

# Assistant Secretary Alexander “Andy” Karsner, Energy Efficiency and Renewable Energy



**Visit**  
**June 4-5, 2008**













DO NOT TOUCH GLASS









The Nobel Prize in Physics 1994

Neutrons reveal structure and...



1994 Nobel Prize in Physics

for their discovery of the neutron

James Chadwick

1891-1974

University of Cambridge

1928

Neutron

1932

1935

1938



Slugs

**THE GRAPHITE REACTOR**  
The Graphite Reactor was a research reactor – a tool used for conducting nuclear research as well as for producing radioisotopes. The five basic features of the reactor's system include: fuel, moderator, control system, cooling system, and shield. Follow the yellow-colored signs found here and in the reactor's Control Room for a description of each feature.

**ELEVATOR AND FUEL CHANNELS**  
This electric elevator allowed access to the fuel channels for loading fuel and other materials into the reactor. A shield plug is located at the opening of each fuel channel. To load the reactor with fuel, these shield plugs were removed, and the uranium fuel slugs were used to center the slugs inside the reactor.

When the reactor was unloaded, the long rods were used to push the slugs into the exit air duct. They fell onto a neoprene slab and down a chute into a canal of water 20 feet deep. Fuel slugs were stored in the canal until they were transferred to a chemical separations facility next to the reactor building for processing.

**FUEL**  
Fuel for the Graphite Reactor was uranium (99.3 percent U-235) contained in aluminum jackets. Only 800 were used, and they were 4.1 inches in diameter. Each slug contained...

**MODERATOR**  
The moderator slows down neutrons. Blocks of graphite were used as moderator in the reactor. It was made of graphite with a...



1954

GRAPHTONE  
NATIONAL HISTORIC LANDMARK  
1954





#### THE GRAPHITE REACTOR

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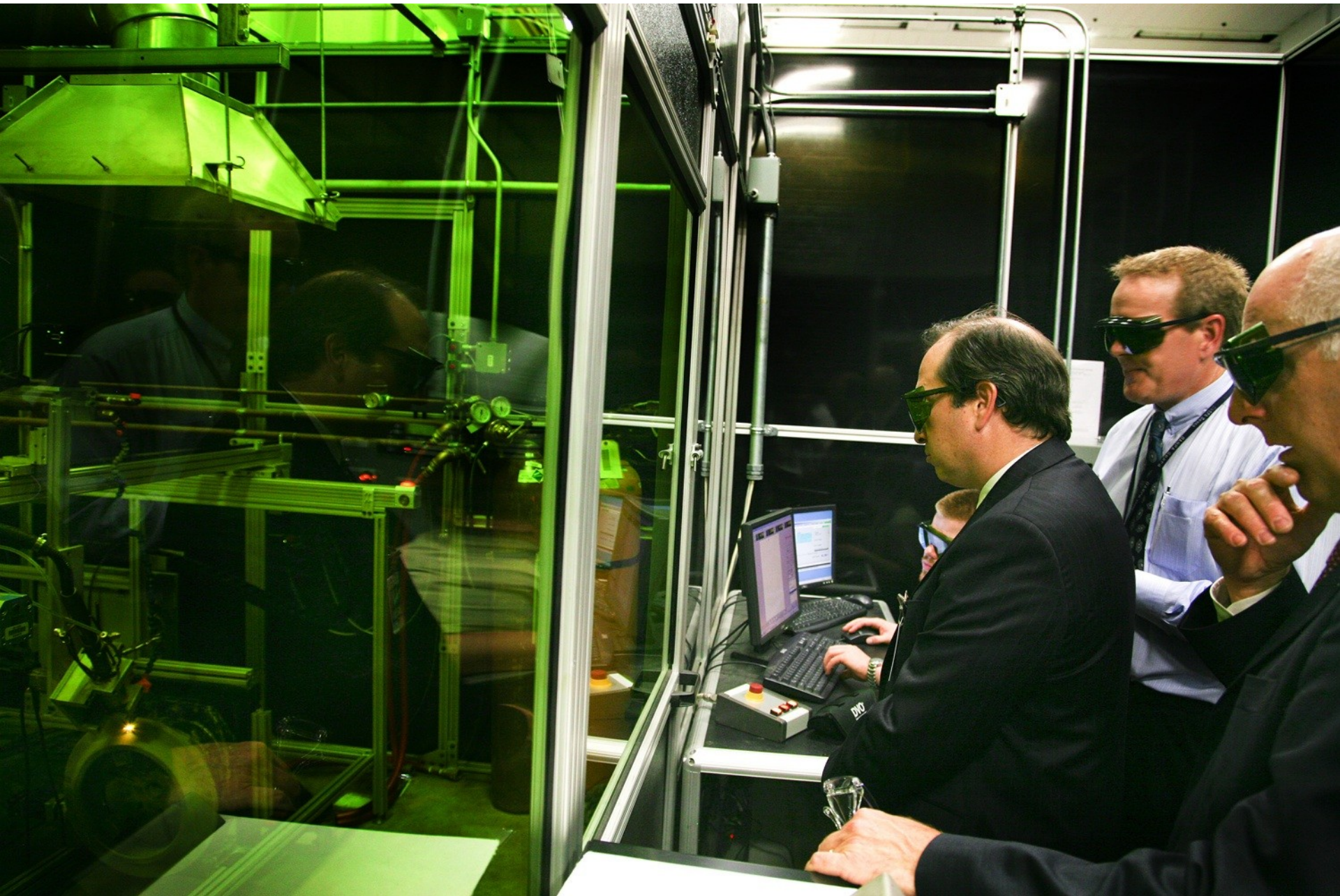






