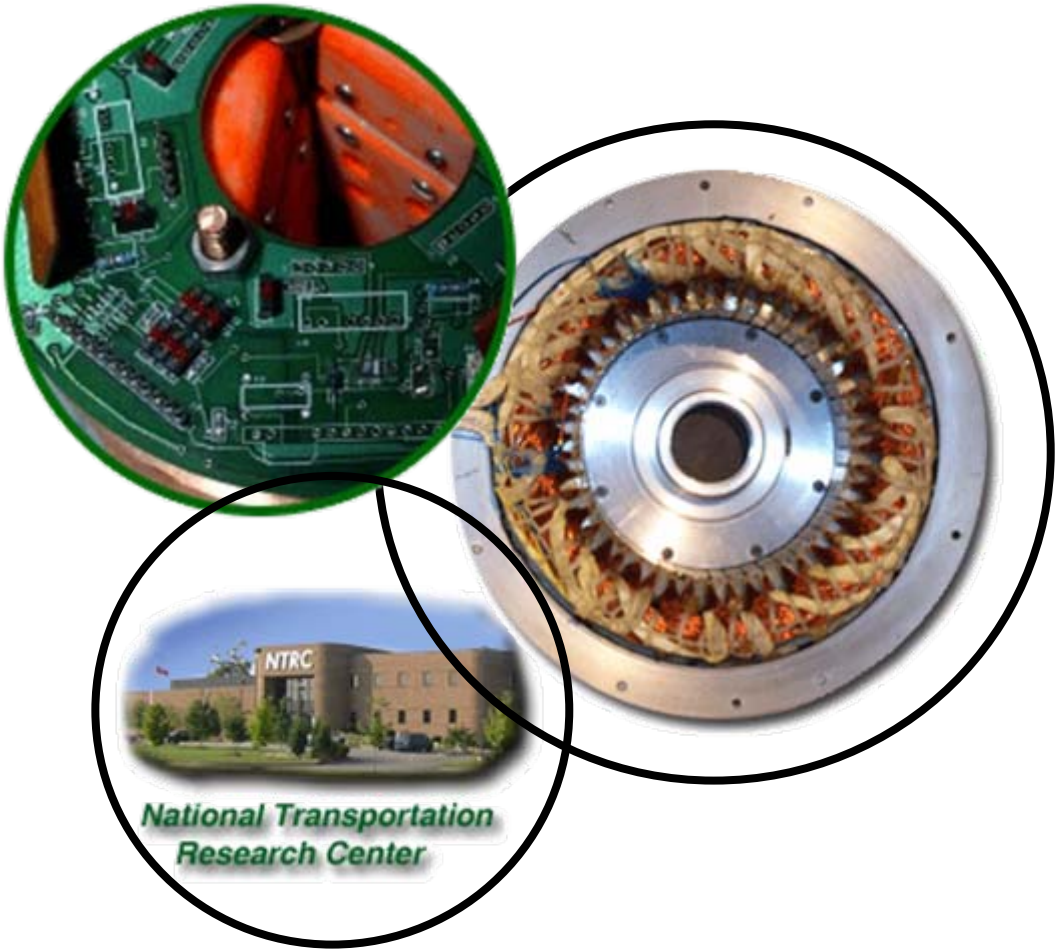
Power Electronics and Electric Machinery Research Center



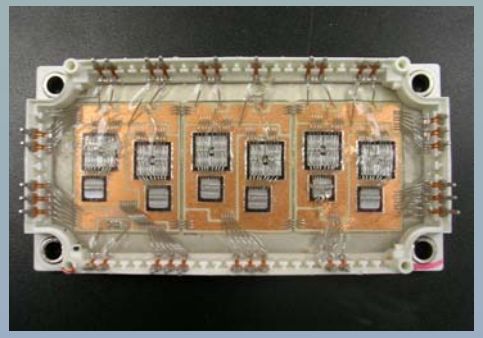
Burak Ozpineci
Email: ozpinecib@ornl.gov
Phone: 865-946-1329
Oak Ridge National Laboratory

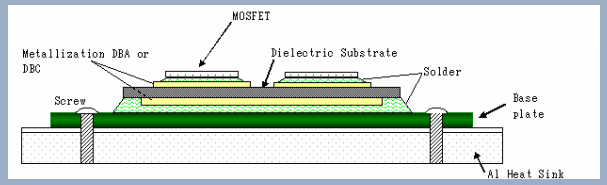
This presentation does not contain any proprietary or confidential information

