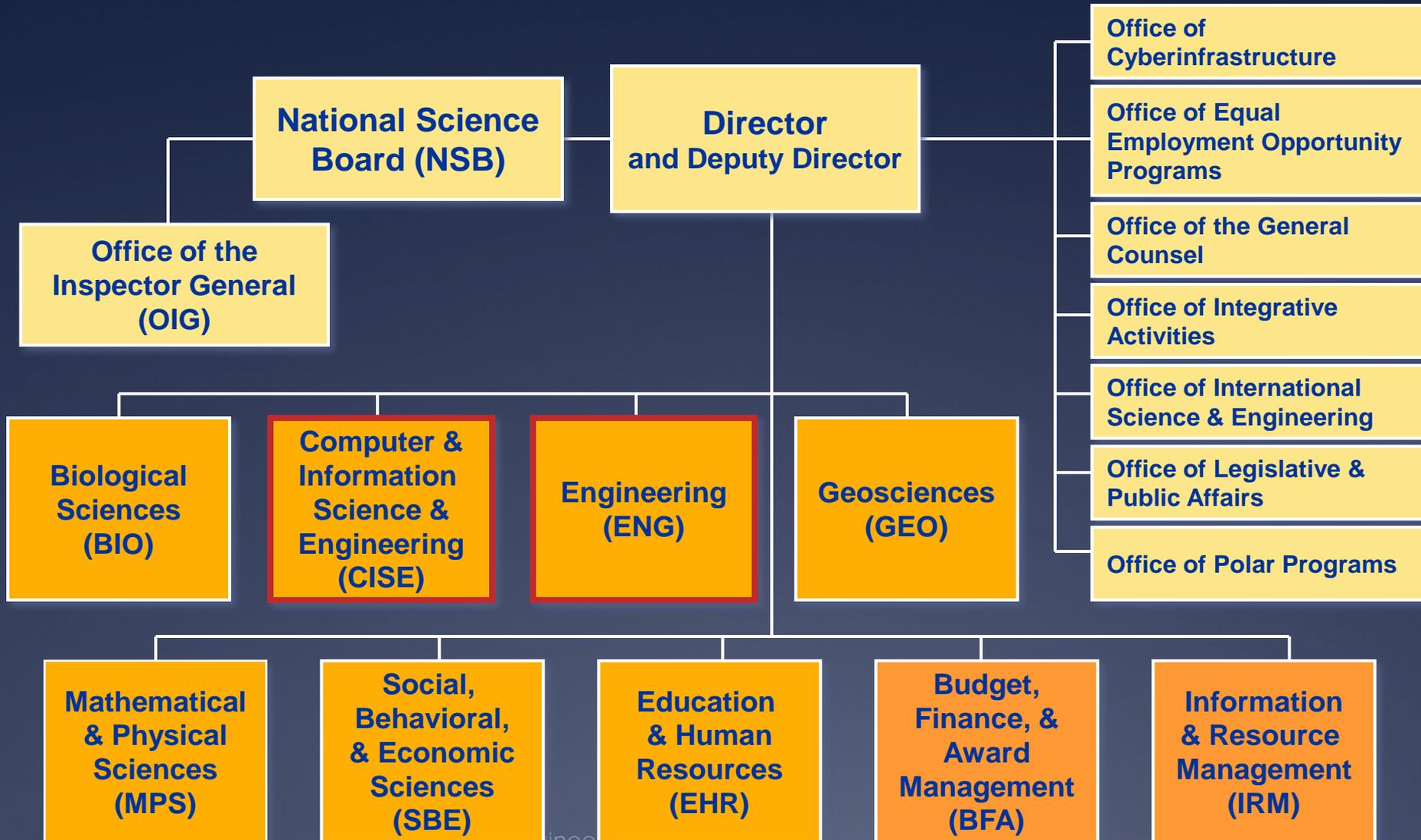


NSF Programs with Electric Power System Activities

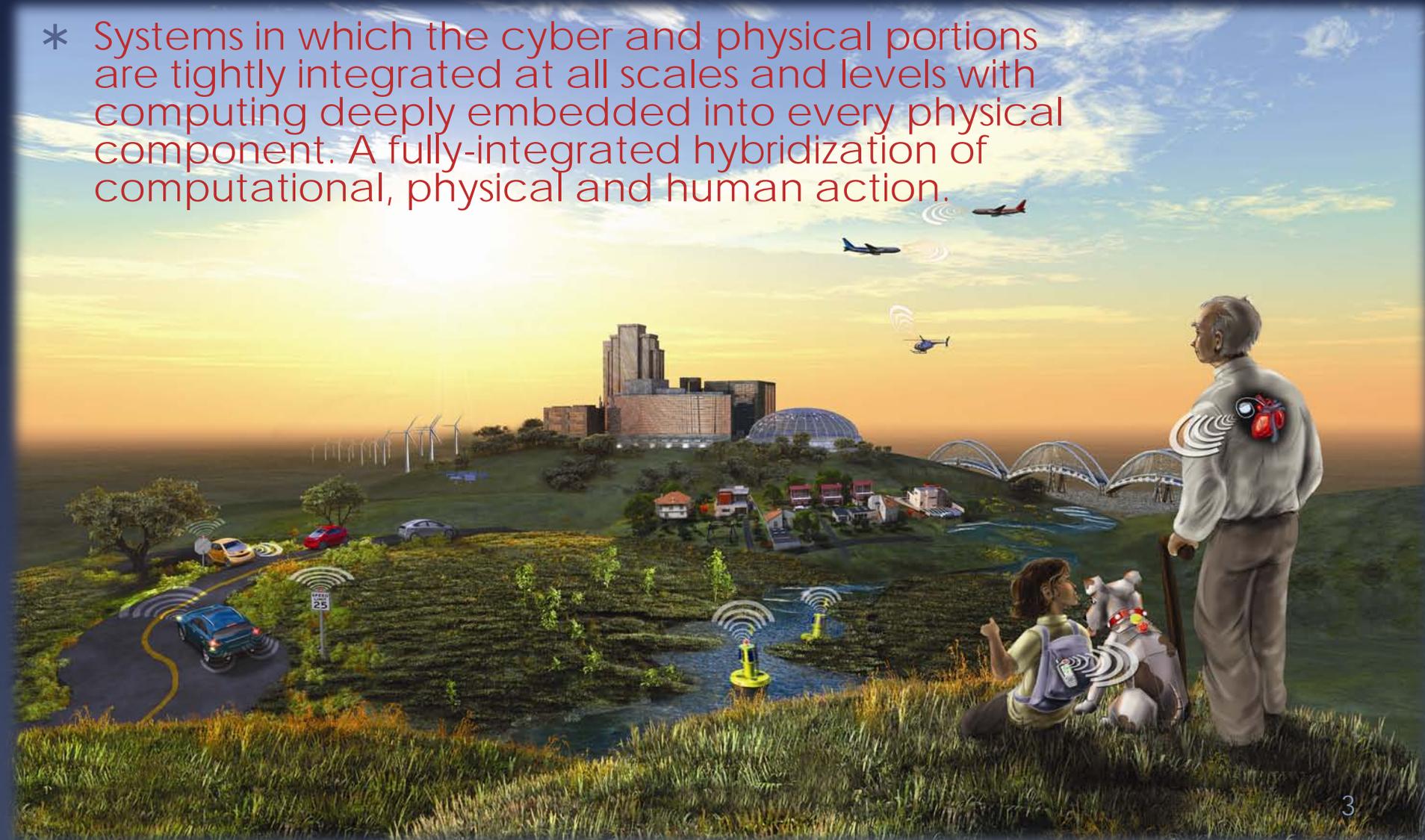
December 13, 2010
Barbara Kenny

National Science Foundation



Cyber-Physical Systems (CPS)

- * Systems in which the cyber and physical portions are tightly integrated at all scales and levels with computing deeply embedded into every physical component. A fully-integrated hybridization of computational, physical and human action.





