Award Specific Terms and Conditions for the EEC-0812121 / 1159198, "NSF Engineering Research Center for Future Renewable Electric Energy Delivery and Management (FREEDM) Systems", North Carolina State University Cooperative Agreement

The terms and conditions stated herein are the minimum requirements to fulfill the responsibilities to achieve the goals expected under ERC solicitation NSF 07-521. All referenced documents including websites are made a part of this Cooperative Agreement. The absence of a compelling strategy for achieving demonstrable impact in and of the key features of a Gen-3 ERC incorporated in this agreement and described in full details in NSF 07-521 is sufficient reason to deny continued funding.

The following includes revisions to the generic ERC terms and conditions that impact all ERCs since NSF 07-521 was issued.

1. Project Description:

The NSF ERC for FREEDM Systems will conduct the fundamental research and develop the enabling technology in power electronics, power systems, energy storage, and distributed control and communication that will enable a paradigm shift for the electric power industry. This transformational shift will move the power system away from today's centralized, utility-owned power generation system to a system that allows decentralized, user-owned, distributed renewable energy resources and storage devices to operate and communicate on a plug-and-play basis. This will allow a higher proportion of renewable energy resources connected in the overall power system, thus increasing long-term energy security and environmental sustainability. The Center will also educate a workforce capable of enabling this transformation.

2. Project Governance and Governing Responsibilities:

The Awardee will ensure that an efficient and effective project governing structure is in place throughout the award period to support all critical significant project activities. The awardee will also ensure efficient and effective performance of all project responsibilities by the governing components throughout the award period.

3. Key Personnel:

The following positions are considered Key Personnel and are essential to the work of this ERC. Any contemplated changes in Key Personnel for these positions should be

discussed with the NSF Program Officer. Written approval from the NSF Program Officer must be secured before any change is implemented. Any anticipated change in the people serving as the Center Director or the Deputy Director to be effective within the next performance year must be disclosed in the ERC's annual report, and a succession plan must be provided in the report.

Center Director – Alex Huang
Managing Director – Rogelio Sullivan
Administrative Director- Audrey Callahan
University Education Program Director- Mesut Baran
Pre-College Education Program Director – Lisa Grable
Education Program Director – Penny Jeffrey
Industrial Collaboration and Innovation Director – Ewan Pritchard
Industry Liaison Officer – Seth Crossno

In the case of the departure of the Center Director, the lead university and the affected university, in consultation with NSF, will find a replacement suitable to NSF. Before a change is implemented within the lead university, written approval from the NSF Program Officer must be secured. In the case of the departure of (a) the Center Director from the lead university, or (b) one of the PIs from a core partner university, and NSF does not find the person recommended by the Center to be suitable, the Foundation reserves the right to recommend termination of the ERC or the core partner's affiliation with the ERC.

4. Lead and Core Partner Universities:

The NSF Engineering Research Center for Future Renewable Electric Energy Delivery and Management (FREEDM) Systems is configured as follows: North Carolina State University is the lead university in the ERC, and Arizona State University, Florida State University, Florida A&M University, the Missouri University of Science and Technology are core partner universities. In the case of inadequate performance at the lead university or at any of the core partner universities, the Foundation reserves the right to recommend termination of, respectively, the ERC or the core partners.

5. Requirements for the Implementation of the Key Features:

a. Strategic Research Planning and the Research Program:

(1) Support for the Research Experiences for Undergraduates Program (REU) program, at a minimum of $42K per year, will be provided using ERC base budget funds. The ERC may seek an REU site award under the REU Program Solicitation to augment these funds. The ERC also may augment base REU Program support through a combination of REU supplemental awards to individual ERC faculty as long as those students have an interdisciplinary ERC experience with exposure to industry.
(2) U.S. Student Involvement at Foreign University Partners: If there is a large

number of U.S. ERC students who work in the foreign partner university(ies)' laboratories resulting in a large accrual of materials costs, the ERC may provide a subaward to that foreign partner to cover those costs.

b. University Education:

The ERC's university education program will function with a governing hypothesis of how to develop creative, innovative, and globally competitive engineers, will implement a set of activities and experiences designed to impart those characteristics to students, and will assess the impact of the program in achieving the desired characteristics in the impacted students.

c. Pre-college Education Program:

