Energy and Engineering Sciences

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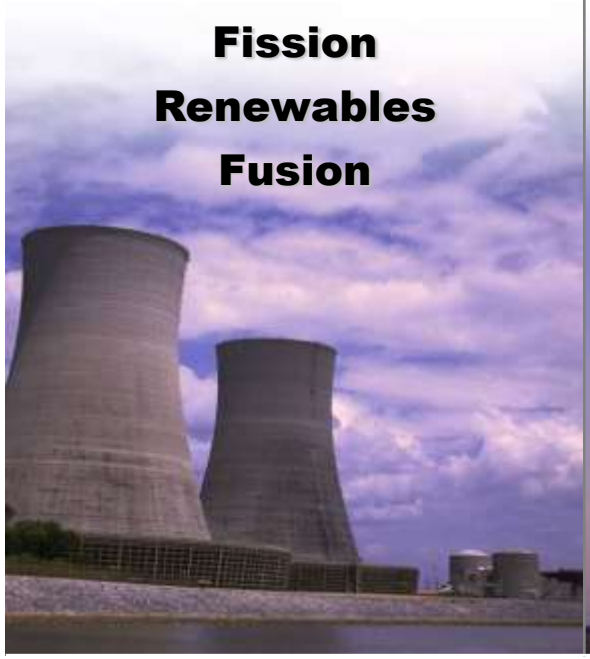
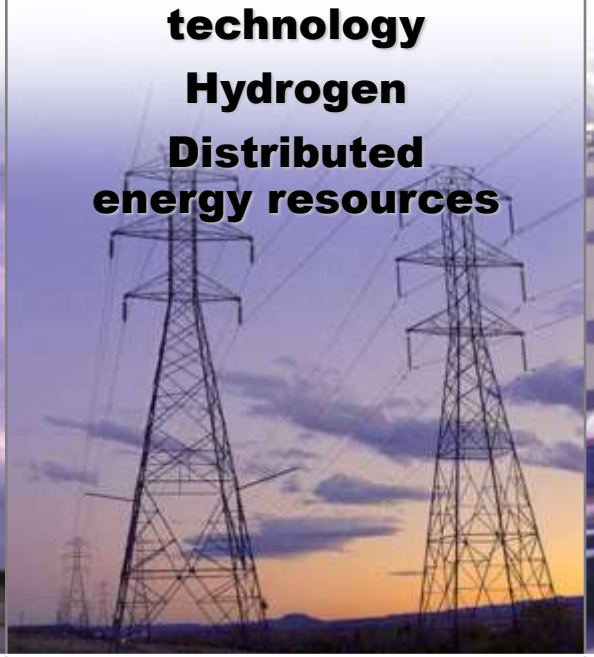
EES Energy and Engineering Sciences

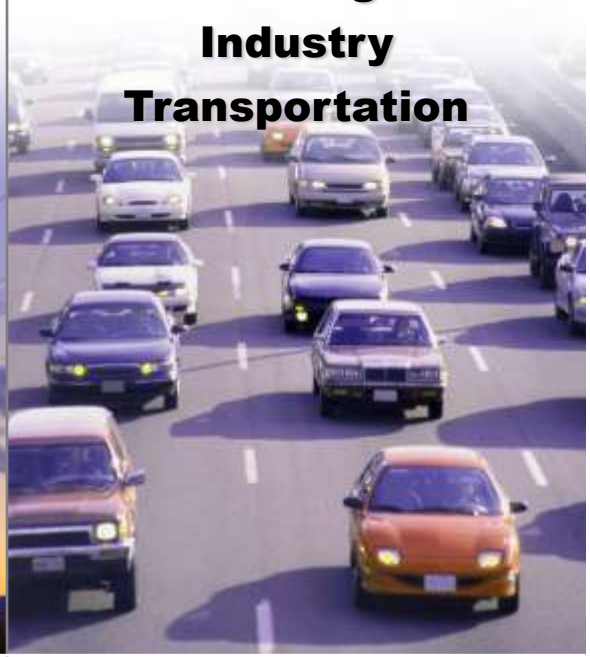
OAK RIDGE National Laboratory

Translating science and technology into energy solutions

Generation	Distribution	Consumption
Fossil Fission Renewables Fusion	Transmission technology Hydrogen Distributed energy resources	Buildings Industry Transportation