NOTICE  
SAFETY GLASSES  
REQUIRED  
BEYOND THIS POINT























## POWER ELECTRONICS AND ELECTRIC DRIVES

### Wide Bandgap Materials

**Objectives:**





- Assess the impact of emerging wide bandgap devices in transportation applications and develop test procedures for such devices (WBG) semiconductor devices.
- Develop device models to support-level simulation studies and analyze the impact of WBG semiconductor based devices in the system performance.
- Build WBG semiconductor based prototype power electronics to validate the simulation results.
- Investigate the advantages and disadvantages in the system properties of WBG semiconductors.

**Technology Importance:**

- WBG semiconductor devices have the potential to operate at higher efficiencies than their Si counterparts.
- Reduced thermal management requirements (smaller heat sinks) due to high temperature operation capability of WBG semiconductor based power devices.
- Smaller passive components are required since WBG semiconductor based power devices can be switched at higher frequencies.
- Smaller heat sinks and passive components result in higher power density converters.

**Target Applications:**

- High temperature power electronics
- High power motor drives
- On-DC converter
- Power factor correction circuits
- Utility applications

## Integrating Motor and HVAC Compressor Drives

**Objectives:**


- Reduce cost, size, volume, and complexity by integrating the motor and compressor drives to reduce the number of switches and other components.

**Technology Importance:**

- Fuel cell powered vehicles require an electric motor-driven compressor for HVAC.
- The electric compressor enables HEVs to shut off the engine during vehicle stops for reducing emissions and improving fuel economy.

**Target Applications:**

- Hybrid electric vehicles
- Fuel cell vehicles
- Other applications using multiple motor drives such as central air conditioning systems




ORNL PHEV Integrated Charger

ORNL Triple Output DC-DC Converter





- Develop device models for system-level simulation studies and analyze the impact of WBG semiconductor based devices on the system performance
- Build WBG semiconductor based prototype inverters/converters to validate the simulation results
- Investigate novel concepts to take advantage of the superior properties of WBG semiconductors

**Technology Importance:**

- WBG semiconductor devices have the potential to operate at higher efficiencies than their Si counterparts
- Reduced thermal management requirements (smaller heat sinks) due to high temperature operation capability of WBG semiconductor based power devices
- Smaller passive components are required since WBG semiconductor based power devices can be switched at higher frequencies
- Smaller heat sinks and passive components result in higher power density converters

**Target Applications:**

- High temperature converters/inverters
- High power motor drives
- Dc-Dc converter
- Power factor correction circuits
- Utility applications

**Objectives:**

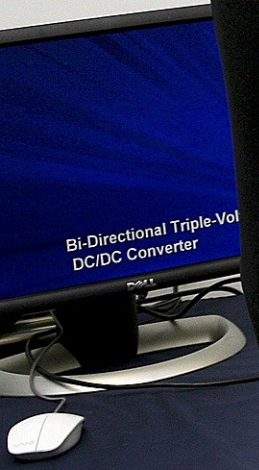
- Reduce cost, size, volume, and complexity by integrating the traction motor and compressor drives to reduce the number of switches and other components

**Technology Importance:**

- Fuel cell powered vehicles require an electric motor driver compressor for HVAC
- The electric compressor enables HEVs to shut off the engine during vehicle stops for reducing emissions and improving fuel economy