NSF CPS Program

- * CPS themes:
 - * Foundations research to develop new principles, algorithms, models, and theories
 - * Methods and Tools research to bridge gaps between approaches to the cyber and physical elements of systems through innovations
 - * Components, Run-time Substrates, and Systems research motivated by grand challenge applications
- * 2009: \$45M into 58 awards, 8 in Energy & Environment
- * 2010: \$32M into 43 awards, 5 in Energy & Environment
- * 2011: \$30M in budget, proposals due in March, 2011

CISE Program Officer: Helen Gill

ENG Program Officer: Kishan Baheti

CPS energy related awards

- * "Cyber-Enabled Efficient Energy Management of Structures," Tyrone Vincent, Robert Braun, Dinesh Mehta, Kevin Moore, Siddharth Suryanarayanan (Colorado School of Mines)
- * "A Framework for Enabling Energy-Aware Smart Facilities," Lucio Soibelman, H. Scott Matthews, Jose Moura (Carnegie Mellon University); Burton Andrews and Diego Benitez (Bosch)
- * "Methods for Network-Enabled Embedded Monitoring and Control for High-Performance Buildings," Prabir Barooah (U. Florida), Alberto Speranzon (UTRC), Prashant Mehta and Sean Meyn (UIUC), Luca Carloni (Columbia)
- * "A Computing Framework for Distributed Decision Making to Ensure Robustness of Complex Man-Made Network Systems: The Case of the Electric Power Networks," Rohit Negi, Franz Franchetti, Marija D Ilic, Ole Mengshoel (Carnegie Mellon University)
- * "LoCal - A Network Architecture for Localized Electrical Energy Reduction, Generation and Sharing," Randy Katz, Eric A Brewer, David E Culler, Seth R Sanders (UC Berkeley)
- * "Architecture and Distributed Management for Reliable Mega-scale Smart Grids," Junshan Zhang, Vijay Vittal (Arizona State University)

Directorate for Engineering (ENG)



Electrical, Communications and Cyber Systems (ECCS)

Division Director: Dr. Robert Trew

Senior Engineering Advisor:

Dr. Lawrence Goldberg

Expert:

Dr. Kawthar Zaki

Associate Program Director:

Ms. Dominique Dagenais

Science Assistant:

Ms. Dana Denick

Program Directors:

Electronics, Photonics, and Magnetic Devices (EPMD)

Dr. Samir El-Ghazaly

- Microwave/mm-Wave/THz Devices & Circuits
- Novel & Next Generation Devices
- Vacuum Devices & Electronics
- Antennas
- Electromagnetic Propagation & Scattering
- Microwave Metamaterials-Based Devices
- Device /Circuit Simulation & Modeling

Dr. Pradeep Fulay

- Flexible & Printed Electronics
- Light Emitting Devices & Displays
- Molecular /Organic Electronics & Photonics
- Energy-Efficient Green Electronics
- Next Generation Memories, Memristors, & other Novel Devices

Dr. Usha Varshney

- Bioelectronics & Biomagnetics Devices
- Science & Engineering Beyond Moore's Law
- Quantum Devices
- Magnetism, Multiferroics, & Spintronics
- Sensor Devices & Technologies

Dr. John Zavada

- Optoelectronics & Photonics
- Nanophotonics
- Plasmonics & Optical Metamaterials-Based Devices
- Large-Scale Photonic Integration
- Ultrafast Photonics

Communications, Circuits, and Sensing-Systems (CCSS)

Dr. Zygmunt Haas

- Cyber-Physical Systems (CPS)
- Embedded Systems
- Wireless Communications Algorithms & Networking
- Integrated Sensing, Communications, & Computational Systems
- Signal Processing & Coding
- Cyber Security

Dr. Rajinder Khosla

- Sensors, Actuators, & Electronic Interfaces
- Chemical, Biological, & Physical Diagnostic Systems
- Implantable & Wearable Systems
- Environmental Sensing & Monitoring
- MEMS/NEMS Devices
- System-Level Fabrication, Packaging, & Assembly

Dr. Andreas Weisshaar

- RF/Wireless, Optical, & Hybrid Communications
- Broadband & Low Power Communications
- RF/Microwave & mm-Wave Components/Circuits
- Inter- and Intra-Chip Communications & Networking
- Submm-Wave/THz Imaging & Sensing
- Mixed Signal Circuits & Systems
- Enabling Technologies for Intelligent Communications Systems
- Interconnects & Packaging Techniques

Energy, Power, and Adaptive Systems (EPAS)

Dr. Radhakisan Baheti

- Control Theory & Hybrid Dynamical Systems
- Distributed & Mobile Networked Control
- Systems Theory in Molecular, Cellular, & Synthetic Biology/Medicine
- Estimation in Sensing & Imaging Systems
- Sensor Networks for Energy-Efficient Buildings
- Transportation Networks
- Human-Robot Interaction
- Stochastic Modeling & Applications