Supporting national goals for energy security and independence

ORNL's energy objective is to help provide a path so our nation has a sustainable affordable energy supply that is environmentally neutral

- Oil Independence
- Reliable secure electricity supply

ORNL's role is to develop technology to provide additional options to achieve these goals

Oil Independence really means sustainable mobility

Scientific Discovery

Modeling & Simulation

Technology Innovation

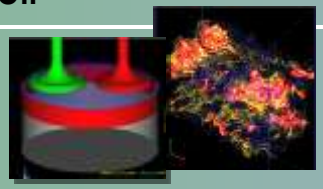
Alternative Fuel Sources

Unconventional Oil

Bio-based fuels

Electrification

Efficient Vehicle Technology

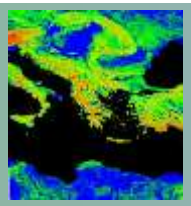


High-efficiency clean combustion

Advanced Materials

Energy recovery and management

Optimized Infrastructure



Geospatial Information Systems

Intelligent Vehicles & Infrastructure, Driver Interface

Integrated Solutions

Objectives

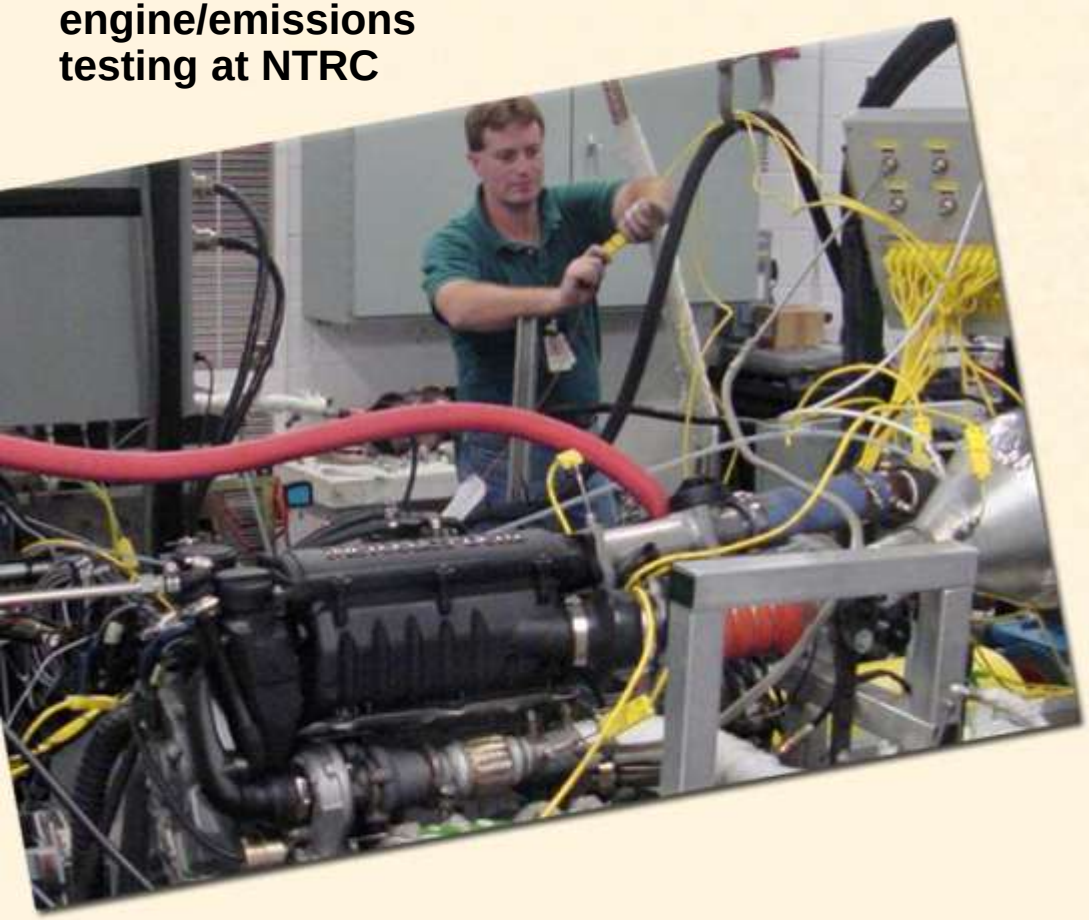
- >100 MPGe Vehicles
- Compatible with Domestic Source Fuels
- Highly Intelligent, Adaptive Vehicles & Infrastructure

