FREEDM Systems Center Partnership Overview and Challenges

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A Global Partnership

- A generation-III Engineering Research Center (ERC) established in 2008
- Potentially a ten year investment by NSF
- Must be a multi-school configuration with international school participation
- Must address a transformative grand challenge engineering problem
- Must focus on industry engagement and developing an innovation ecosystem
- Must address the workforce preparation

To develop an efficient and revolutionary power grid

- ☞ Utilizing revolutionary **power electronics** technology and **information technology**
- ☞ Integrating distributed and scalable alternative energy sources and storage with existing power systems
- ☞ Automate the management of **load, generation, and storage**

Building The Energy Internet

FREEDM Systems Center

- Domestic Partner Universities
 - NC State University
 - Missouri University of Science & Technology
 - Florida State University
 - Arizona State University
 - Florida A & M University
- International Universities
 - Aachen University (Germany)
 - Swiss Federal Institute of Technology (Switzerland)
 - University of Auckland (New Zealand)
- Industry Partners (49)
- Innovation Partners (13)
- Pre-College Partners (12)
 - 7 middle schools
 - 5 high schools

49 Industry Members

Full (10):

Associate (21):

Affiliate (18):

Membership growth and challenge

- How to engage industry better and deliver greater value
- How to maintain growth and attract new members

- Industry Advisory Board
 - More industry directed research
- IPPF: Fast track intellectual property protection
- Dedicated annual industry review and interaction
- Industry champions:
- Faculty champions:
- Workforce advising program
- Working Group
 - Education working group

Member Benefit Survey

On a scale of 1-5 with 5 creating the most value and 1 creating the least value, what activities or aspects of the FREEDM Systems Center create the most value for you as an industry partner?

Innovation Ecosystem

Innovation Roundtables

“The SLC believes that this type of discussion is critical to students’ research “

- Student Leadership Council Member

- Graduate students do not know what cannot be done
- Industry or Faculty present the round table with several succinct problems or challenges
- Facilitated open, lively and positive discussion
- Every attendee should go home thinking
- Two held in year three
- Plan to continue next year

“I believe that this kind of seminar will play a very important role in my research and real life interaction process which is normally not available otherwise. “

– Graduate Student and Innovation Roundtable Attendee

Innovation Bootcamp

- Once per semester
 - Fulfills one of the components of the Portfolio Program
 - Available online for all schools
 - Hands on activities to get center students involved
 - Taught by Center Members, Staff and Innovation Partners
- Typical Agenda:
 - FREEDM Innovation Process
 - Disclosure Process and how to submit an easy yet compelling disclosure
 - The Protection Process
 - Licensing
 - Startups
 - Translational Research
 - Hands on activities using existing Patents

Engaging External Organizations

External Organizations and Committees	Related FREEDM Technology	Tentative FREEDM Representatives
NIST Smart Grid Interoperability Panel (SGIP): Data and software Priority Action Plan subgroups	DGI	Bruce McMillin
NIST Smart Grid Interoperability Panel (SGIP): Communication Priority Action Plan subgroup	RSC	Wenye Wang
IEEE PES (Power Engineering Society) Transformer Committee C57.12.20: Standard for Overhead Type Distribution Transformers, <500 kVA	SST	TBD
IEEE P1547.8 "Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Standard 1547"	Interconnection standards and SST grid interface	Mischa Steurer
IEEE - PELS on ETTC (Electronic Transformer Technical Committee) and TTA (Transformer Technical Association). IEEE Standards Organization recently advocating for standards based drive in this area.	SST	Subhashish Bhattacharyya
IEEE P1826 "Standard for Power Electronics Open System Interfaces in Zonal Distribution Systems rated	DC distribution and SST interface standard	Mischa Steurer

System Engineering: Use Cases

Use Case 1: A User owned device is plugged into the system, it is recognized and it works

Diagram: UC1 - Scenario 1 Plugging In

NSF expectation: HIGH

(cited from the recent solicitation nsf11537...)

- *These ERCs will be at the forefront as the U.S. competes in the 21st century global economy where R&D resources and engineering talent are internationally distributed.*
- *Provide international opportunities for research and education collaboration that will prepare U.S. engineering graduates for leadership in innovation in a global economy;*
- *Form teams of diverse and talented faculty who will prepare diverse and talented domestic and international graduates to function effectively in a global world where research, design and production efforts cross national borders;*
- *.....The foreign university, its government, or other non-NSF sources will provide funds for this partnership.*

Challenges: Research Collaboration

- What is the main driver for the partner institutions?
- Inability to fund foreign partners directly
- Communication challenge
- Source of funding/IP protection challenge

Questions?