Support for the RET Program, at a minimum of $42K per year, will be provided using ERC base budget funds. The ERC may seek an RET site award under the Program Solicitation to augment these funds. The ERC also may augment base RET Program support through a combination of RET supplemental awards to individual ERC faculty as long as those teachers work in ERC laboratories and have an interdisciplinary ERC experience. A short-term workshop designed only to inform pre-college teachers about engineering concepts may also be carried out but not in lieu of the required RET program.

d. ERC Innovation Ecosystem:

(1) The ERC's industrial/practitioner partnership program will be governed by an ERC-wide membership agreement, including a uniform IP policy for ERC-generated IP at the lead and each of the ERC's partner universities. The membership agreement defines the scope and function of the ERC's partnership with industry/practitioner organizations, the types of membership such as full, affiliate, contributing, etc., the respective membership fees, and the ERC's Intellectual Property (IP) policy. The ERC will develop an IP policy that facilitates the roles of industrial partners in Gen-3 ERCs and be flexible in recognizing IP jointly developed by faculty in different universities or that developed by joint industry and university research.

(2) Foreign firms may be members of the ERC as long as they participate in accordance with the same membership agreement as U.S. firms do. Domestic and foreign member firms/practitioner organizations will contribute financially to the ERC and will have an option to acquire a royalty-bearing license to make, use and sell products or processes for commercial purposes.

(3) The ERC will function with an Industrial Advisory Board (IAB) involving all of its Full and Associate Industry/practitioner members. The IAB will meet at least twice a year, carry out an annual analysis of the ERC's strengths, weaknesses, opportunities, and threats to survival (a SWOT analysis), and

participate in the annual NSF review of the ERC's performance and plans. During the meeting with the NSF site visit team, the Chair of the IAB will present the IAB's SWOT analysis to the review team and discuss the findings. The SWOT will be updated annually and progress of the ERC in addressing the SWOT will be discussed with the NSF site visit team as well. The Chair and the IAB members also will discuss the annual SWOT analysis with the ERC Director and the ERC Leadership team to determine appropriate future strategies to deal with the weaknesses and threats.

(4) Industrial consortia may join the ERC, but benefits of membership do not accrue to firms that are consortia members, unless they are also paying membership fees to the ERC as members separate from the consortia.

(5) Throughout the course of the ERC's funding by NSF, the Center shall continue to develop and refine its technology transfer and innovation strategy and its Intellectual Property policy, the latter in accordance with NSF's Intellectual Property guidelines (NSF Award and Administration Guide, Chapter VI.D., "Intellectual Property") and the Awardee's policies.

(6) Industrial membership fees are treated as Program Income, and must be allocated for use for Center purposes. Industrial membership fees that are not expended in the year in which they are received must be placed in a Center account and reported to NSF and industry as 'unexpended funds' that are held in reserve for future use. Progress reports on the expenditure of these funds should be included in the Center's annual report and reported to IAB during the IAB meetings. Industrial members may provide additional support for activities such as sponsored research projects, equipment donations, intellectual property donations, or educational grants.

(7) Costs for organizing meetings with industry members will be borne by the ERC or the participants through a registration fee, as deemed appropriate. Costs for attending these meetings by industry members will be borne by their organizations.

(8) All ERCs will have member firms engaged in translational research through sponsored projects, and small firms carrying out translational research supported by funds from the ERC Program's Translational Research Fund or other non-ERC, non-member, non-university sources for ERC-generated Intellectual Property (IP) that member firms do not license.

(9) In addition, the ERC will develop and nurture the innovation ecosystem for the purposes of accelerating the translation of knowledge into innovation, by:

(i) Stimulating member firms to support sponsored projects for the purposes of translating center-generated IP to commercialization,
(ii) Forming collaborations with small firms for the purpose of translating

ERC-generated IP to the marketplace, if member firms do not license the IP - (This should be done via licensing IP, knowledge transfer to the firm, and/or securing translational research funds to accelerate commercialization of the technology by the small business in partnership with the ERC. Translational research funds could be secured from the ERC Translational Research Fund and/or from funding from other non-ERC/non-member/non-university sources);

(iii) Building partnerships with federal, state, or local government programs designed to develop entrepreneurs, support start-up firms, and otherwise speed the translation of ERC-generated knowledge and technology into practice and products;

(iv) Leveraging technology commercialization opportunities offered by the federal Small Business Innovation Research (SBIR)/Small Business Technology Transfer Research (STTR) programs. The ERC will include analyses to determine the most effective methodologies to use to achieve these innovation goals through these types of partnerships.