**Target Applications:**

- Hybrid electric vehicles
- Fuel cell vehicles
- Electric powertrains using



















RIDGE  
National Laboratory

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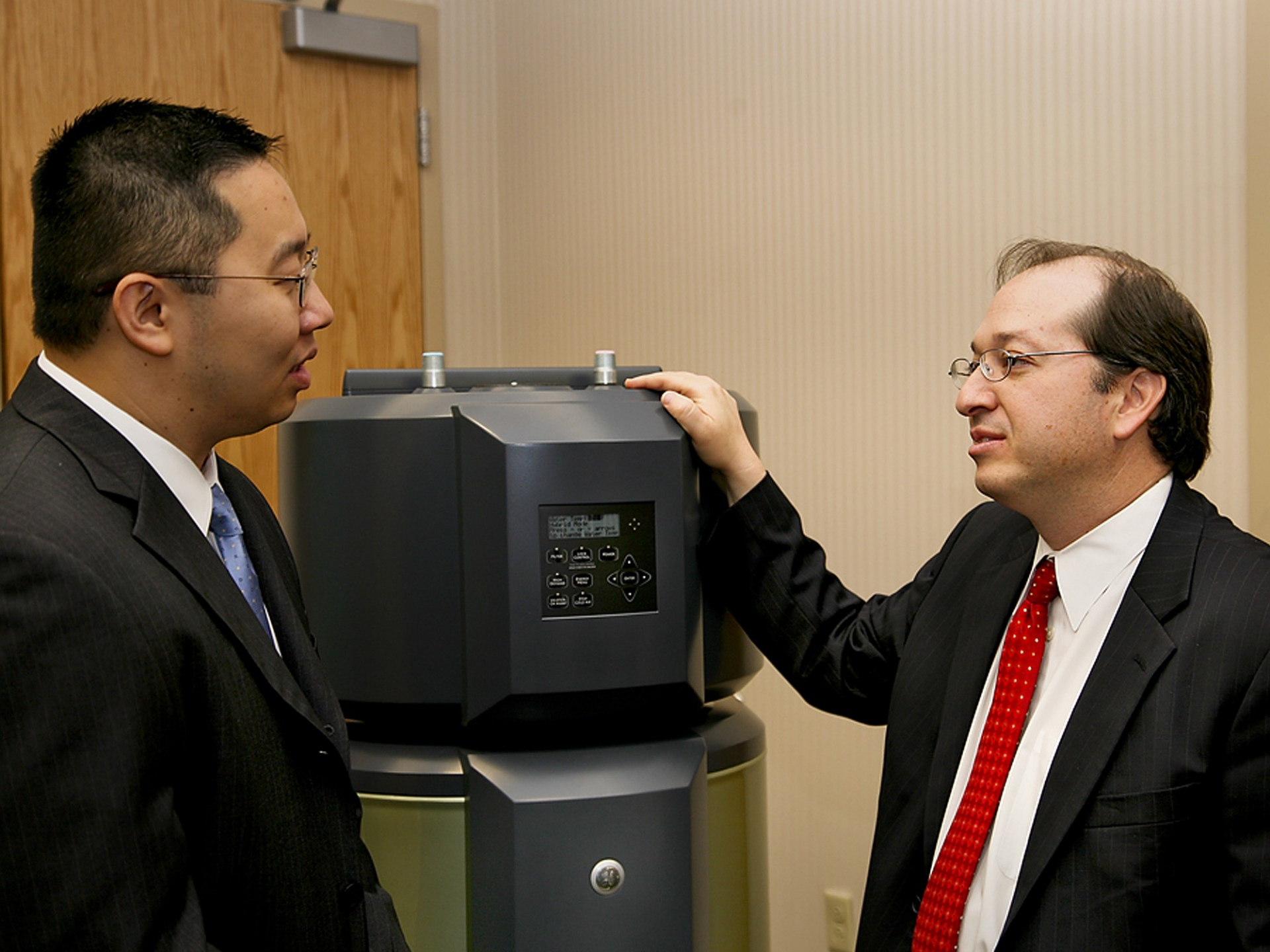
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OAK RIDGE NATIONAL LABORATORY







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NATIONAL LABORATORY







**Carbon Nanotubes: Synthesized in Macroscale Architectures for Energy Applications**

Loose single-wall nanotubes by laser synthesis

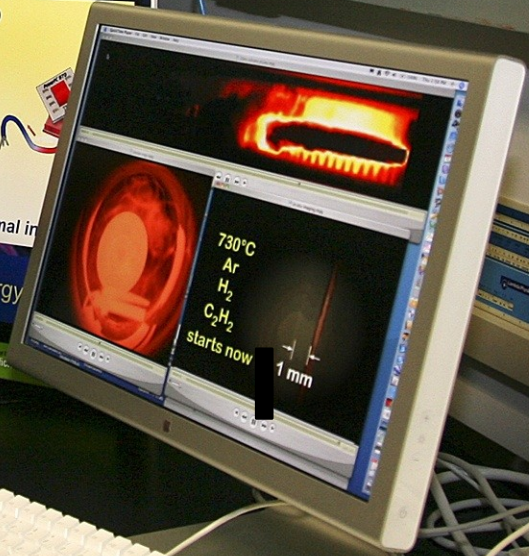
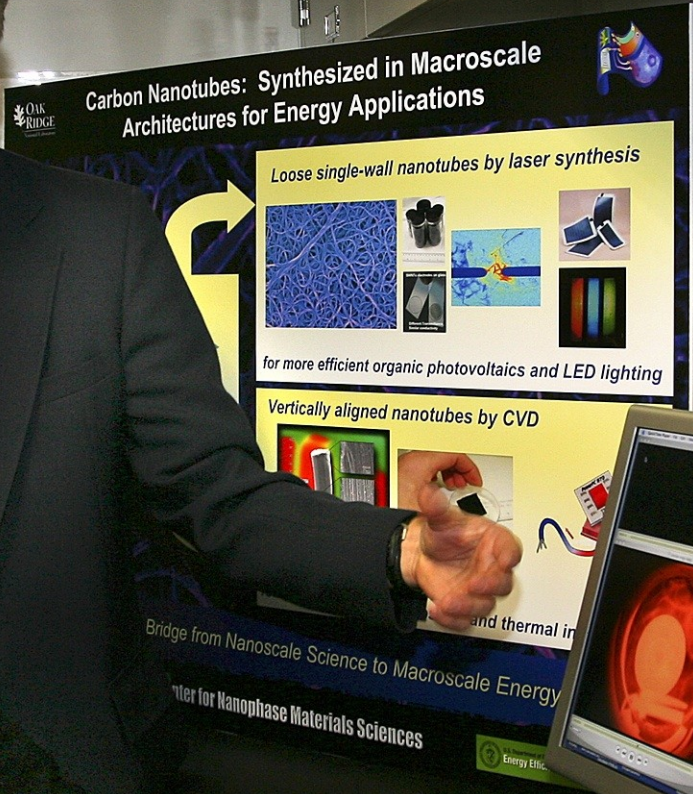
for more efficient organic photovoltaics and LED lighting