ORNL has expertise in power electronics development

Power electronics for two-way power flow control (reliable and low-cost)

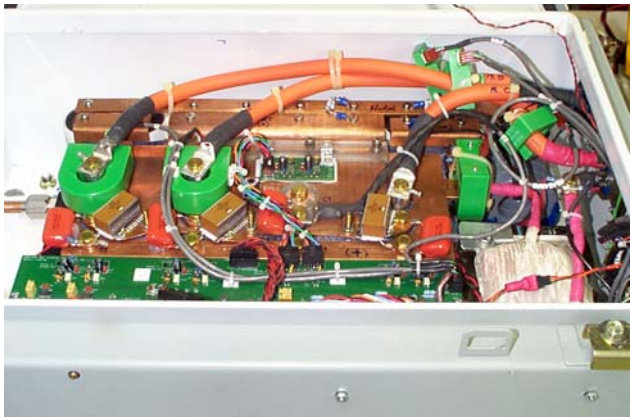
Advancements in High Temperature Packaging and Thermal Management





Unique: Power Electronics & Electric Machinery Research Center

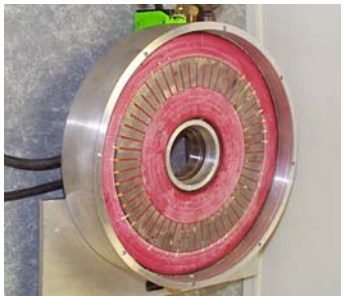
- A staff of 35 researchers
- 700 m^2 laboratories
- Only DOE national laboratory with an all-encompassing PEEM program.
- The Center's world-wide reputation is supported by awards, patents, publications, and recognition by professional societies, academia, industry and DOE.



100 kW, installed (Chattanooga Bus)
Soft switching and sensorless

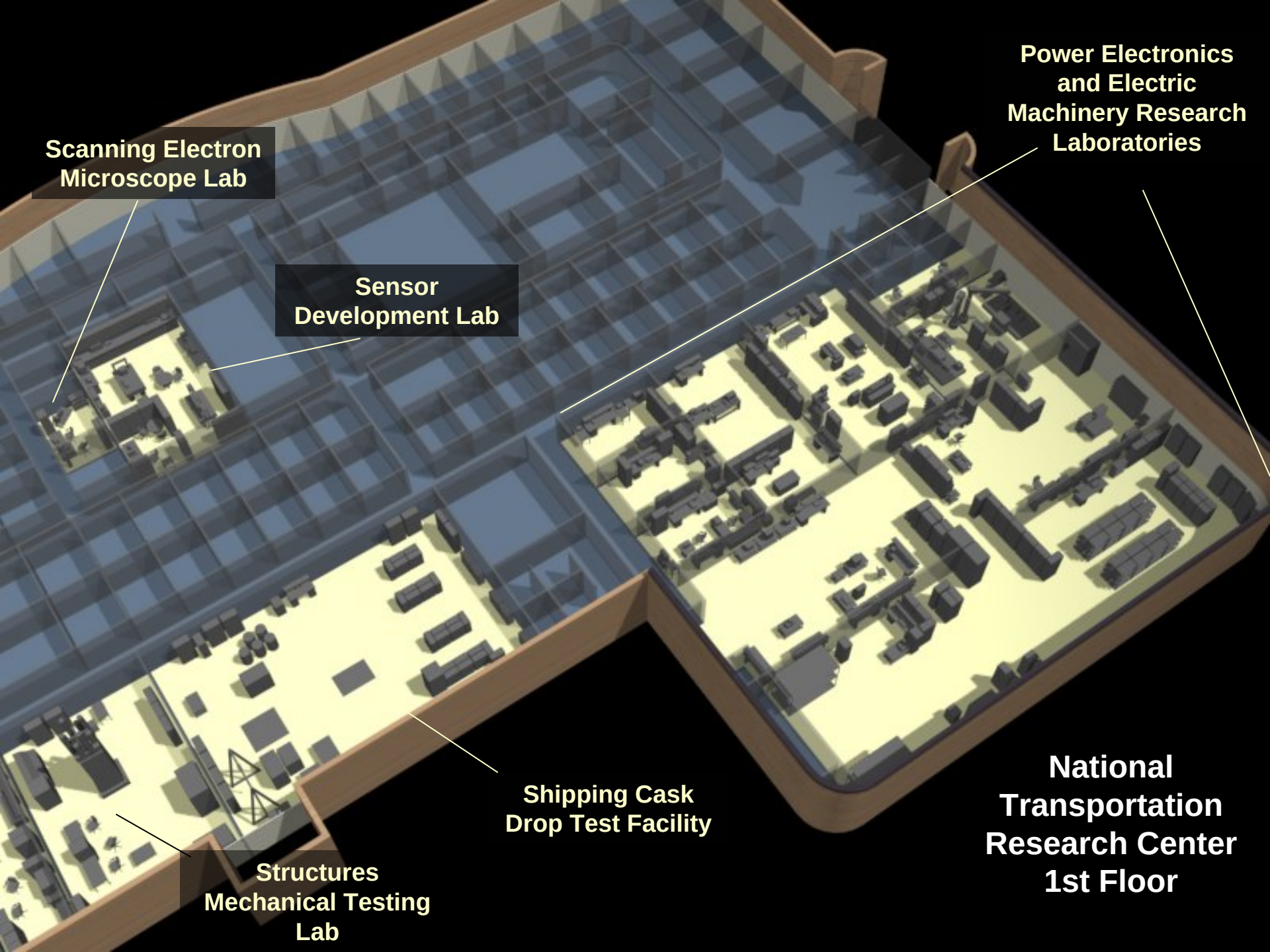
- The Center is actively involved in partnerships with several universities, private and public companies, other federal agencies, and consortiums.
- Projects supported by various offices of DOE, DOD, and industry.
- Plurality of funding is for hybrid-electric vehicles, and other areas include heavy hybrid vehicles, fuel cells, distributed energy, power quality and transmission, and motors and drives for special applications.
- Projects directly funded by industrial partners allow proprietary work.