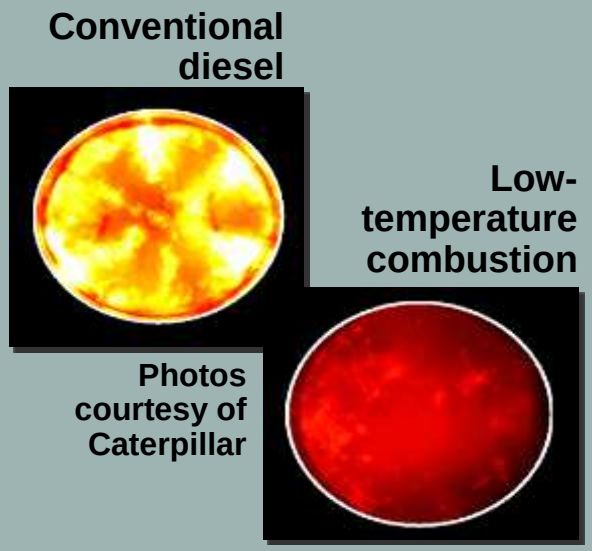
Attributes of Pathways

- Improved Mobility
- Competitive and Affordable
- Safe and Secure
- Clean and Sustainable

Developing energy-efficient, low-emissions engine technologies

Integrated fuels/ engine/emissions testing at NTRC





Demonstration of advanced combustion regime with reduced emissions

- Soot: reduced 2x
- NO_X: reduced 10x

Without fuel efficiency penalty

Lighter weight vehicles at affordable costs

Lignin Precursor

Unique Dynamic Testing Coupled with Modeling

ORNL is Advancing Composite Technologies for Automotive Applications via Internal Research and Partnerships with Others

- **Introduction of renewable feedstocks (lignin) for carbon fiber precursor**
- **Recent breakthroughs in Carbon Fiber Conversion Technologies utilizing microwaves and plasmas**
- **Advanced processing technologies via robotics and other techniques**
- **Predictive tools and streamlined approaches for design optimization and durability projection**

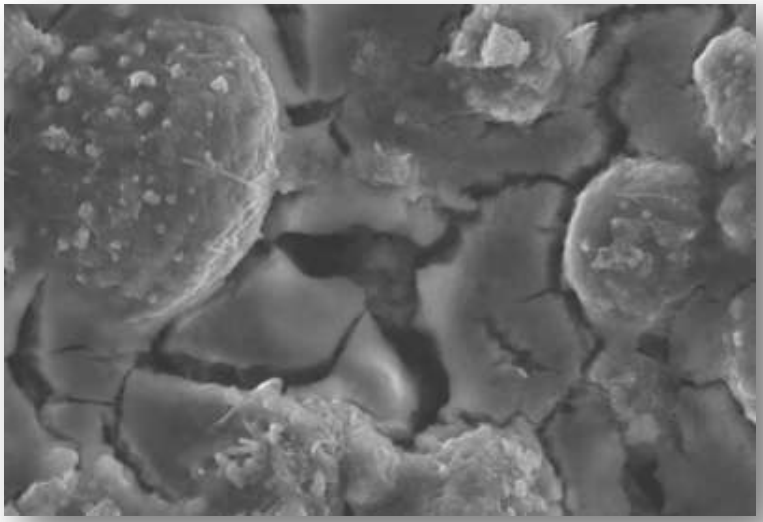
Microwave-Assisted Plasma Carbonization/Graphitization

Robotic Processes for Programmable Preforming

Energy storage solutions

- Improved safety, increased life, and reduced costs of lithium-ion batteries
- Applied materials and manufacturing
- In situ characterization
- Computational framework for evaluating safety and performance of batteries

An x-ray diffractometer is used to evaluate how battery materials change during charges and discharges