Vertically aligned nanotubes by CVD

Bridge from Nanoscale Science to Macroscale Energy

Center for Nanophase Materials Sciences

Energy Efficient











Intermediate Ethanol Blends (IBlend)

Storing energy is easy. Making the switch is hard.

ENERGY

EXIT

C-6

C-3



# Source & Engineering Systems

## OFFICE OF THE BIOMASS PROGRAM

Environmental Sciences Division



- Where are the feedstocks?
- What are the sustainability constraints?
- What are the supply options?

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A Research

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Richard...  
Mar 4, 2011



# Energy Resource & Engineering Systems

OFFICE OF THE BIOMASS PROGRAM

What feedstocks are available?  
How much is available and at what cost?

- Where are the feedstocks?
- What are the sustainability constraints?
- What are the supply options?



Resource analysis & biorefinery capacity



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LIJ  
ase

**BESC**  
Oak Ridge National Laboratory

Increase efficiency of the biofuel production process

**CURRENT PROCESS**

- 1 Cellulose Hydrolysis
- 2 Sugar Fermentation

**RE SINGLE-STEP PROCESS**  
Consolidated Bioprocess

Develop microbes to convert biomass to fuels in a single







the biofuel process

Center Mission

reduce

processing related

3

on



### for Biomass Supply Chains

Group - ORNL Environmental Sciences Division

U.S. Department of Energy  
Energy Efficiency and Renewable Energy

**Biomass**  
Advanced Bioenergy Program

OAK RIDGE  
National Laboratory

Research at ORNL is to accelerate development of technologies that reduce the costs of producing power from biomass to be competitive with other energy sources.

#### Transportation and Storage

How are the costs of transporting and storing biomass reduced by changing the feedstock harvest, packaging, or transportation method?

#### Options for Packaging Biomass to Reduce Transportation and Storage Costs

Commercially available feedstocks are being tested for their ability to reduce transportation and storage costs.

#### Biomass Supply Analysis and Model (IBSAL)

IBSAL simulates equipment and processes along the biomass supply chain from the field to the biorefinery. It can be used to estimate costs, energy requirements, and carbon emissions of harvest, handling, storage, transport, and preprocessing of a feedstock.

### Bioenergy Cycle

AGRICULTURAL FEEDSTOCKS

NEW BIOMASS CROPS

BIOMASS

FUEL POWER, HEAT AND NEW BIOPRODUCTS

AGRICULTURAL FEEDSTOCKS

WOOD PRODUCTS AND ENERGY OR FOOD/FEED CHEMICALS

ORNL

bioenergycenter.org logo



# Engineering Systems OF THE BIOMASS PROGRAM

are the feedst  
re the susta  
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Environmental  
Sciences Division

OAK  
RIDGE  
National Laboratory



data-based data (describing more  
in 3D environmental factors)  
multi-variate, spatial-  
temporal clustering are being  
used to predict  
optimal locations and productivity  
of collection and storage systems  
and source sustainability issues  
and production risks