Dr. George Maracas

- Energy Collection, Photovoltaics, & Thermal Devices
- Novel Energy Conversion Devices
- Renewable Energy Devices & Systems
- Power Conversion, Generators, Motors & Network Interfacing
- Energy & Power Sensing Technologies
- Energy Storage Technologies
- High Voltage, High Power Switching & Conversion Devices

Dr. Paul Werbos

- Adaptive & Intelligent Systems
- Transmission & Distribution Systems
- Intelligent Power Grid
- Quantum Systems & Modeling
- Neural Networks
- High Performance & Multiscale Modeling
- Cognitive Optimization & Prediction
- Intelligent Vehicles & Robots

Energy, Power and Adaptive Systems

- * Emphasis on electric power networks and grids
 - * Generation
 - * Transmission and integration of renewable, sustainable and distributed energy systems
 - * High power electronics and drives
 - * Associated regulatory and economic structures
- * Topics of interest
 - * Alternate energy sources
 - * Smart Grid
 - * Interdependencies of critical infrastructure in power and communications

Sample EPAS projects

- * "Tools for assessment of transmission-constrained market power in electricity markets," Ross Baldick, UT-Austin
- * "Electricity auction: optimization, market behaviors, and comparative studies," Peter Luh, U.Conn.
- * "Multiple FACTS devices coordination using synchornized wide area measurements," Yilu Liu, University of Tennessee, Mariesa Crow, MST
- * "Dynamic grid control using virtual quadrature sources," Deepakraj Divan, Ronald Harley, Georgia Tech
- * "Transmission line fault location utilizing sparse measurements," Yuan Liao, University of Kentucky
- * "Customized Wavelets for Analysis of Fault Transients in Power Systems," Ali Abur, Northeastern University
- * "Creating the next generation power grid with massively distributed intelligent sensors," Vijay Jain, Alexander Domijan, Shekhar Bhansali, University of South Florida

Directorate for Engineering (ENG)



Emerging Frontiers in Research and Innovation

* FY 2007

- * Auto-Reconfigurable Engineered Systems
- * Cellular and Biomolecular Engineering

* FY 2008

- * Cognitive Optimization
- * Resilient and Sustainable Infrastructures

* FY 2009

- * Biosensing & Bioactuation
- * Hydrocarbon from Biomass

* FY 2010

- * Renewable Energy Storage
- * Science in Energy and Environmental Design: Engineering Sustainable Buildings

* FY 2011

- * Engineering New Technologies Based on Multicellular and Inter-kingdom Signaling
- * Mind, Machines and Motor Control

Sample EFRI Projects

- * "Neuroscience and Neural Networks for Engineering the Future Intelligent Electric Power Grid," Ganesh Venayagamoorthy, MST
- * "21st Century National Energy and Transportation Infrastructures: Balancing Sustainability, Costs, and Resiliency," James McCalley, Iowa State
- * "A Multi-Scale Design and Control Framework for Dynamically Coupled Sustainable and Resilient Infrastructures, with application to vehicle-to-grid integration," Jeffrey Stein, University of Michigan
- * "Resilient and Sustainable Interdependent Electric Power and Communications Systems," Lamine Mili, Virginia Tech.
- * \$2M awards for 4 years

Directorate for Engineering (ENG)





Industry/University Cooperative Research Center (I/UCRC) Program

- * Promotes long-term partnerships among industry, academe, and government
- * Centers are catalyzed by a small investment from NSF and are primarily supported by industry center members during their development and evolution
- * ~\$9M for 2-8 full center awards (\$55-80K/year for up to 5 years) and 4-12 planning grant awards (\$10K for 1 year)
- * Approximately 60 centers currently NSF funded

Power Related I/UCRCs

- * Power Systems Engineering Research Center (PSERC)
 - * Originally funded in 1996, now in Phase III
 - * 13 partner universities, led by Arizona State University
- * Grid-Connected Advanced Power Electronic Systems (GRAPES)
 - * Funded in 2009
 - * University of Arkansas and University of South Carolina
- * <http://www.nsf.gov/eng/iip/iucrc/directory/index.jsp>

Directorate for Engineering (ENG)

