$		HDPE
Paraffin C_{22}–C_{45}	$Zn(NO_3)_2\cdot 6H_2O$		Trans-1,4-polybutadiene (TPB)
Paraffin C_{23}–C_{50}	$Na_2CO_3\cdot 10H_2O$		
Paraffin wax	$CaBr_2\cdot 6H_2O$		Propionamide
Oktadekan	$Na_2HPO_4\cdot 12H_2O$		Naphtalene
	$Na_2S_2O_3\cdot 5H_2O$		Erythitol
	$Na(CH_3COO)\cdot 3H_2O$		Dimetly-sulfoxide
	$Na_2P_2O_7\cdot 10H_2O$		Capric acid
	$Ba(OH)_2\cdot 8H_2O$		Caprinic acid
	$Mg(NO_3)_2\cdot 6H_2O$		Laurinic acid
	$(NH_4)Al(SO_4)\cdot 6H_2O$		Miristic acid
	$MgCl_2\cdot 6H_2O$		Laksiol
	$NaNO_3$		Palmitin acid
	KNO_3		Stearic acid
	KOH		Acetamid
	$MgCl_2$		Propionamid
	NaCl		
	Na_2CO_3		
	KF		
	K_2CO_3		

[5] Chen, Y.,Evans, J.W., 1993, "Heat transfer phenomena in lithium/polymer –electrolyte batteries for electric vehicle application," Journal of the Electrochemical Society, 196(2), pp. 793-800.

[6] Pesaran, A.A., 2001, "Battery Thermal Management in EVs and HEVs: Issues and Solutions," proceedings of Advanced automotive battery conference, February 6-8, 2011, Las Vegas, Nevada.

[7] Pesaran, A.A., Burch, S., and Keyser, M., 1999, "An Approach for designing Thermal Management Systems for Electric and Hybrid Vehicle Battery Packs," proceedings of The Fourth Vehicle Thermal Management Systems Conference and Exhibition, May 24-27, 1999, London, UK.

[8] Wu, M.S., Liu, K.H., Wang, Y.Y., and Wan, C.C., 2002, "Heat dissipation design for lithium-ion batteries," Journal of Power Sources, 109(1), pp. 160-166.

[9] Rao, Z., Wang, S., 2011, "A review of power battery thermal energy management," Renewable & Sustainable Energy Reviews, 15(9), pp. 4554-4571.

[10] Dutil, Y., Rousse, D. R., Salah, N. B., Lassue, S., Zalewski, L., 2011, "A review on phase-changing materials: mathematical modeling and simulations," Renewable & Sustainable Energy Reviews, 15(1), pp. 112-130.

[11] Al-Hallaj, S., Kizilel, R., Lateef, R., Farid, M., and Selan, J.R., 2005, "Novel PCM thermal Management maks Li-ion Batteries a viable option for high power and high temperatureapplications," proceedings of the 22nd International Battery Seminar & Exhibit, March 18, 2010, Fort Lauderdale, FL, USA.

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

In addition, based on the suggestions from the reviewers, we have started to contact more experts in the area of battery packaging, such as Dr. Gerd Cedar at MIT, and researchers from A123. No responses have been received so far. We will keep doing that.

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 1A (Rating: 2)
It is unclear whether any of the investigators has first-hand experience in battery development of manufacturing.

Reviewer 1B (Rating: 3)
This is a strong multidisciplinary team that has already successfully introduced related applications into the marketplace. They have both a technical and a commercial background, which is valuable for this effort.

Reviewer 1C (Rating: 3)
The PIs do not have a strong track record in this field. They appear to be competent engineers and scientists, but without a deep understanding of the field.

Reviewer 1D (Rating:3)
The PIs have experiences in battery manufacturing, system control, and management. The background is adequate for conduct the research for the proposed work.

Response: The following is for responding the comments from Reviewers 1A and 1C.

With degrees in Electronic Engineering, Systems Engineering, and over twenty years of career experience as an electronics engineer and senior business manager, Principal Investigator, Dr. Yong Hou had been working with the Neosonic Li-Polymer Energy Corporation (www.neosonic.com.cn) until he founded Clean Republic LLC with Michael Shope. Neosonic is a professional lithium battery manufacturer which designs and produces lithium polymer battery cells and various types of lithium battery packs. Dr. Hou was Vice President of Product Development at Neosonic, and this company had over 400 employees while he was working there. His main responsibility at Neosonic included (1) directing the design and development of a new style of lithium polymer battery used for light electric vehicles; (2) directing the Business Department in mainland China; (3) being in charge of the ERP (Enterprise Resource Planning) system and Product Testing Lab.

Bringing with him the first-hand experience of battery R&D and manufacturing from Neosonic, Dr. Hou partnered with Co-Investigator, Michael Shope to found Clean Republic LLC. The current primary business of Clean Republic LLC is manufacturing electric bike conversion kits. Their company developed its own lithium battery packs which are the key to the success they have enjoyed during the past three years. The track record of both two investigators in the lithium battery field has been introduced above, through the R&D experience of their V1-V4 models of lithium battery packs.

Below we also attach a few pictures (about battery development and testing) taken at our Grand Forks facility to showcase that we have been conducting R&D and producing lithium batteries at Clean Republic LLC.