Energy Efficiency and  
Renewable Energy

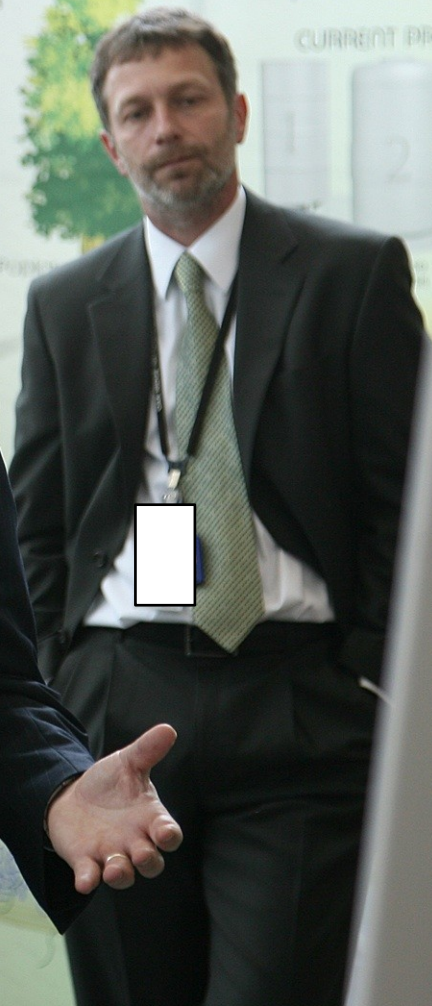
# BESC BioEnergy Science Center

A Research Partnership led by Oak Ridge National Laboratory

Develop biomass  
that is easier to  
break down  
into sugars

Increase efficiency of the bi  
production process

CURRENT PROCESS



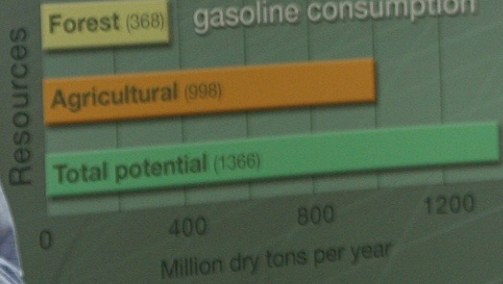


# Bioenergy Resource & Engineering

## Resource Analysis Objectives

- What feedstocks are available?
- How much is available and at what cost?
- Where are the feedstocks?
- What are the sustainability costs?
- What are the supply options?

Billion-ton resource analysis



Land resources are capable of producing a sustainable supply of biomass sufficient to displace more than 30% of the country's present gasoline consumption

Resource analysis is every state with potential



Corn stover is the single largest biomass resource that is currently available:

- Availability dependent on yield increase
- Efficiency of collection equipment
- Use of no-till cultivation
- Sustainability requirements accounted for

Resource analysis is used to predict the growth in the distribution of perennial crops - 2012 and 2030







OAK RIDGE  
National Laboratory

ORNL's 1st Annual Hybrid Vehicle Showcase

LEDS  
GREEN





# Single-Axis Tracking Photovoltaic System



The Oak Ridge National Laboratory is a leader in the development and deployment of single-axis tracking photovoltaic systems. This system is a key component of the laboratory's efforts to reduce energy consumption and increase efficiency. The system is designed to maximize energy production by following the sun's path throughout the day. This technology is being used in a variety of applications, including the laboratory's own energy needs and in other facilities across the country. For more information, please contact the Oak Ridge National Laboratory Energy Management Department.

