Energy & Infrastructure Future

Overview

Rush Robinett

Energy &Infrastructure Future Group

Sandia National Laboratories

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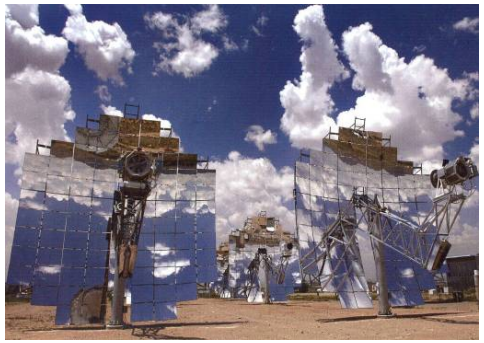
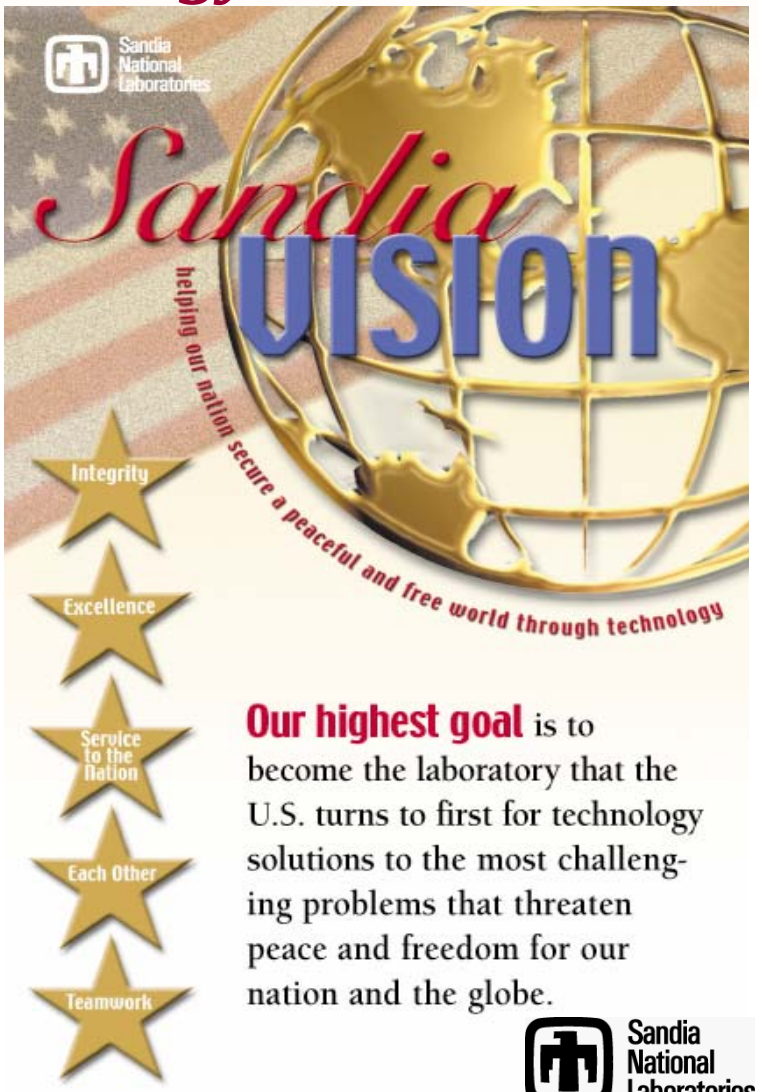
Sandia National Laboratories

Sandia's Core Purpose

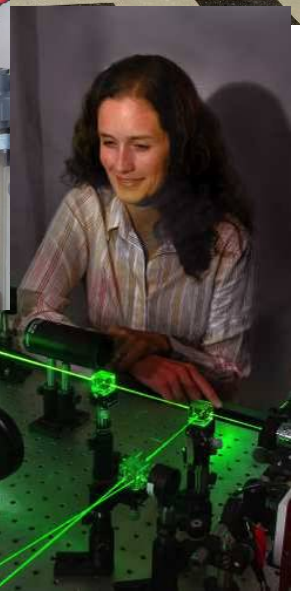
"Helping our Nation Secure a Peaceful and Free World through Technology"

