FREEDM Systems Center

Future

Renewable

Electric

Energy

Delivery and

Management

Rogelio Sullivan
Managing Director

Vision

- **To develop an efficient and interactive power grid:**
  - **Utilizing revolutionary power electronics technology and information technology**
  - **Integrating distributed and scalable renewable energy sources and energy storage with existing power systems**
  - **Automate the management of load, generation and storage**

To create the "Energy Internet"



A Global Partnership

An Engine for Change
Driven By:

- Focused Research
- Industry Participation
- Comprehensive Education Programs
- Innovation and Technology Commercialization

Industry Membership

Pre-College

Middle & High Schools

US Universities

- Arizona State University
- Florida State University
- Missouri S&T — University of Science & Technology
- Florida Agricultural and Mechanical University
- NC State University

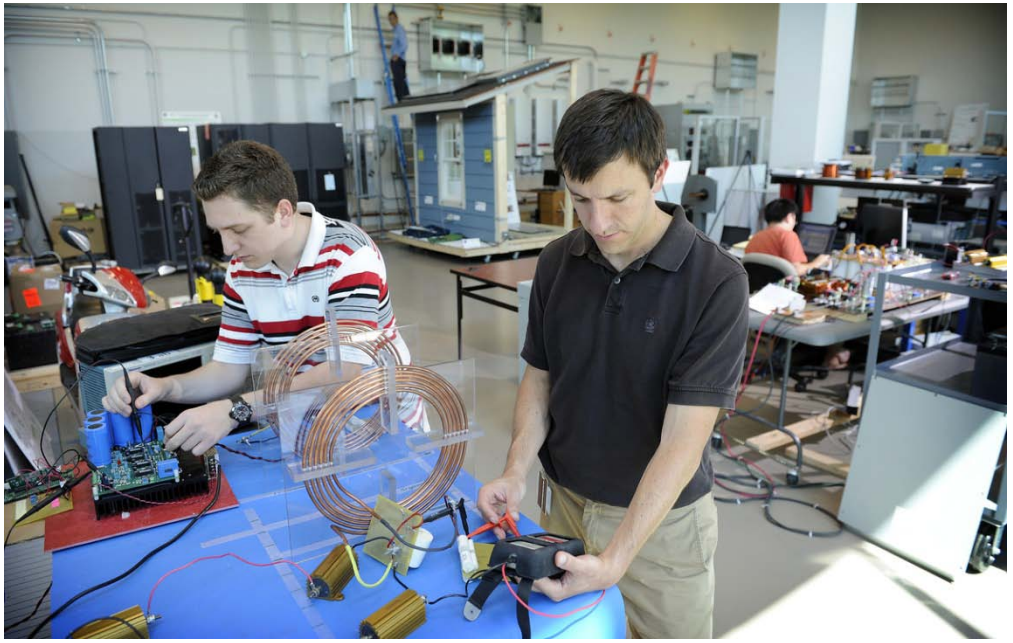
International

- RWTH Aachen University
- ETH — Eidgenössische Technische Hochschule Zürich, Swiss Federal Institute of Technology Zurich
- The University of Auckland, New Zealand — Te Whare Wānanga o Tāmaki Makaurau

NSF

Comprehensive University Education Program

Pipeline of FUTURE ENGINEERS for a GREEN ENERGY ECONOMY



- Renewable Energy Systems Concentration & Certificate
- **M.S. in Electric Power Systems Engineering**
- Professional Mentoring
- Industry Training
- Research Experiences
- Integrate research findings into courses
- Portfolio Program

48 Industry Members

Full (10):