### Leader



### ENERGY MANAGEMENT







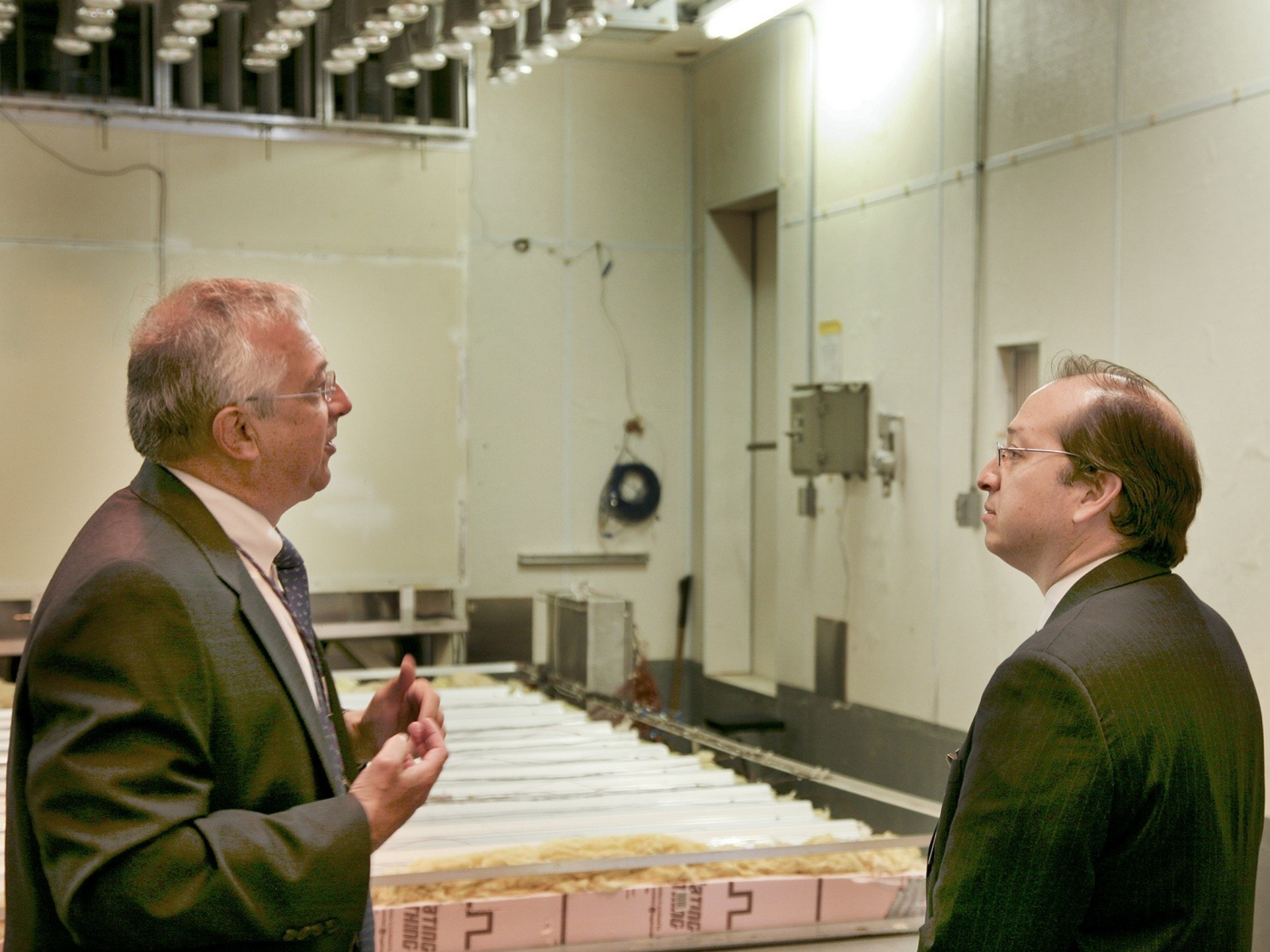






















# Industry: Global Energy Picture

## Industry largest using s

- 37% of natural gas demand
- 29% of U.S. electricity demand
- 30% of U.S. greenhouse gas emissions

Open Total Energy

## Oak Ridge Industrial Technology Solutions

**Energy Solutions**

Manufacturing Fuel and Feedstock Flexibility

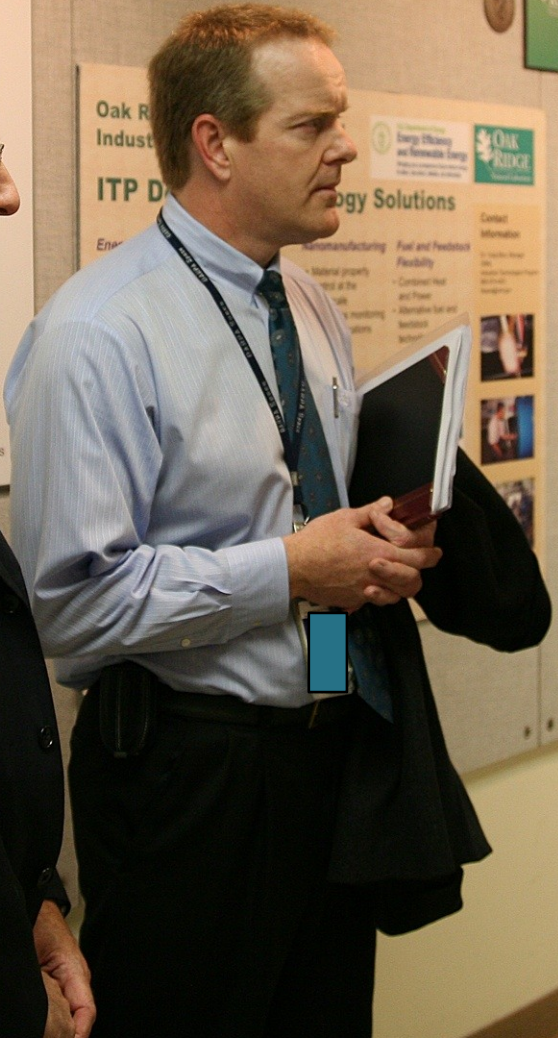
- Material growth
- Controlled heat and pressure
- Alternative feed and feedback

## Industrial Technologies Program

**Science**

Rapid Infrared Heating  
Energy Efficient  
Enhancement &...

**Energy**





OAK RIDGE  
**Industrial Technologies Program**

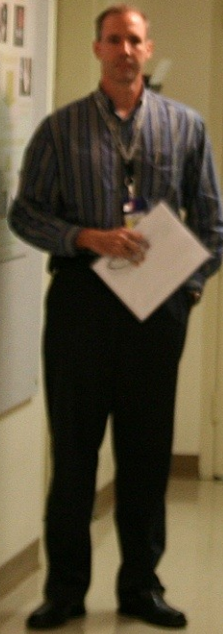
Rapid Infrared Heating Technology offers a Low-cost, Energy Efficient Heating Methodology with Significant Enhancement in Material Properties

Science



100% more heat transfer  
The addition of infrared  
radiation to the heating process  
allows for a significant increase in  
heating rate and energy efficiency.

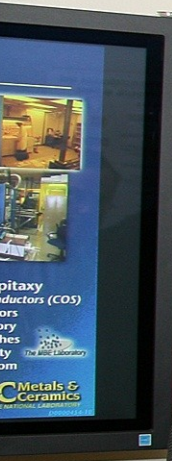
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**RD 100**

# 2006 Award Winner

**TMA<sup>®</sup> 6301 and TMA<sup>®</sup> 4701**

**Heat Resistant Alloys**

The first new heat resistant cast stainless steels with improved ductility and strength at higher maximum operating temperatures have been developed using a computer-aided alloy development process.

Department of Energy  
U.S. Department of Energy

The poster includes a group photo of six people and a small image of a heat-resistant alloy component.