Micrograph shows cracking due to mechanical degradation of cycled carbon anodes

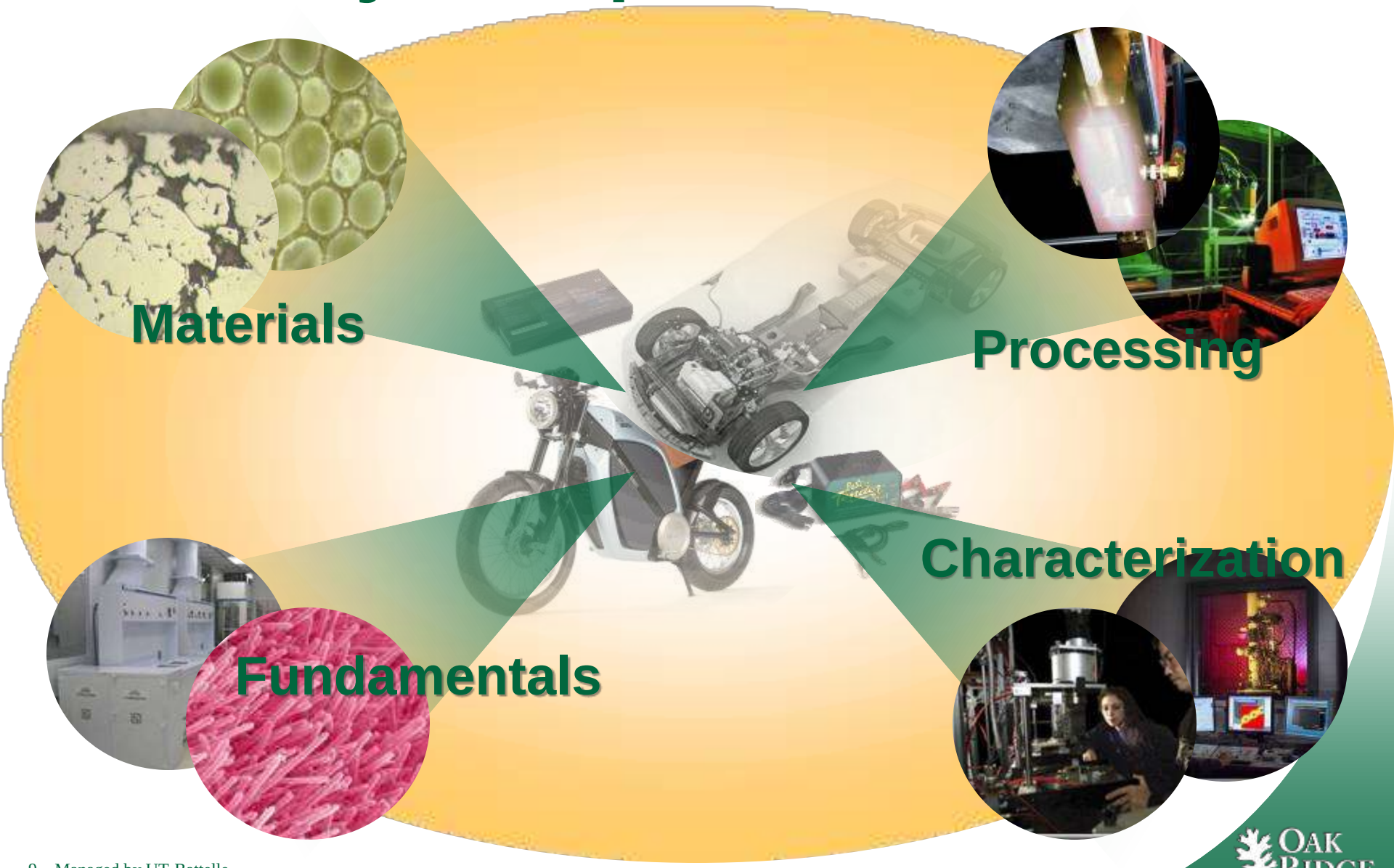
Lithium-ion battery assembly for performance testing inside a glove box

Battery breakthroughs are needed

- Cost
  - raw materials
  - materials processing
  - cell and module packaging
  - manufacturing
- Performance
  - discharge pulse power limitations at low temperatures
  - capacity and power fading
  - power and energy densities
- Abuse Tolerance / Safety
  - short circuits
  - overcharge, over-discharge
  - fire or high temperatures
  - thermal runaway
- Life
  - calendar life