ABB
SAMSUNG
SIEMENS
AEG
Progress Energy
TVA
Itron
cisco
Duke Energy
IOR

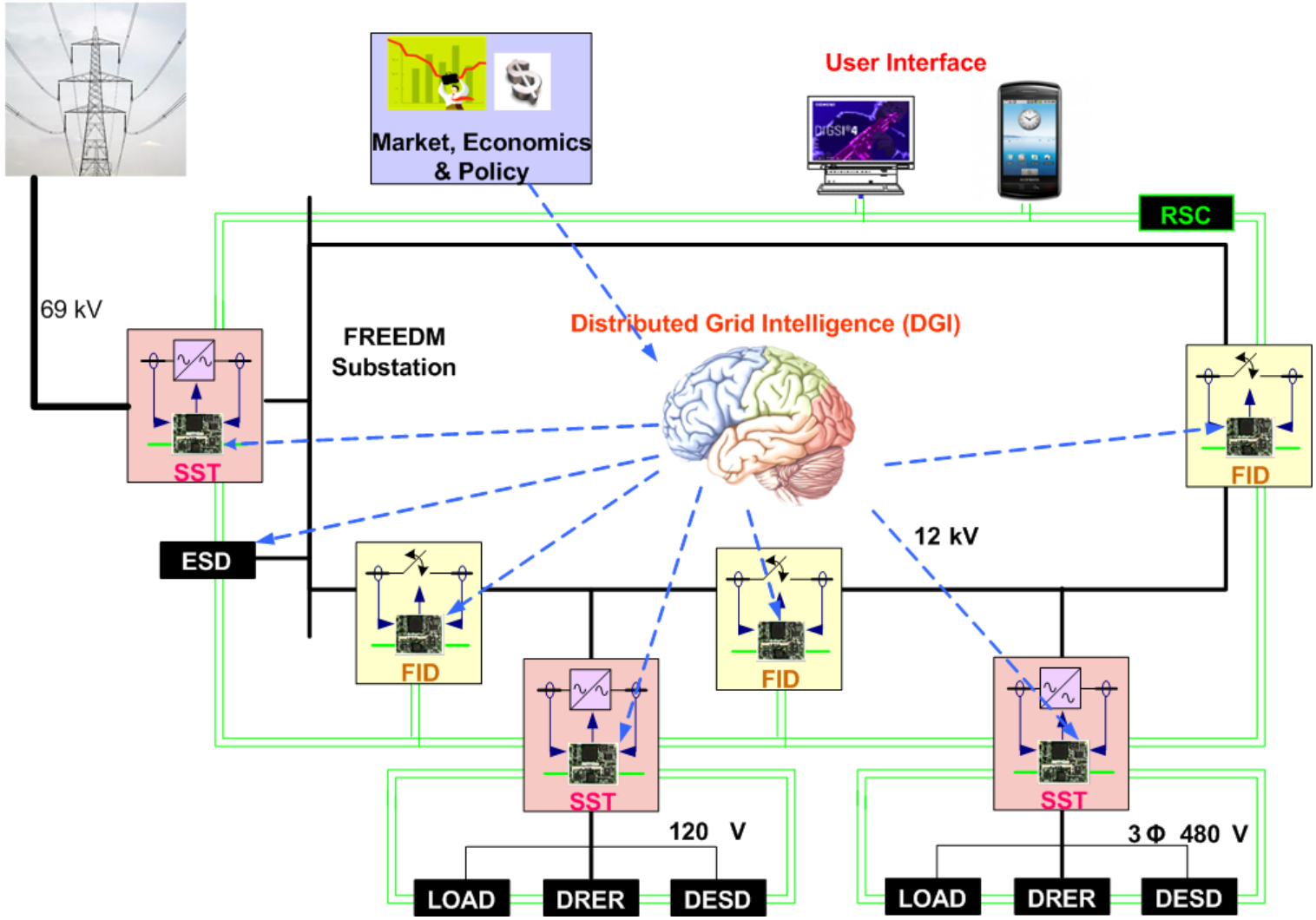
Associate (21):

green energy corp
GE
intel
CREE
OAK RIDGE National Laboratory
AEP AMERICAN ELECTRIC POWER
EATON
Fuji Electric
Dominion
pjm
HUAWEI
FPL
elster
TE connectivity
M.C. DEAN BUILDING INTELLIGENCE
SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company
HRL LABORATORIES
RFMD
TOYOTA
QUANTA TECHNOLOGY
PETRA SOLAR Intelligent Energy By Design

Affiliate (17):

EnerNex CORPORATION
A.L.E.C. American Lithium Energy Corp
McKIM&CREED
Newport News Shipbuilding
Advanced ENERGY
MICROCELL Delivering the Future...
DELTA
KEMA
Peregrine Power LLC
AVRC Advanced Vehicle Research Center
EVANS CAPACITOR COMPANY
NSF
EPRI
US Hybrid
Maxwell TECHNOLOGIES
United Technologies Research Center
North Carolina's Electric Cooperatives
POWEREX

FREEDM System



DRER: Distributed Renewable Energy Resource **DESD**: Distributed Energy Storage Device

Technology Comparison

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) ?