[see pictures in confidential response document]

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 1A (Rating: 3)
The management plan is simple, but the scope of the proposed work is also small. The proposed work is too preliminary for field tests or production of prototype.

Reviewer 1B (Rating: 4)
The plan is well-defined and the investigators have a process for communicating regularly. Milestones are as well-defined as they can be at this stage of what is a somewhat open-ended investigation. It does not appear that the full salary and related labor costs for a team of 3-4 researchers over two years is included in this proposal, but that is probably to be considered an unidentified in-kind contribution from the investigators.

Reviewer 1C (Rating: 4)
No concerns here.

Reviewer 1D (Rating:2)
The project management is limited. The proposal does not listed timetable with milestones.

Response:
In response to Reviewer 1A, after providing the additional information, we believe that the reviewer can now acknowledge the justification of the proposed work, and appreciate the strong needs, commitment, and potential from the company to develop the successful products based on the proposed work.

In response to Reviewer 1D, we believe that we have specified the project management and timetable with milestones in the "Management" and "Timetable" sections in the original proposal. Although they are concise, they should be clear and complete.

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 1A (Rating: 5)
No major equipment purchased is requested. The scope of work does not require unusual machinery or equipment.

Reviewer 1B (Rating: 5)
The only equipment purchases appear to be necessary components and supplies for developing the prototypes.

Reviewer 1C (Rating: 4)
The only funds for equipment identified was $13k in kind from Solargy Lights for field testing. These funds are well justified.

Reviewer 1D (Rating:4)
The proposed purchase of equipment (such as cell components, BMS boards, etc) is well justified in the budget justification.

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 1A (Rating: 5)
Since the proposed work is rather simple, it should not be difficult to have access to adequate equipment to perform the work.

Reviewer 1B (Rating: 3)
There doesn't appear to be any specialized lithium ion battery production facility being used, although some could be available via contractors (AllCell for example). Fortunately, at the prototype level lithium ion batteries are not very difficult to make. However, making them at commercial-grade and cost-competitive levels would require a very significant additional investment.

Reviewer 1C (Rating: 3)
There are not many details about the specific test equipment available that are relevant to battery testing.

Reviewer 1D (Rating:4)
The team has facilities and equipment to fabricate battery cell pack and test the performance.

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 1A (Rating: 2)
Although the company is providing extensive cost matching, because of the low probability of commercial success, the value of the proposed budget is not high.

Reviewer 1B (Rating: 3)
Because of the low likelihood of this turning into a commercially viable manufacturing operation, at least as written up in this version of the proposal, the proposed $185k in grant support may not provide good value. This perspective can change, if upon further exploration of existing lithium ion research and competitive offerings, the investigators revise the proposal and demonstrate a viable, price-competitive commercial opportunity they can build.

The financial commitment from other sources is attractive, and probably understated in this proposal as salaries of the 3-4 team members doesn't appear to be captured and thus is potentially in-kind via the investigators and partners.

Reviewer 1C (Rating: 4)
The proposal included significant time of faculty that were used as cost share. This feature seemed to be a strong endorsement of the concept and adds value to the project.

Reviewer 1D (Rating:4)

The proposal provide high quality match fund and supported by other sources such as faculty members from UND and NDSU, and other company. The proposed budget value is high value.

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 1A ***(Do Not Fund)***
In general, this proposal lacks imagination and the proposed approaches lack novelty. The investigators do not seem to be familiar with competing technologies, and cannot provide a convincing argument of the technical or economic advantages compared with competing technologies. There is a lack of bench-marking. Overall, this is a weak proposal.

Reviewer 1B ***(Funding May Be Considered)***
Large-format energy storage to firm wind and solar renewable energy projects is indeed a large opportunity. There are, however, a multitude of efforts being undertaken in pursuit of this opportunity. For reasons of high cost, it is unclear that lithium ion will be a large-scale solution to this, above things like flow batteries, compressed air energy storage, other battery formats, etc.
Even within lithium ion, there is a very stiff competitive environment and a lot of research and development underway at many of the nation's leading research institutions.

To find this proposal fundable, I would need to better understand that the investigators have tracked down many of these researchers and existing companies, examined not only what is currently commercially available but what is also being developed, and make an informed argument that this proposed effort would result in a differentiated and cost-competitive opportunity that would warrant the extremely capital-intensive effort of building out a battery manufacturing operation.

Reviewer 1C ***(Funding May Be Considered)***
It is difficult to make recommendations in a bit of vacuum having only seen one proposal and not having a track record with this process. That being said, my recommendation is not to fund the project. The principal weakness is the lack of details showing innovation in the bms development and thermal management approach.

Reviewer 1D ***(Funding May Be Considered)***
As low cost battery packs with good cycling stability and safety is in demand for efficient use of renewable energy storage resources, the proposal fits the need and goal of North Dakota Renewable Program. The proposed research work address the key issues in development of battery packs for distributed stationary applications such as storage of solar/wind energy. The combination of battery management with cell discharge/charge balances, thermal management and fabrication of removable architectures is unique, although it is not clear how the proposed phase change materials effectively

improve the performance of battery pack at different thermal conditions for better thermal management. I would recommend the proposal funded.

ATTACHED: CONFIDENTIAL INFORMATION DOCUMENT CONTAINING MORE DETAILED RESPONSES.