DOE, Energy Storage Research and Development Annual Progress Report 2008

Materials and Processing Thrust for U.S. Battery Developers and Automakers



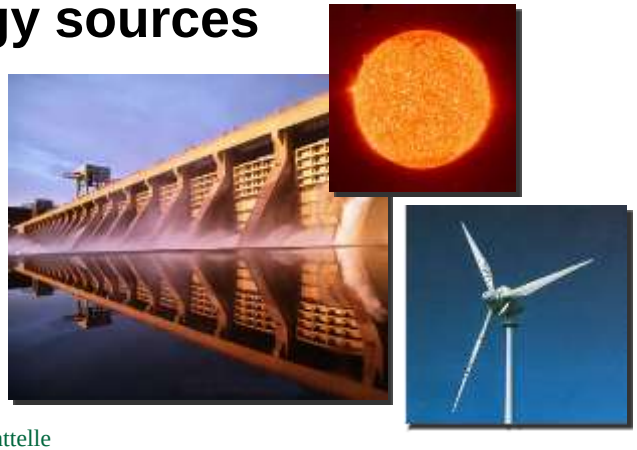
Research development and deployment can transform the electric grid

Energy storage and power electronics	Distributed systems integration	Grid visualization and controls	Smart grid technology deployment
• Transform the grid through storage and power flow control • Reliability and low cost devices are needed • Materials research will play a key role in advancing the technologies	• Deployment of distributed systems expected to double in 20 years • Voltage support from clean, distributed sources • Penetration impact and analysis needed	• Wide-area situational awareness • Real-time status of transmission lines • Energy interdependency and extreme contingency analyses needed	• Upgrading the grid to make it intelligent and interactive • Systems integration and cost benefit analyses are needed

Moving to electrical energy depends on revolutionary innovations in energy storage

Energy storage is critical to expanded use of renewable energy sources

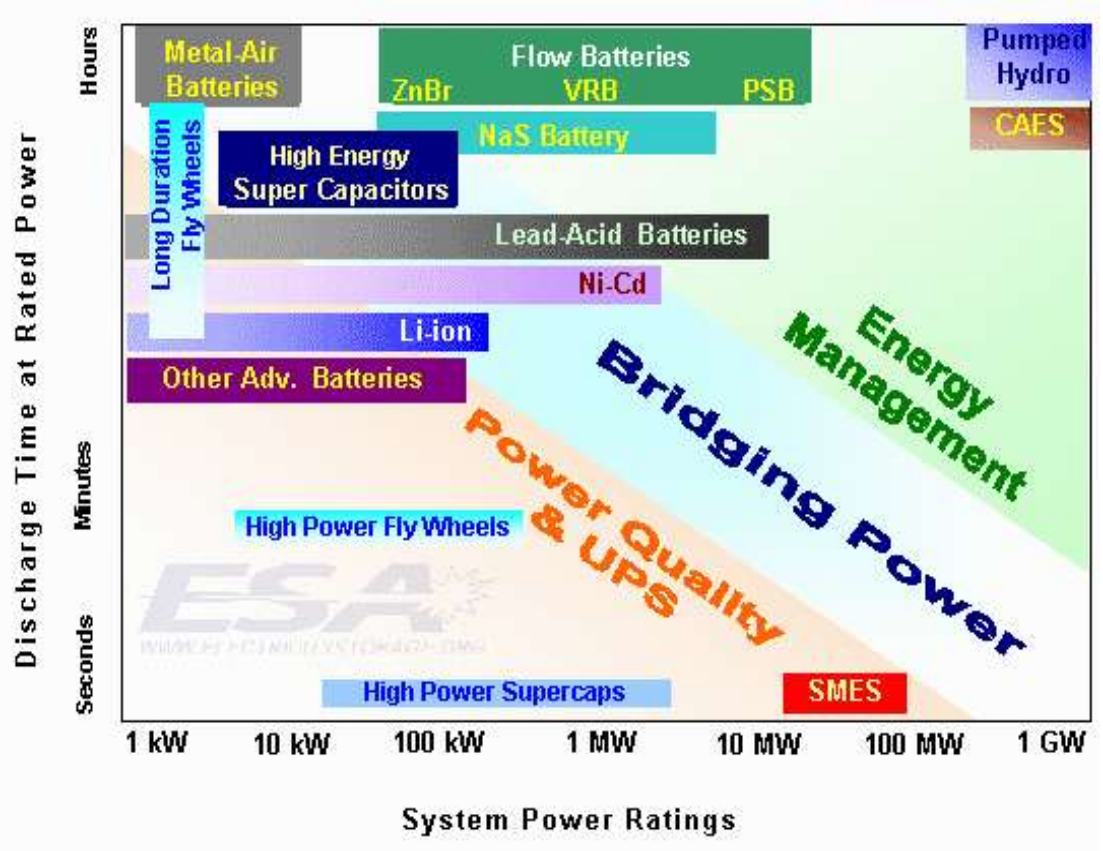
- Power quality
- Reliability
- Load leveling
- Efficient use of cyclical energy sources