Rotor of a HSUB motor



Stator armature of a HSUB motor

Stator DC field end bracket

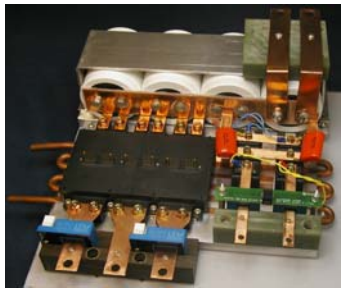

Scanning Electron Microscope Lab
Sensor Development Lab
Power Electronics and Electric Machinery Research Laboratories
Shipping Cask Drop Test Facility
Structures Mechanical Testing Lab
National Transportation Research Center 1st Floor

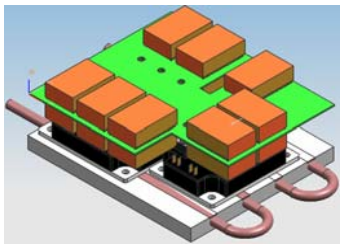
Research Capabilities

- Advanced power converters and adjustable speed drives
- Novel and conventional electric machines
- Power quality, efficiency, and power measurements
- Prototype development and evaluation
- Power transmission and distribution research and development

- Major equipment available:
  - 600 Volt, 600 ampere bi-directional dc power supply
  - 100 HP, 10,000 rpm 4-quadrant dynamometer test cell
  - 400 HP, 6500 rpm and 150 HP, 7500 rpm eddy current brake dynamometers
  - High speed rotational equipment safety tank
  - Environmental chamber (-50C to 700C)
  - Rapid prototype machine shop
  - Fuel cells

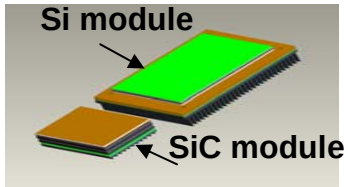
Power Electronics Research Areas





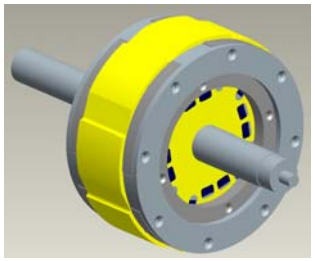
- **Interface with distributed energy resources such as microturbines, fuel cells, and solar cells**
- **Multilevel converters for utility applications such as static var compensation, voltage sag support, HVDC intertie, large variable speed drives**
- **Harmonics, power quality, and power filters**
- **Aggregation of multiple fuel cells to form a high power generator**
- **Application of DC distribution to existing AC infrastructure**
- **Smart plug-in hybrid electric vehicle chargers with grid support**