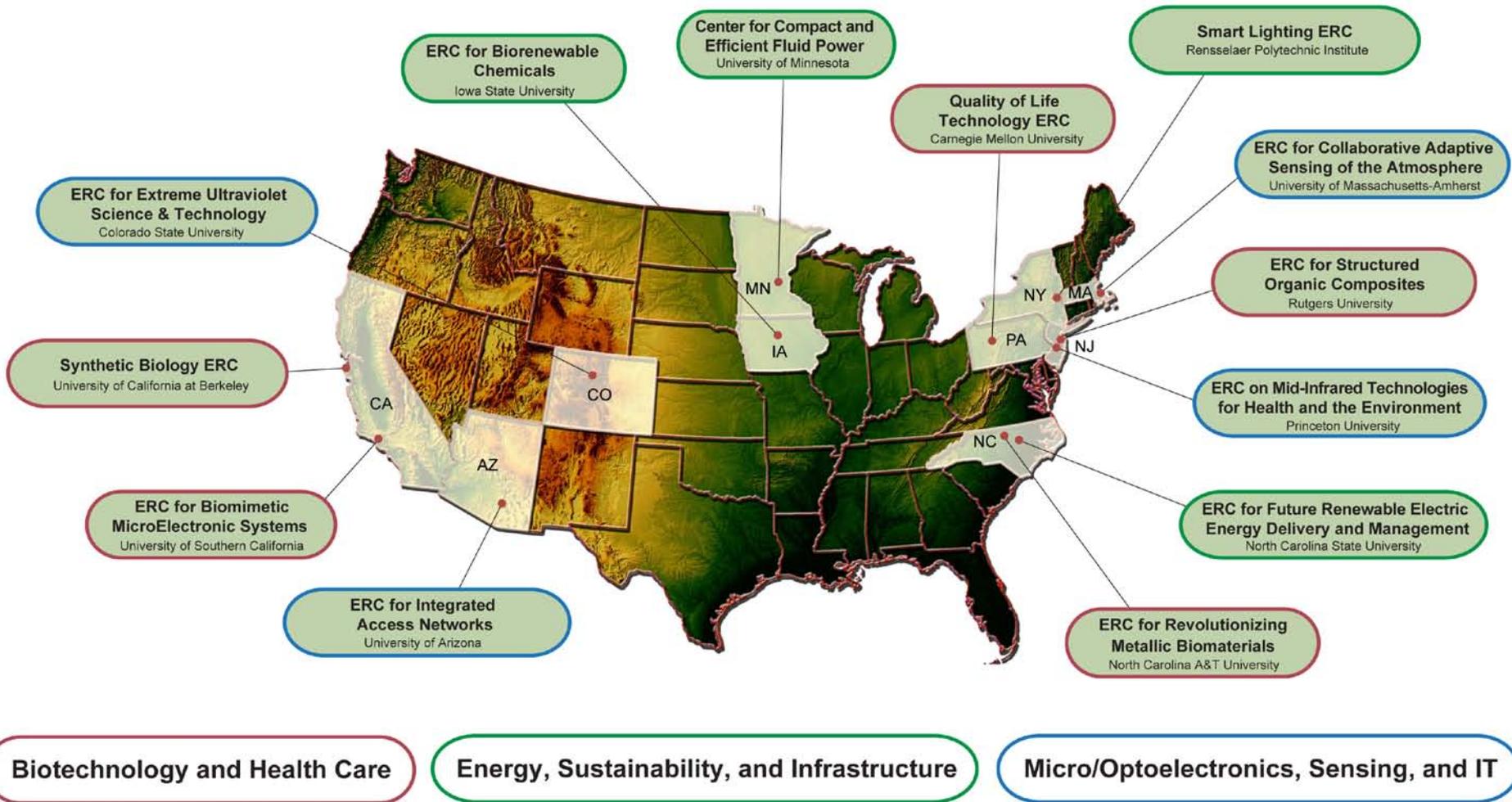




Engineering Research Centers

- * Key Features of an ERC
 - * Transformational Engineered Systems Vision
 - * Systems-Motivated Strategic Research Plan
 - * Engineered systems, Enabling technology, Fundamental research
 - * Inter-Disciplinary Research Program
 - * University and Pre-College Education Programs
 - * Industrial Collaboration
- * Funding for up to 10 years
 - * \$4M per year
 - * Rigorous post-award oversight and annual peer review
 - * 2 year competition cycle
- * For FY11, 2-6 awards (pending funding), possible DOE co-funding