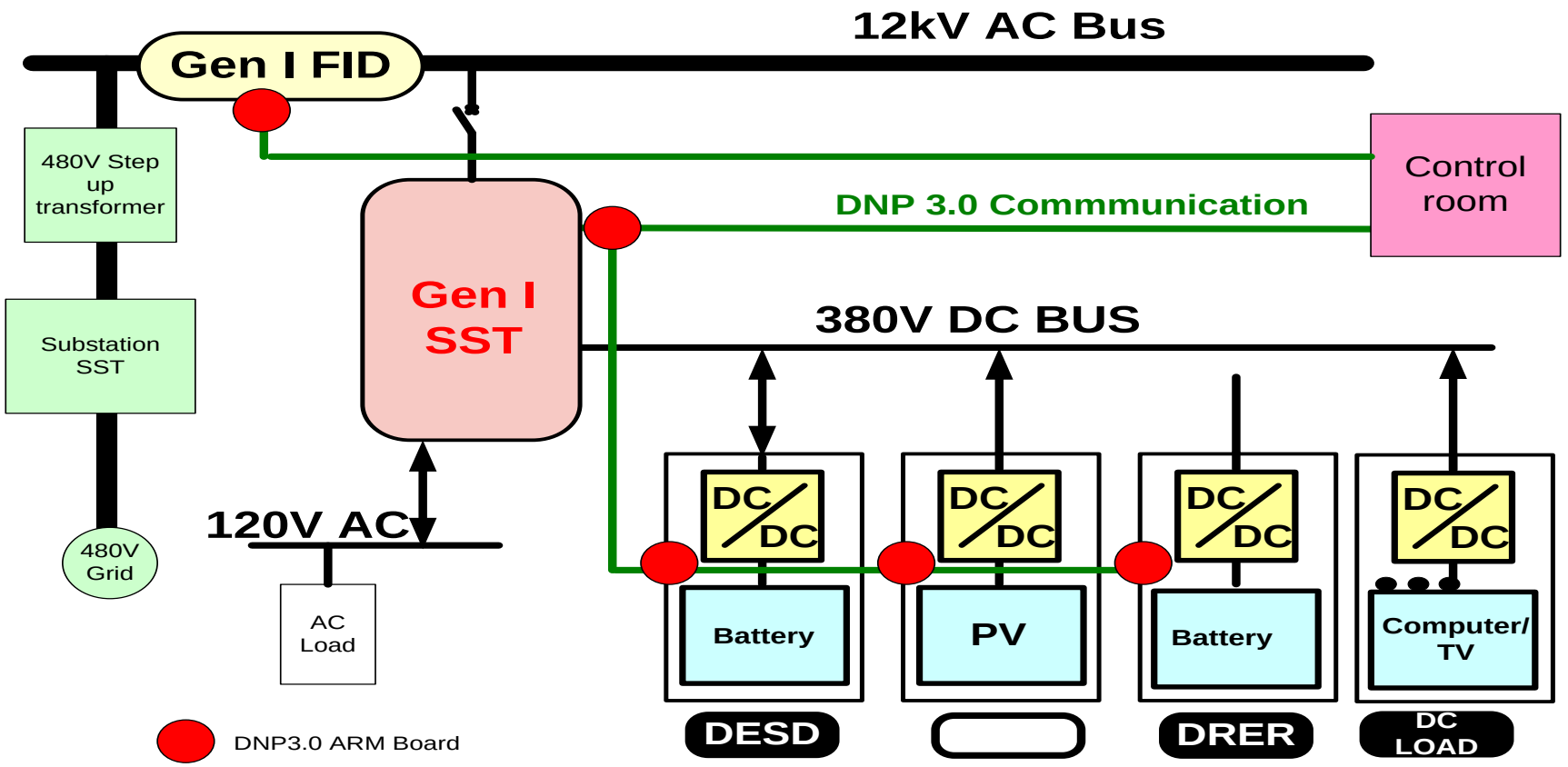
3) ?

4) ?

5) ?