(v) In reference to 9(ii) above, ERCs will classify their IP generated from research under the scope of the ERC's strategic plan as Core IP (IP resulting from center-controlled unrestricted funds) and Project IP (IP resulting from restricted funds that flow through the center or flow directly to a PI). For Core IP and Project IP, the member firms/practitioner organizations or the sponsoring firm/ practitioner organization, respectively, will be offered the first option to negotiate a license. If there is no license forthcoming in either case, the IP can be offered to a non-member small firm and a partnership formed between that firm and ERC faculty to carry out translational research to accelerate product development. Support for a translational research project to accelerate product development can be sought from NSF through the ERC Translational Research Fund; in that case, the small firm would be the submitting organization, with a subaward to the ERC faculty. In addition, in that case, the university must screen the project for ERC faculty, Industrial Liaison Officers (ILO) and/or ERC Executive Management personnel conflicts of interest. When conflicts are disclosed for any of the above three categories of personnel, the university impacted must develop a conflict management plan for each disclosure.

(vi) In the case of a conflict, there will be a conflict of interest management plan. Progress and impacts of the project would be reported in the ERC's annual report. Because NSF would support such a project as an associated project outside the center's core funds, any additional IP developed from that project would not revert to the university or member firms.

e. Student Leadership Council. The SLC is responsible for organizing student activities to achieve the ERC's goals for research and education. The SLC will be comprised of undergraduate and graduate students and will have a Chair and a Co-Chair. The Chair will serve as a member of the ERC's Leadership Team. The

SLC also is responsible for carrying out a SWOT analysis of the ERC and communicating the results to the ERC Director, the ERC's leadership team, and the NSF site visit team.

6. Programmatic Activity Requirements:

a. Joint NSF-Awardee Activities:

(1) The ERC will participate in evaluation and other types of studies of the ERC Program initiated by NSF. Such studies include but are not limited to the outcomes and impacts of the ERC Program. The ERC will also participate in workshops organized by NSF to study various issues common to the system of centers. Costs for attending these meetings must be included in the budget submitted to NSF.

b. Electronic Access: The Awardee shall establish and maintain an electronic access capability via the Internet to transfer the quantitative and qualitative data to an NSF database. The access to this electronic information will be protected and only NSF will have and grant access. The Center will establish a WWW "Home Page" containing some elements with public access to make available any information about the Center's goals, activities, and accomplishments. The Center will develop and use an identifying logo that is consistent with the Awardee's policies and procedures and approved by the Awardee as a graphic identity to be used on brochures, newsletters, on the Center's WWW "Home Page," etc.

7. NSF Ongoing Project Oversight:

The Awardee will ensure full commitment and cooperation among the governing structure components, and all project staff during ongoing NSF project management and oversight activities. The awardee will ensure availability of all key institutional partners during any desk or on-site review as well as timely access to all project documentation. As a minimum requirement, the Center Director will meet annually at NSF with the NSF ERC Program Officer assigned to the ERC for oversight to discuss progress and other issues. The timing of the visit is to be determined by mutual agreement between the Center Director and ERC Program Officer.

a. Annual Review: NSF will carry out annual site visits to review the progress and plans of the Center. Renewal reviews will be carried out in years three and six. Based on the performance of the ERC, and in consultation with the ERC Director, the NSF Program Officer may determine that an annual site review is not necessary. In that case, the Center Director and a team of key individuals may visit NSF to update the NSF Program Officer and other NSF staff on progress and plans of the Center. For the purpose of the annual review, site visits will be conducted a minimum of six weeks prior to the anniversary date of the award to review performance and to provide advice to the ERC. The level of

continued NSF support will be negotiated with the Awardee annually and will depend upon a review of progress through the annual site review or other means, the performance metrics, the industrial support level, and the Program Officer's assessment of progress, and the availability of funds for the program.