Production of  
tical Vehicles  
istic Testing Passed  
Front and back of  
tested T-64-41 Plate  
John White, Strategic Services  
and Marketing Manager, HTNL  
HTNL's New RSUC Laboratory  
Advanced Materials Technology

HTNL  
Production  
Center

Material Storage Cabinet  
HTNL  
Production  
Center

HTNL's New RSUC Laboratory  
→

**NOTICE**  
SAFETY GLASSES  
REQUIRED  
BEYOND THIS POINT

HTNL  
Production  
Center

129-A







WTRM's New ORMC Laboratory  
→

CAUTION

NOTICE  
SAFETY GLASSES  
REQUIRED  
BEYOND THIS POINT







# Development of Materials Analysis Tools for Studying NO<sub>x</sub> Adsorber Catalysts

A comparative research and development agreement with Cummins Engine Company  
 Roger England, Bill Eging, Howard Fong and Rich Tomczak  
 Cummins Engine Company

Thomas Malin, Larry Kline, Dan Bunn, Michael Lomas, Christine Park and Barry Meyer  
 Oak Ridge National Laboratory

## Introduction

NO<sub>x</sub> and PM emissions regulations require significant reductions in NO<sub>x</sub> and particulate emissions from diesel engines.

- Diesel particulate and NO<sub>x</sub> emissions mitigation strategies
- Diesel particulate emissions are a function of engine speed, load, and engine temperature
- Cummins and ORNL are developing the next generation of NO<sub>x</sub> adsorber catalysts for diesel engines

## Objective

The goal of this project is to provide a quantitative analysis of the structure and composition of the NO<sub>x</sub> adsorber catalysts used in diesel engines. The project will focus on the development of materials analysis tools for the study of NO<sub>x</sub> adsorber catalysts.

- Develop a quantitative analysis tool for NO<sub>x</sub> adsorber catalysts
- Develop a quantitative analysis tool for NO<sub>x</sub> adsorber catalysts
- Develop a quantitative analysis tool for NO<sub>x</sub> adsorber catalysts

## Results: X-ray Diffraction

- X-ray diffraction (XRD) data were taken every 10 min during the length of simulation time
- The XRD data were analyzed to determine the structure of the catalyst as a function of simulation time
- A single phase of NO<sub>x</sub> adsorber catalyst was observed
- The catalyst was found to be a mixture of NO<sub>x</sub> adsorber catalyst and NO<sub>x</sub> adsorber catalyst
- Significant contributions to peak broadening of XRD patterns were observed

## Summary

- XRD and TEM results were used to increase the length of catalyst
- XRD and TEM results were used to increase the length of catalyst
- XRD and TEM results were used to increase the length of catalyst







FED FR

Quilting PAN Fiber

Commercial Grade PAN Fiber

PAN Precursor





Booz | Allen | Hamilton





### Composites for Transportation

Contact: Robert E. Adams, Jr.  
National Center of Composite Research and High Material Laboratory  
Phone 800-58-1710, [composites.frc.org](http://composites.frc.org)



**Advanced Processing**  
Advancing the Performance of a New Generation of Processes for Manufacturing Composites



**Energy Efficiency**  
Optimizing the Performance of Composites for the Next Generation of Transportation Technologies



**Lightweight Structures**  
Optimizing the Performance of Composites for the Next Generation of Transportation Technologies

**Process Stability**  
Optimizing the Performance of Composites for the Next Generation of Transportation Technologies

**Product Reliability**  
Optimizing the Performance of Composites for the Next Generation of Transportation Technologies

**Low Cost Solutions**  
Optimizing the Performance of Composites for the Next Generation of Transportation Technologies

**Green & Blue with the Automotive Composites Consortium**  
Optimizing the Performance of Composites for the Next Generation of Transportation Technologies

**Market and Component Testing**  
Optimizing the Performance of Composites for the Next Generation of Transportation Technologies

**Advanced Manufacturing**  
Optimizing the Performance of Composites for the Next Generation of Transportation Technologies

**Composites Leading to a Sustainable Future**  
Optimizing the Performance of Composites for the Next Generation of Transportation Technologies

**Composites for a Sustainable Future**  
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### POWER ELECTRONICS AND ELECTRIC MACHINES

## Wide Bandgap Materials

**Objectives:**

- Assess the impact of replacing silicon (Si) power devices in transportation applications with devices based on wide bandgap (WBG) semiconductors
- Develop device models for system-level simulation studies and analyze the impact of semiconductor based devices on the system architecture

**Technology Importance:**

- WBG semiconductor devices have the potential to operate at higher efficiencies than their Si counterparts
- Reduced thermal management requirements parallel heat sinks due to high temperature operation capability of WBG semiconductor based power devices
- Smaller passive components are required since WBG semiconductor based power devices can be switched at higher frequencies
- Smaller heat sinks and passive components result in higher power density converters

**Target Applications:**

- Hybrid electric vehicles
- Fuel cell vehicles
- Other applications using multiple motor drives such as central air conditioning systems

### POWER ELECTRONICS AND ELECTRIC MACHINES

## Integrated Traction Motor and HVAC Compressor Drives

**Objectives:**

- Reduce cost, size, volume, and complexity by integrating the traction motor and compressor drives to reduce the number of switches and other components