FREEDM System: The Energy Internet

FREEDM System Local Level



Main Objectives:

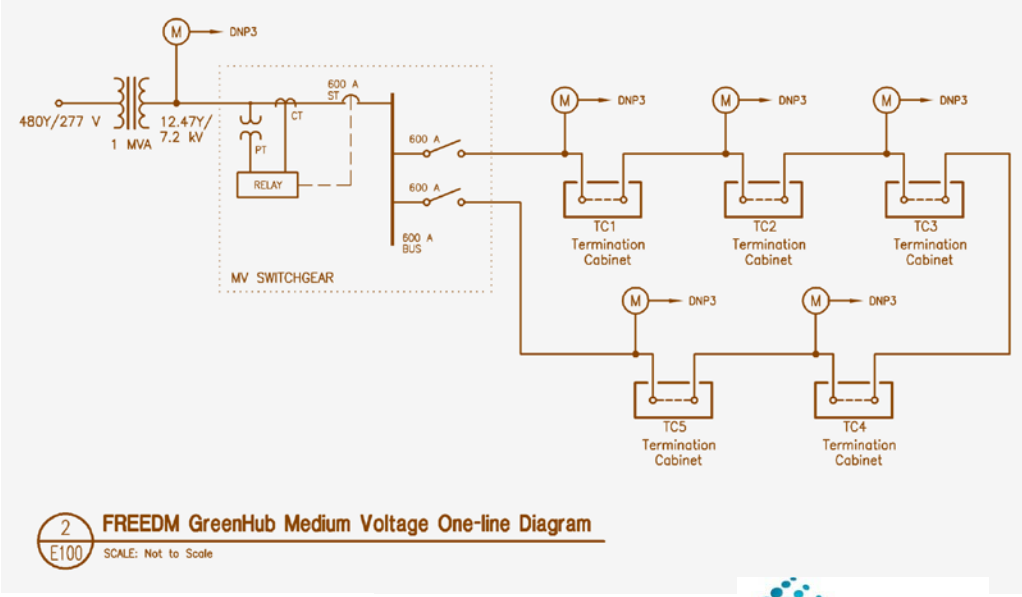
1. System Integration
2. Demonstration of Functionalities/Use Cases
3. System Engineering

Solid State Transformer

- Selected by MIT's Technology Review as a Top 10 Emerging Technology
- Router for Energy
- Eliminates the need for multiple energy conversions for inherently DC Devices
- Control of Voltage, Power Factor, Harmonics, Frequency, Fault current limiting

1 MW Green Energy Hub

- Real-world Smart Grid Test-bed for FREEDM and industry technologies
- 1 MVA 12 kV three phase distribution grid
- Third-party renewable energy resources (solar, wind, fuel cell)
  - 40 kW solar (AEG)
  - 20 kWH battery storage (GreenSmith)
  - 10 PHEV/PEV charging stations
  - Nissan Leaf/Toyota Prius/GM EV Truck
- Test bed for FREEDM developed technologies
  - SST/FID/DESD/Wind emulator
  - Smart Home/DC/AC Microgrids
  - DNP3.0/IEC61850 based RSC and SCADA
  - Future FREEDM DGI



GEH Working Group

Recent Accomplishments

1. Developed a safe, arc free, 380V DC plug
2. Successful lab demonstration of a DC home distribution system (lighting, computer, PV, EV, battery, consumer electronics)
3. Successfully tested the Gen 1 SST and demonstrated control with SCADA system
   - Input: 7.2kVac; Output: 240Vac/120Vac & 400Vdc; Power rating: 20kVA, Rectifier: 1080Hz;
   - DCDC: 3kHz; Efficiency: 90.88%
4. Measured GaN impact ionization coefficients as a function of temperature
5. Two successful spinoffs based on center developed technology
   1. Bing energy
   2. GridBridge

FREEDM systems center

Industry & Innovation

Working Groups

Industry Champions

IP licensing and Spin-offs

Lab User Facility for Members

NSF

Paradigm Shift: Computer Industry

Pre-1980s

Centralized
Mainframes

Distributed Computing
Ubiquitous Ownership,
Use, and Sharing

Google

ebay YouTube
Broadcast Yourself

NETFLIX

Internet

**Innovation &
Industry Transformation**

Paradigm Shift: Power Industry

Today

Centralized Generation

Distributed Renewable Energy Resources
Ubiquitous Ownership, Use, Sharing and Sales

- New technologies for distributed renewable energy
- New energy companies based on IT and power electronics technologies

FREEDM

Innovation & Industry Transformation