Plug-in and all-electric vehicles place even greater demands on energy storage

- Higher energy and power densities
- Appropriate recharge rates
- Long life cycle
- Reliability and safety

Many energy storage technologies are needed for the different applications

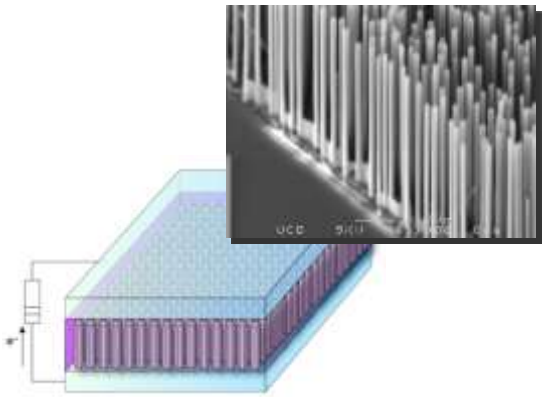


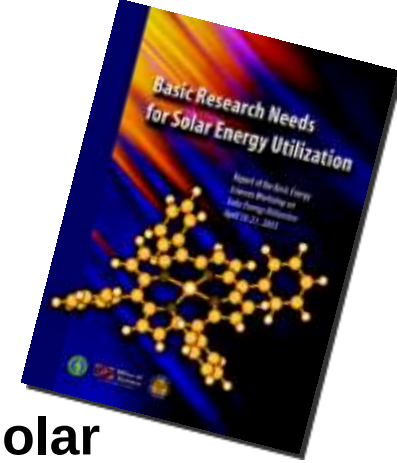
Courtesy of ESA

Revival of interest world-wide in energy storage and its applications. Not only batteries, but other techniques such as advanced flywheels and superconductivity are also attracting interest.

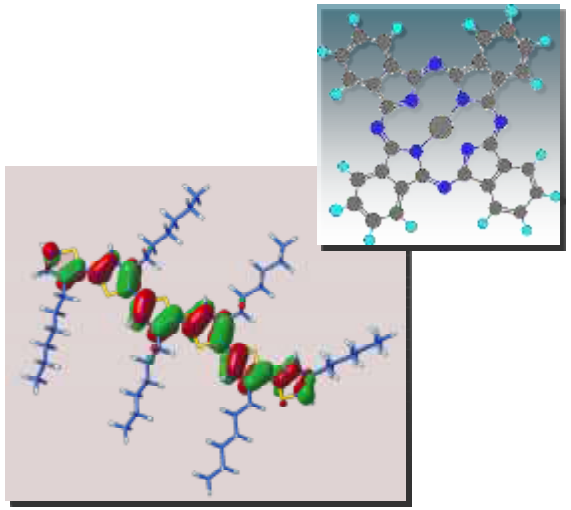
Power electronics are enabling systems for storage applications

Challenges for solar electricity





- **New materials**
  - **To harvest sunlight and channel it without losses**
  - **To take full advantage of the solar spectrum, especially red and near-IR absorbing**
  - **Higher absorption coefficients**
  - **Tailored electronic and assembly properties**



- **New processes**
  - **High-speed and large-area deposition**
  - **Multiple ultrathin layers**
  - **Complex microstructures with defect-free interfaces**
  - **Catalytic pathways: H_2O splitting, CO_2 reduction, and other energy storing reactions**

There will be a number of areas for R&D in solar technologies

Photovoltaic

- Increasing the efficiency of thin film systems
- Next generation organic and organic/inorganic hybrids
- New processing methods for current silicon and thin film PV material systems

Concentrated Solar

- Increase efficiency and reduce costs of the concentrators
- Decrease manufacturing costs and increase reliability of collectors and mirrors
- Develop thermal energy storage and heat transfer technologies

Grid Integration

- Reliability and cost of power electronics

ORNL has strong capabilities to meet the energy challenges

To be successful we also must have strong partners