**Technology Importance:**

- Fuel cell powered vehicles require an electric motor driven compressor for HVAC
- The electric compressor enables HEVs to shut off the engine during vehicle stops for reducing emissions and improving fuel economy

**Target Applications:**

- Hybrid electric vehicles
- Fuel cell vehicles
- Other applications using multiple motor drives such as central air conditioning systems

### POWER ELECTRONICS AND ELECTRIC MACHINES

## Bi-directional Triple-Voltage DC-DC Converter

**Objectives:**

- Reduce cost and size of dc-dc converters for power management in multi-voltage hybrid electric and fuel cell vehicles

**Technology Importance:**

- Minimize the number of switching devices and the associated gate drivers
- Utilize soft-switching and common-mode neutralization techniques to reduce EMI noise and improve efficiency
- Require no additional components or complex control dedicated for soft switching
- Enable the use of multi-voltage electronic systems in 1.5kV systems
- Enable used for medium to high power conversion

**Target Applications:**

- Hybrid electric vehicles
- Fuel cell vehicles

### POWER ELECTRONICS AND ELECTRIC MACHINES

## Cascade Multilevel Inverter for Fuel Cell Based HEV

**Objectives:**

- Reduce the voltage stress on IGBTs and diodes by using the higher order of the cascaded multilevel inverter
- Reduce the number of power devices and gate drivers

**Technology Importance:**

- Reduce the number of switching devices and the associated gate drivers
- Utilize soft-switching and common-mode neutralization techniques to reduce EMI noise and improve efficiency
- Require no additional components or complex control dedicated for soft switching
- Enable the use of multi-voltage electronic systems in 1.5kV systems
- Enable used for medium to high power conversion

**Target Applications:**

- Hybrid electric vehicles
- Fuel cell vehicles



ORNL PHEV Integrated Charger



Output inverter







# Energy Efficiency, Renewable Energy, & Electricity Delivery



## Pursuing Energy Solutions



Disc  
Dev  
Del





### CORN IS A LEADER IN SUSTAINABILITY

While we use lots of energy, we don't want to waste any. We have added 12% more area to CORNL with 5% energy change.

**A SUSTAINABLE CAMPUS**

Leadership in Energy and Environmental Design (LEED)  
- 8 new buildings constructed to LEED standards  
- Largest LEED-certified campus in the South  
EPA WaterSense Gold Achievement Award

**High-level metric:**  
Ratio of total data center power to IT equipment power

Year	Ratio
2007	1.0
2008	1.2
2009	1.4
2010	1.6
2011	1.8
2012	2.0

Other data center developments by University of North Carolina at Chapel Hill

### STATUS OF CORNL TEAM INITIATIVES

Initiative	Start	End	Status
LEED Gold Certification	2007	2008	Completed
WaterSense Gold Achievement Award	2008	2009	Completed
Energy Star Rating	2009	2010	Completed
LEED Platinum Certification	2010	2011	Completed
LEED Platinum Plus Certification	2011	2012	Completed
LEED Platinum Plus Certification	2012	2013	Completed
LEED Platinum Plus Certification	2013	2014	Completed
LEED Platinum Plus Certification	2014	2015	Completed
LEED Platinum Plus Certification	2015	2016	Completed
LEED Platinum Plus Certification	2016	2017	Completed
LEED Platinum Plus Certification	2017	2018	Completed
LEED Platinum Plus Certification	2018	2019	Completed
LEED Platinum Plus Certification	2019	2020	Completed
LEED Platinum Plus Certification	2020	2021	Completed
LEED Platinum Plus Certification	2021	2022	Completed
LEED Platinum Plus Certification	2022	2023	Completed
LEED Platinum Plus Certification	2023	2024	Completed
LEED Platinum Plus Certification	2024	2025	Completed
LEED Platinum Plus Certification	2025	2026	Completed
LEED Platinum Plus Certification	2026	2027	Completed
LEED Platinum Plus Certification	2027	2028	Completed
LEED Platinum Plus Certification	2028	2029	Completed
LEED Platinum Plus Certification	2029	2030	Completed

**ES&C We create**

Year	ES&C of client	Design engineering	Award	Design - build	Measurements and verification
2007	2007	2007	2007	2007	2007

**Proposed projects**

Project name	Design	Contractors
Design project	100 per year	10 years
Design project	100 per year	10 years
Contractors	10 years	10 years

**COMMITMENTS**

- Reduce energy intensity by 100% (Office buildings)
- Reduce greenhouse gas emissions by 50% (Office buildings)
- Reduce water usage by 25% (Office buildings)
- Reduce waste by 25% (Office buildings)
- Reduce greenhouse gas emissions by 25% (Office buildings)
- Reduce water usage by 25% (Office buildings)
- Reduce waste by 25% (Office buildings)

















U.S. Department of Energy  
Energy Efficiency and Renewable Energy





U.S. Department of Energy  
Energy Efficiency and Renewable Energy





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Energy Efficiency and Renewable Energy

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