Power Electronics Research Areas



- Hybrid electric vehicle (HEV) applications such as motor drives or dc-dc converters
- Soft-switching inverters and dc-dc converters
- Application of wide-band gap power electronics
- Simulation, modeling and analysis of power electronics for transportation and utility applications
- High temperature packaging of power devices
- Reliability assessment of present power semiconductor module packages

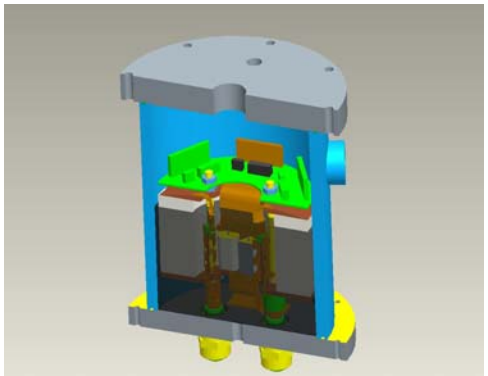
Electric Machine Technology Research Areas

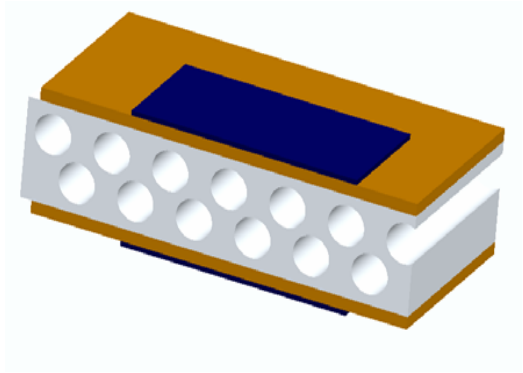


- Novel electric machine technology
  - Permanent magnet (axial and radial gap)
  - Switched reluctance
  - Induction (novel designs and rotor bar technology)
  - DC machines (advanced brush technology, soft-commutated, homopolar)
  - Superconducting generator
- Motor control – sensorless motor drive techniques, circuits and control for extended constant power range for high speeds
- Design, thermal, efficiency, and performance models for AC machines
- Prognostics and failure diagnostic techniques

Thermal Management

- Investigated various kinds of coolants and cooling systems of power electronics and electric machines.
- Sample Projects
  - Refrigerant-cooled inverter (direct cooled power devices; actively cooled capacitors)
  - Thermal buffer
  - Direct-cooled power electronics substrate