b. Renewal Proposal Review: If a renewal proposal is submitted during the sixth year of the Center's operation, the ERC will be evaluated in the manner described above to determine whether NSF will continue to support full ERC operations or provide decreased funding to phase out NSF support of the ERC over Years 7 and 8 of the Center's operation. If NSF decides to continue full ERC operations, a new level of funding support will be negotiated for years 7 and 8 and two years will be added to the agreement to extend it through year 10. If the Awardee chooses not to submit a renewal proposal, NSF support to the ERC will be phased down over the two-year period covering Years 7 and 8 of the Center's operation.

c. NSF will specify the format of the progress report/renewal proposal, the review process, and review criteria approximately six months before the date agreed upon for submission.

d. Termination of the Cooperative Agreement. NSF's agreement with a Center might be terminated as a result of an annual review indicating insufficient progress in organizing the ERC to achieve its vision, or not addressing one or more key features of the Center. In the case of termination, NSF support to the Center will be phased down over the next one or two years.

e. NSF may carry out a summative site visit at the end of the 10th year of support to determine the long-term value added by the ERC.

f. After the end of the Cooperative Agreement with NSF, NSF expects the ERC to continue in a self-sufficient mode, maintaining the ERC culture with support from funds outside the ERC Program. Under no circumstances will the ERC receive ERC Program support to continue its full center operations after the Cooperative Agreement expires, although it may receive ERC Program support through subawards from other ERCs or through special purpose awards designed to capitalize on past ERC Program investments.

8. Reporting Requirements:

Awardee will provide *ad hoc* and regular reports as designated by the NSF cognizant Program Official, with content, format, and submission time line established by the NSF cognizant Program Official. The Awardee will submit all required reports via FastLane using the appropriate reporting category; for any type of report not specifically mentioned in FastLane, the Awardee will use the "Interim Reporting" function to submit reports.

a. Annual Report:

The Awardee shall submit an Annual Report which will contain specific information including, but not limited to, the following: the progress and plans of the ERC in all areas in achieving its vision with supporting data developed from the data submitted to the ERC Program's data base of indicators of progress and impact, information on revenues and expenditures, and proposed budgets. The annual report should also include plans, quantitative information on performance and the ERC's impact on diversity. The annual report is due at least five weeks prior to the annual site visit and at least 11 weeks prior to the anniversary date of the award. The annual report must be prepared according to the online document "Guidelines for Preparing ERC Annual Reports and Renewal Proposals," which is available at: https://www.erc-reports.org

b. Data Tables:

NSF maintains a database, ERCWeb, to collect and report quantitative and qualitative data for all of the ERCs. Each center is required to enter data into the database annually as instructed the "Guidelines for Preparing ERC Annual Reports and Renewal Proposals" and the "Guidelines for ERCWeb Data Entry." Both documents can be found at the website https://www.erc-reports.org. Many of the data tables required in the Annual Report are produced from the data submitted to the ERC database. The Center will print these tables directly from the database website and use them in their respective Annual Reports. Details, data collection requirements and procedures for entering data are available in the "Guidelines for ERCWeb Data Entry" document.

c. Renewal Proposal.

In lieu of the sixth-year annual report, the Awardee may submit a renewal proposal that contains a cumulative progress report covering the period from the beginning of the fourth year to the date of submission of the renewal proposal, a request for support for years seven through ten, and plans for center activities during that last four-year period of this Cooperative Agreement. The progress report/renewal proposal is due at NSF by a date agreed upon between NSF and the Awardee. If the Awardee chooses not to submit a renewal proposal, NSF support to the Center will be phased down over the two years remaining in the period of support provided by this Cooperative Agreement.

d. Summative Report. If NSF decides to carry out a summative review of the long-term impact of the ERC, a summative preliminary final report covering the period from the beginning of the Center to the anniversary date shall be submitted to NSF at least five weeks prior to the final 10th year summative site visit. More details are available at https://www.erc-reports.org on the "ERC Library" link.

e. Final Report: A final report prepared according to guidelines provided by the ERC will be due within 90 days of the expiration date of this Cooperative Agreement. Guidelines for the ERC final report are available on the following site: https://www.erc-reports.org on the “ERC Library” link.