- Pipeline of future engineers for green energy economy and graying power systems workforce:
 - Continuum of programs from middle school to Ph.D.
 - Industry training and lifelong learning
 - New undergrad concentration in Renewable Energy Systems
 - UG research scholars
 - Research Experiences for Undergraduates (>100 over 5 years)
 - **New M.S. program in Renewable Energy Systems (est. 2011)**
 - ERC research findings integrated in courses
- Pipeline of future leaders, innovators, and creators for green energy economy:
 - Innovative ERC graduate student **portfolio program**
 - Required and assessed for all ERC graduate students

Graduate Student Portfolio

**Developing Creative, Innovative, Knowledgeable,
and Global Engineers (Engineer 2020+)**

**Global Green Tech/
Modern Grid Economy**

NC STATE UNIVERSITY

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Internet/Computer

- 1) Plug-and-Play Interface
(RJ45, USB)

- 2) Router

- 3) Open Standard Protocol and
Operation System
(TCP/IP, HTML)

- 4) Data Storage

- 5) WWW/Twitter/Facebook

Today's Power Grid

1) ?

2) ?

3) ?

4) ?

5) ?

**FREEDM
System:
The Energy
Internet**

FREEDM System @ Home Level

FREEDM System Diagram

DRER: Distributed Renewable Energy Resource

DESD: Distributed Energy Storage Device

Strategic Research Plan

Year 4 ERC Projects (14)

Hardware-in-the-loop Testbed		
Y4.HIL1	FREEDM System Demonstration: Hardware-in-the-Loop	Steurer, McMillin, Yu, Raja, Vyatkins, Chow
Green Energy Hub Testbed		
Y4.GEH1	FREEDM System Demonstration: 1 MVA Green Energy Hub	Huang, Baran, Wang, Bhattacharya, Husain, Steurer
Y4.GEH2	Design and Development of Gen-II Solid State Transformer (SST) Based on 15kV SiC Devices	Huang, Bhattacharya, Gould, Kolar
Y4.GEH3	Development of Stationary DESDs	Lukic, Huang, Li, Zheng, Chow
Y4.GEH4	ENERGY MANAGEMENT AND COMMUNICATIONS INFRASTRUCTURE FOR GREEN HUBS	Baran, Gregory
Y4.GEH5	Secondary Traction Battery Utilization in Community Energy Storage Systems	Lukic, Glenn
Y4.GEH6	Three-Phase SST Project Based on SiC Devices	Bhattacharya, Corzine, Ferdowsi
Large Scale System Simulation		
Y4.LSSS1	FREEDM System Demonstration: Large Scale System Simulation	Crow, Baran, Chowdhury, Kimball, Karady, Edrington, Srivastava
Fundamental Science Project		
Y4.F1	Comprehensive protection of high voltage (HV) and low voltage (LV) electrical distribution circuits in FREEDM	Karady, Baran, Steurer, Li, Huang
Y4.F2	Power engineering system modeling and control in the FREEDM system	Gerald Heydt
Y4.F3	Silicon Carbide Devices for FID and SST Applications	Baliga, Huang, Hopkins
Y4.F4	GaN Power Device and Fabrication	Misra, Huang, Hopkins, Baliga
Y4.F5	Development of Efficient Oxygen Electrocatalyst for Reversible Li-Air Batteries	Kalu, Weatherspoon, Zheng
Y4.F6	High-Power and Long-Cycle Life Rechargeable Batteries	Xiangwu Zhang

- Energy Storage
 - Improved Li-ion Batteries
 - Battery modeling and online SOC/SOH
- Vehicle Systems
 - Power electronics for BMS and Motor Drive
 - Advanced motor design
 - High temperature packaging
 - Powertrain optimization
- Infrastructure
 - Advanced Charger
 - PHEV/PEV parking garage optimization
 - Charger management

Challenges in Implementing ERC International Program

Dr. Alex Huang
Director, FREEDM Systems Center
(class of 2008, energy cluster)

~~Challenges: Student Exchange~~

- How to handle extensive requirements to travel abroad
 - Passport
 - Visa
 - Industry internships

~~Challenges: Student Exchange~~

- How to assess the amount of monetary award a student should receive to participate in an international experience
 - Travel
 - Local transportation
 - Housing
 - Meals
 - Expenses
- Receipts

~~Challenges: Student Exchange~~

- Was the experience beneficial to the student and the host university?
 - Pre and post survey
 - Interview

- 27 Responses out of several hundred invites
- Respondents are predominately senior management

Please choose which description best represents your job position.

Responses include:

- ABB
- TE Connectivity
- Advanced Energy
- McKim and Creed
- Eaton
- Cree
- PJM
- Progress Energy
- International Rectifier
- Siemens
- Delta
- Newport News Shipbuilding
- Powerex Inc.
- AVRC
- Quanta
- Florida Power and Light
- MC Dean
- Oak Ridge National Labs

Challenges: Student Exchange

- How to handle language and cultural barriers
 - Should students be required to take 1 semester or a short course on the language that will be spoken at host university before traveling?
 - Should students be required to complete a workshop on diversity?
 - How important is it to find the best host/mentor for the student

Meaningful funding to leverage NSF support