For More Information

http://peemrc.ornl.gov

http://www.ntrc.gov

http://www.eere.energy.gov/vehiclesandfuels

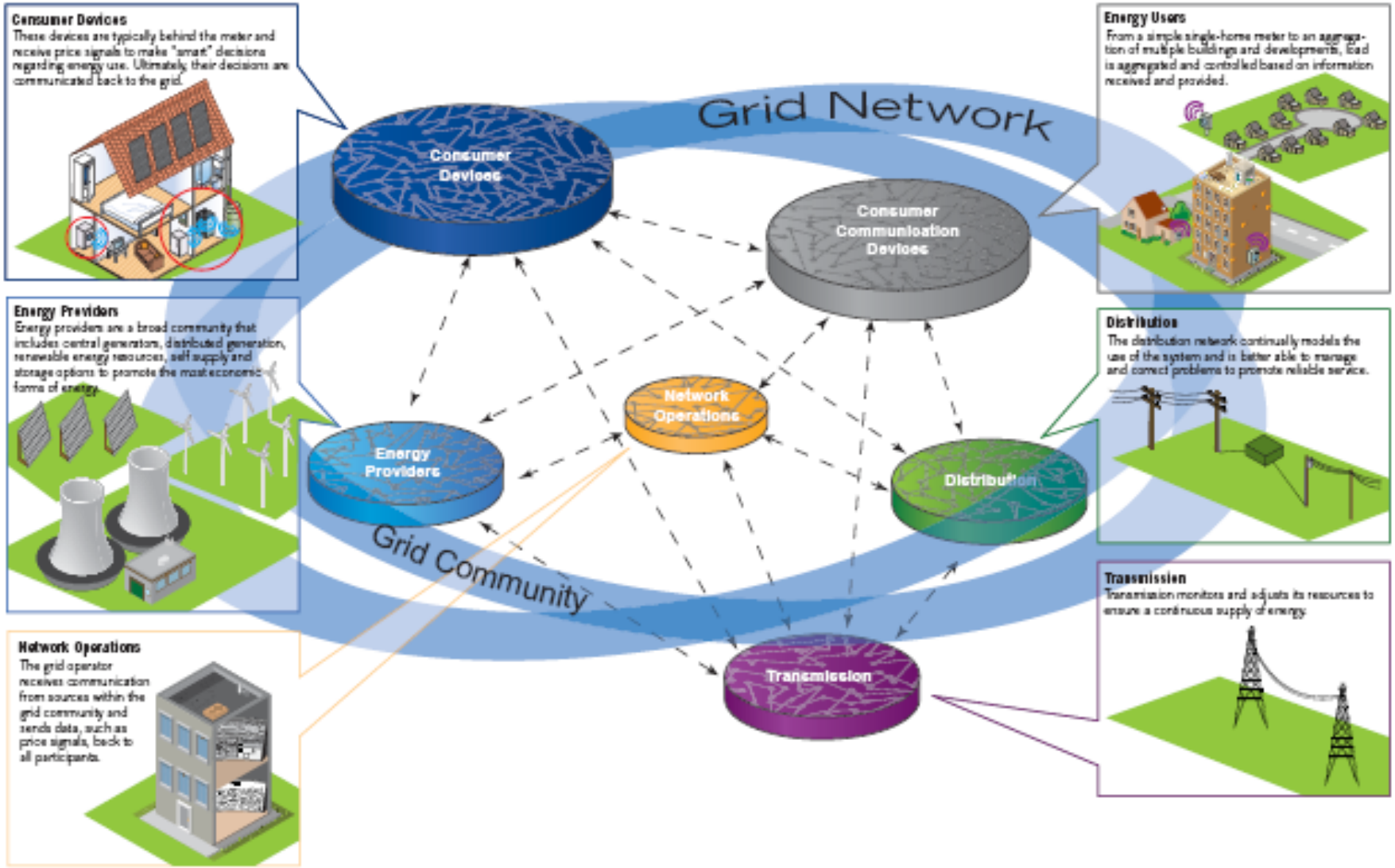
Electric Grid R&D Program at ORNL

“Smart Grid” R&D

Tom King
John Kueck
Tom Rizy

OAK RIDGE National Laboratory

Modernizing the Electric Grid



PJM Interconnection

ORNL was involved in the first fully integrated distribution automation system

- DOE funding from Office of Energy Storage and Distribution
  - FY82-FY88
- Project Team
  - ORNL
  - AUB, Athens Utilities Board
  - TVA, TVPPA, EPRI
  - Baltimore Gas & Electric
- Industrial Advisory Committee
- Athens Utilities Board (1985)
  - Municipal utility for the city of Athens, Tennessee
  - Population of 30,000 with 10,000 electric customers
  - 90 MW peak load
  - Three substations with 11 feeders

Athens Automation and Control Project

- **The purpose of the Athens Automation Control Experiment was to develop and test:**
  - **load control options,**
  - **voltage and reactive power control options,**
  - **distribution system reconfiguration capabilities**

  on an electric distribution system from the transmission substation transformer to individual residential appliances.