In addition, to assist NSF in evaluating the ERC programs, the PI must also respond to the request for information about project outcomes following the end of the award period. These include the project's impact on workforce needs, awards and other measures of the quality of the project's products, including project technology transfer results not reported in prior years, but due to the ERC investment of prior years. NSF will provide guidelines for the collection and reporting of data and project information.

9. Diversity Strategic Planning:

The leadership, faculty, and students involved in an ERC shall be diverse in gender, race, ethnicity and persons with disabilities at levels that are benchmarked against the academic engineering-wide national averages. The faculty and staff of the ERC and the administrations of lead and partner universities receiving NSF funding shall devote the time and effort required to ensure that the diversity of the Centers' leadership teams, faculty, and students at all levels serves as a model for diversity within each institution and for the nation as a whole. The ERC will prepare and execute diversity strategic plans in collaboration with the home departments of the ERC-affiliated faculty. These plans shall articulate the ERC's diversity goals and intended actions but need not specify quantitative targets. The ERC also will be multicultural through the involvement of faculty and students from other countries by virtue of their role as faculty or students in the ERC's institutions and, through the involvement of faculty and students from the foreign partner universities. The involvement of foreign faculty and students also is expected to be diverse, representing a broad spectrum of cultures and countries. In fulfilling its obligations under the agreement and in compliance with the requirements of federal law, no university receiving federal funds will employ quotas or set-asides based on race.

Each ERC will:

a. Demonstrate the existence of a partnership among the affiliated Deans of Engineering, other Deans, and the chairs of departments of the affiliated ERC faculty to increase the diversity of the Center's leadership team, faculty, undergraduate and graduate students, and graduates over the duration of NSF's support.

b. Include as the lead or one of the domestic partner universities a university that serves large numbers of students predominantly underrepresented in engineering in the U.S. (i.e. women, African Americans, Pacific Islanders, Native Americans, Hispanic Americans, or persons with disabilities). The ERC may also develop non-core partner outreach connections with the same types of institutions.

c. Develop and strengthen long-term core or outreach partnerships with predominantly female, African-American, Native-American, and Hispanic-American serving institutions and/or institutions serving large number of these underrepresented students who are majoring in engineering and science programs.

d. The ERC may also, but is not required to, develop outreach connections with NSF programs focused specifically on increasing diversity of engineering students and faculty through the involvement of women, underrepresented racial minorities, and Hispanic-American students. This may include connections with one of the NSF's Louis Stokes Alliance for Minority Participation (LSAMP), and/or with one or more of the NSF-sponsored awardees focused on diversity such as the NSF Alliances for Graduate Education and the Professoriate (AGEP), Colleges and Universities that serve predominantly Native American Populations, and other ongoing NSF programs serving underrepresented groups.

e. Focus the Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET) programs on increasing diversity.

10. ERC Key Features

a. Vision of the ERC

The vision for the ERC for Future Renewable Electric Energy Delivery and Management (FREEDM) Systems is an efficient electric power grid integrating highly distributed and scalable alternative generating sources and storage with existing power systems to facilitate a green energy based society, mitigate the growing energy crisis, and reduce the impact of carbon emissions on the environment. The Center is based on the premise that the key to solving the energy crisis is not necessarily the renewable energy itself, but the infrastructure needed to deliver and manage large scale distributed renewable energy resources.

b. ERC's Strategic Goals

The ERC will achieve its vision through strategic planning in research, education, and technology transfer and innovation. It will use the ERC Program’s 3-plane strategic planning chart to display its strategic research goals and the integration of its research program. In addition, the ERC will develop a milestone chart depicting the major deliverables through time and their interdependencies.

c. ERC's Research Areas:

The ERC will perform research in the following areas as listed below. The research topics are initially organized into three thrusts that correspond to the three levels of the three-plane chart.

Thrust 1 – Fundamental Science Thrust:

System Theory, Modeling and Control: The research challenge of the System Theory, Modeling and Control sub-thrust is to determine how to best maximize the use of available renewable resources, many of which are intermittent in nature, and energy storage devices that are deployed in a distributed network while ensuring the continuity and quality of service, efficiency, and stability of the entire non-linear system. In addition, this sub-thrust includes research into economic policy issues to optimize the mix of energy sources based on pricing or other signals.

Advanced Storage: In the Advanced Storage area, the FREEDM team will research advanced battery and ultracapacitor materials to increase energy density and improve lifetime. Accurate and verifiable models of advanced storage devices will be developed and used in the other research areas as necessary.