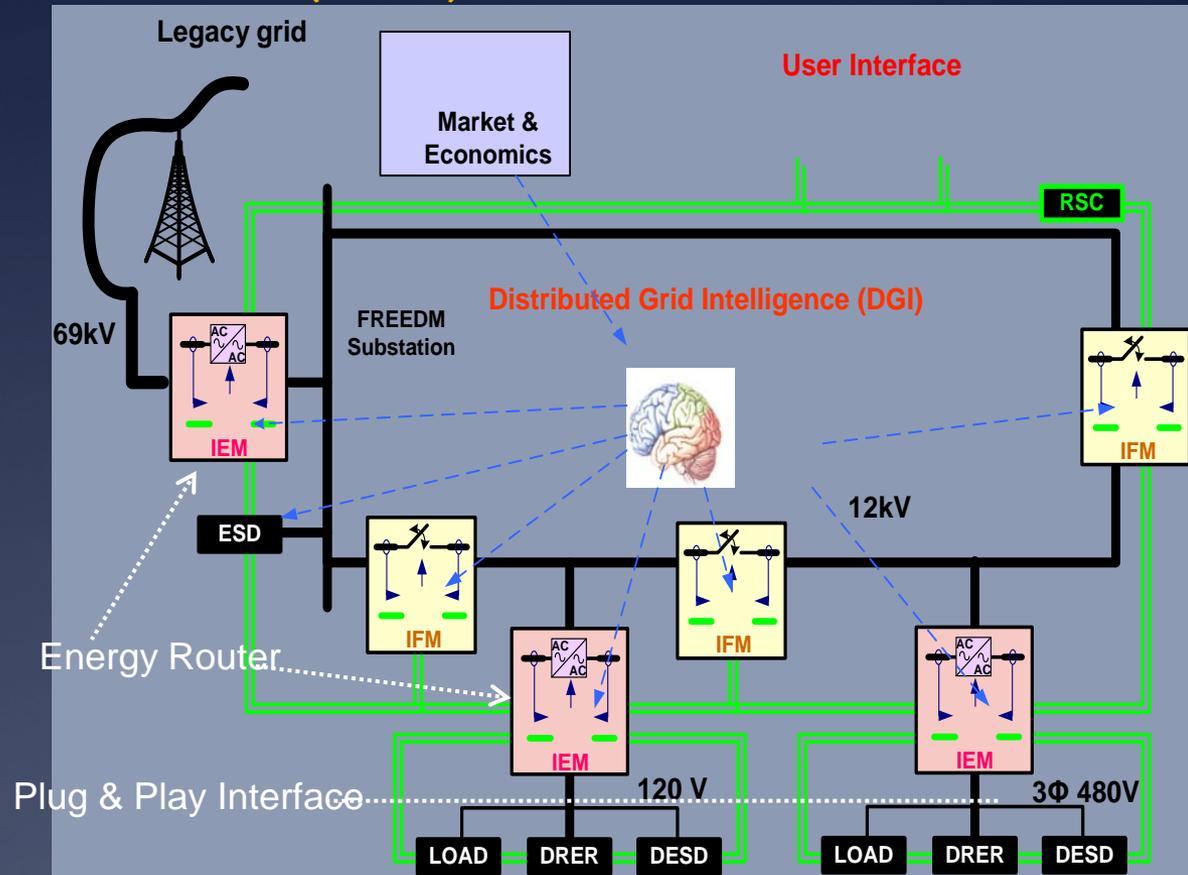
NSF's FY 2011 Engineering Research Centers



Note: All centers are multi-university partnerships; university shown is lead institution.

Future Renewable Electric Energy Delivery and Management (FREEDM) System Engineering Research Center (ERC)

- * “Energy Internet” concept to enable every citizen to participate in energy production, conservation and utilization
- * Develop plug-and-play infrastructure to enable the use of distributed renewable energy resources



In Summary

- * Many programs in various divisions and directorates at NSF with funding for energy related research
- * Engineering and Math & Physical Sciences Energy Working Group recently formed to more closely coordinate activities
 - * Co-chaired by George Maracas, ENG, and Linda Sapochak, MPS