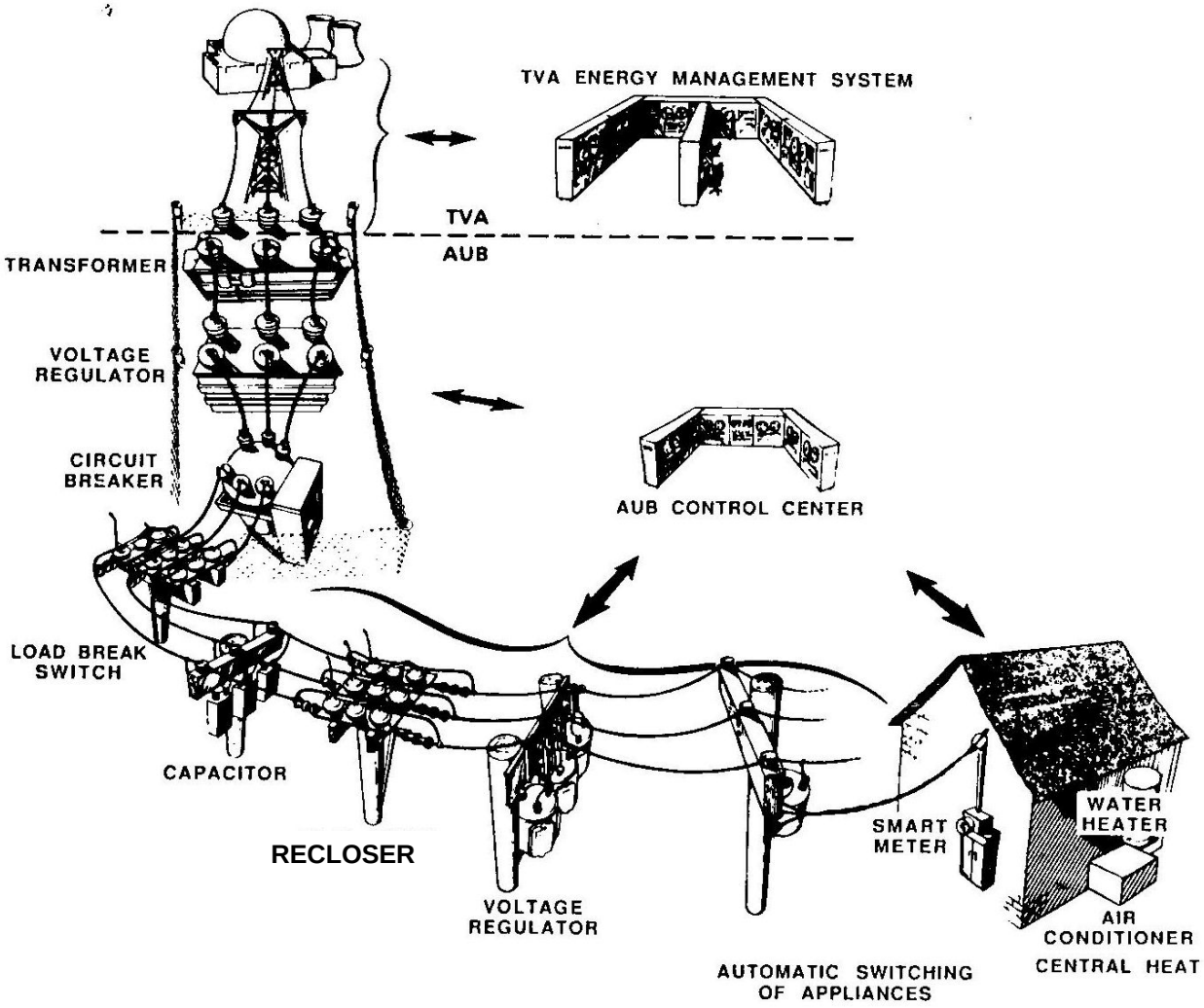


Figure 1-1 Automated equipment for the Athens Automation and Control Experiment.

Improving Grid Reliability through Distributed Energy Systems

DECC Facility

- Unique facility for testing reactive power from distributed energy (DE) established in 2006
- Located on ORNL campus and interfaces with ORNL distribution system
- Developing controls for voltage and power factor regulation to improve system reliability
- Partnering with utilities and generation suppliers

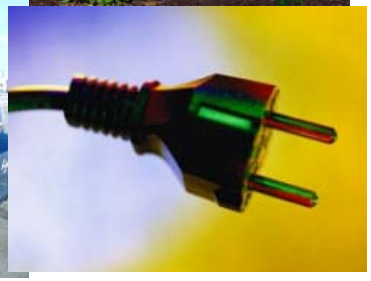
Distributed Energy Communications and Controls (DECC) Facility can test inverter and rotating generation equipment

Develop the Scalable, Adaptable Algorithms in DECC, then Apply in the Field

- **We will develop methods to find control constants.**
- **Methods must be simple, easy to use, similar to NEMA MG1 for motor application using nameplate data.**
- **We will perform simulations and preliminary testing here at the DECC laboratory which is connected to the ORNL distribution system.**

DECC Facility Plans

- Photovoltaic units to assess opportunity for reactive power compensation
- PHEV to study interface with grid
  - Charging while providing reactive power
  - Ancillary Services



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