Post-Silicon Devices: The ERC will conduct research into silicon-carbide and gallium nitride power semiconductor devices to advance the state of the art to higher voltage, current and switching frequency ratings. These devices will be used in several of the other FREEDM research areas, such as the solid-state transformer and the fault isolation device, to enable the necessary power ratings to achieve the vision.

Thrust 2 – Enabling Technology Thrust:

Reliable and Secured Communication: The Reliable and Secured Communication sub-thrust will develop hardware and software needed to implement the necessary power system communications with the appropriate levels of reliability and security.

Distributed Grid Intelligence: The Distributed Grid Intelligence sub-thrust will perform the necessary research to develop the hardware and software required to implement the power management and fault detection and containment strategies while taking into account market conditions (power demand and availability).

Solid State Transformer: The Solid State Transformer sub-thrust will use the devices developed in the Post-Silicon Devices sub-thrust of Thrust 1 to build compact, efficient and controllable transformers.

Faults Isolation Device: The Fault Isolation sub-thrust will use the power semiconductors developed in the Post-Silicon Devices sub-thrust of Thrust 1 to design fast and reliable fault interruption and reclosure devices.

Distributed Energy Storage Device: The Distributed Energy Storage Device sub-thrust will integrate the results from the advanced battery and ultracapacitor work in Thrust 1 with a bi-directional power conversion system (based on the power semiconductors developed in Thrust 1) and communication interface (based on the Reliable and Secured Communication sub-thrust) to

develop a plug-and-play energy storage unit that can be used for residential applications with possible later applications to Plug-in Hybrid Electric Vehicles (PHEV).

Thrust 3 – System Demonstration Thrust

Green Energy Hub: This Test Bed will support the physical demonstration of the FREEDM vision and will enable the integration of all the hardware and software systems that are required to execute the FREEDM functions. This will be the physical embodiment of the FREEDM system in a realistic 12 kV distribution system.

Large Scale System Simulation: This testbed will use mathematical models and analytical tools to digitally demonstrate the FREEDM system on a scale that cannot easily be replicated in the physical realm. This will provide a valuable tool for exercising the system functions and stressing the system to evaluate its response.

Hardware in the Loop: This test bed will utilize a combination of physical hardware and digital models for FREEDM components to demonstrate and exercise the FREDM functions. This capability can provide real time assessment of distributed grid intelligence functionality and system stability.

d. ERC's University Education Program:

By creating a pipeline for students and participants at the pre-college and college level to engage in engineering education, research, and industry, the FREEDM Systems Center's education programs will create an environment in which participants have the opportunity to develop increased awareness, interest, knowledge and skills in renewable electric energy delivery and management systems. Through the theme of "each one mentor one", the FREEDM Systems Center will create opportunities for interconnections between industry members, faculty, graduate students, undergraduate students, teachers, and middle and high school students for the desired outcome of competencies and attributes outlined in The Engineer of 2020. The FREEDM ERC's Educational Hypothesis is that these connections may help to develop a diverse group of adaptive, creative, global, and innovative participants who advance fundamental knowledge, enabling technology and engineered systems innovations in renewable electric energy delivery and management systems. The hypothesis is evaluated through assessment of the Center's education programs, e.g. the pre-college RET, the REU, the academic year undergraduate research scholars program, curriculum, the Young Scholar Program, the graduate portfolio program, etc. The ERC will assess the impact of all aspects of its education programs using both quantitative and qualitative measures.

The ERC will develop a new concentration in renewable energy systems to be offered to undergraduates at each partner institution. In graduate education, a non-thesis master's degree program will be established in renewable energy systems that will be offered at each partner institution.

The ERC will support approximately 15 summer REU students per year for years 4-8 that includes students from community colleges and schools serving groups traditionally underrepresented in engineering. In addition, the ERC will support approximately 15 academic year REU students (undergraduate researcher scholars) per year for years 4-8.

e. ERC's Pre-college Education Program:

The ERC will partner with approximately 21 middle and high schools in activities that include ERC researcher classroom visits, a Young Scholars program, teacher curriculum development workshops and research experiences, and summer camps in renewable energy targeted for under-represented minority children in grades 6 through 9. The pre-college program will be coordinated for the domestic partner sites by The Science House at NC State, the K-12 STEM outreach center for the College of Physical and Mathematical Sciences.

The ERC will support approximately 40 RET slots over years 4-8. Each RET experience will consist of five weeks participating in ERC research including a hands-on curriculum development workshop. ERC staff will track the lessons and provide supplies for carrying out in the classroom.

The ERC will offer approximately 70 Young Scholars positions over years 4-8 to rising high school juniors and seniors recruited from partner schools. Each student will have a 5-week paid summer research experience that will conclude with a research project to be submitted to the International Science and Engineering Fair or equivalent venue.

The ERC will sponsor a one week summer science camp for middle school children each year at NCSU, FSU/FAMU, and ASU for a total of approximately 140 campers over years 4-8.

The ERC SLC, in conjunction with The Science House, will design and sponsor one of the competitive events involving electrical engineering for middle and high school students at the statewide North Carolina Science Olympiad. The ERC will present two $500 NCSU scholarships to the two-member winning team of the individual event that is sponsored by the Center.

f. ERC's Innovation Ecosystem

The ERC will develop a membership program that consists of constituents from all major stakeholders such as utility companies, energy storage companies, electrical equipment manufacturers, power electronic device companies, and small business start-ups. In addition to the IAB and SAB, the ERC will convene an Industry Policy Panel annually to discuss the relevant external issues and

challenges that are faced by the industry, and how these may affect the potential implementation of the FREEDM System.

The ERC will utilize the Office of Technology Transfer, the Small Business Technology Development Center, Innovation Roundtables and Innovation boot-camps to offer training, assistance, and mentorship for all center participants for the purpose of helping to build and support a vibrant innovation ecosystem. The ERC will invite appropriate incubator programs and other small business and entrepreneurial supporting organizations to provide training and other assistance to center participants who wish to pursue new business development. In addition, NCSU will help SBIR/STTR awardees submit requests to the North Carolina Board of Science and Technology SBIR/STTR Matching Funds Program.

FREEDM will partner with small firms to accelerate the translation of FREEDM's technology per the terms of the ERC Program.

g. Special Deliverables:

The ERC will conduct the fundamental research, develop the enabling technology, develop component and subsystem models, and demonstrate component and subsystem operation that will result in the development and demonstration of a 1 MW rated distribution system testbed at the NCSU campus that will eventually power the ERC headquarters and other small buildings on the Centennial Campus. This testbed will be used to demonstrate the FREEDM system operational principles of plug-and-play distributed power generation from renewable sources and energy storage devices, coordinated system operation including source and load management, and fault protection with system reconfiguration.

11. Award Specific Terms and Conditions for this ERC:

a. NCSU will continue to provide 20,000 square feet of newly constructed space for the ERC in the Centennial Science Center, which opened on NCSU's Centennial Campus in 2009. This Center will include approximately 15,000 square feet of ERC headquarters office space and low-bay lab space as well as 5,000 square feet of dedicated high-bay lab space to house the 1MW FREEDM Systems demonstration site.

b. Other space and laboratory resources available to the ERC includes

(i) Nanofabrication facility at NCSU
(ii) Flexible AC Transmission Systems (FACTS) Laboratory at MST
(iii) Center for Advanced Power Systems (CAPS) at FSU-FAMU
- Real-time Digital Simulation (RTDS) facility
(iv) Electric Power and Energy Systems Program Laboratories at ASU

c. NCSU is committed to six additional faculty positions in power systems, four tenure-track, two research, over the first six years of the Center with a special recruiting focus on women, minorities and persons with disabilities.

d. The ERC will fund approximately two $30,000 and two $5000 graduate fellowship supplements annually for domestic graduate students who are women, underrepresented minorities or persons with disabilities.

e. In an effort to increase undergraduate student diversity, the ERC will reserve 2 of 15 academic-year undergraduate research scholar positions annually for students in any of the partner universities who are women, underrepresented minorities, or persons with disabilities by recruitment efforts through Society of Women Engineers, Society of Women Environmental Professionals, Women of Wind Energy, National Society of Black Engineers, American Association of Blacks in Energy, Society of Hispanic Professional Engineers, the American Indian Science and Engineering Society, etc..