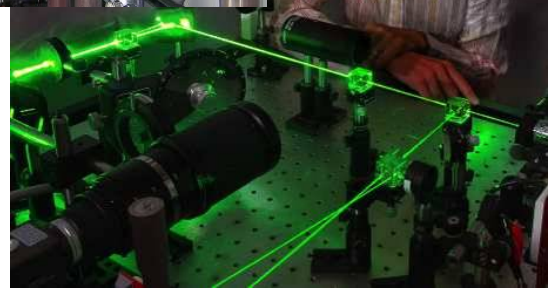
- **National Security Laboratory**
- **Broad mission in developing science and technology applications to meet our rapidly changing, complex national security challenges**
- **Safety, security and reliability of our nation's nuclear weapon stockpile**

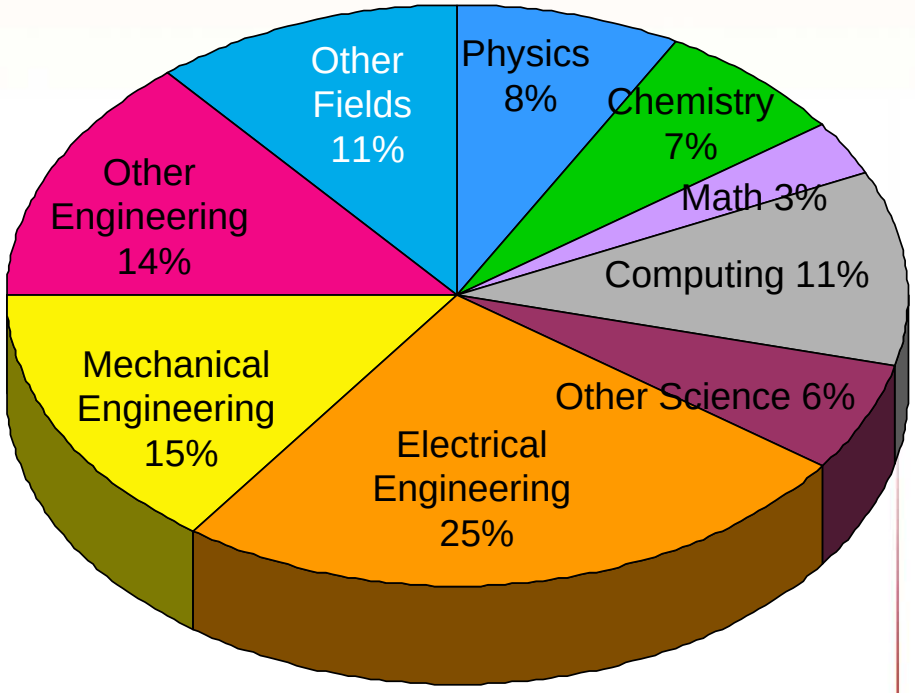




Sandia Employs More Than 8,000 Highly Skilled Workers







- **Over 8,500 employees**
- **Over 1,500 PhDs; over 2,500 MS/MA**
- **Over 700 on-site contractors**
- **$2.3 billion operating budget**

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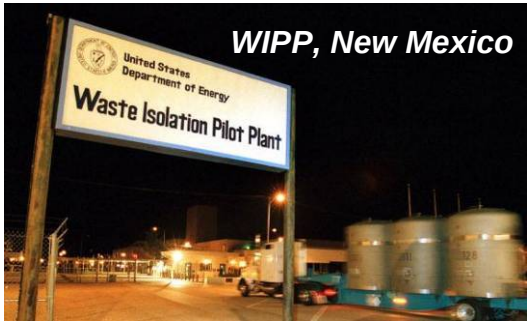
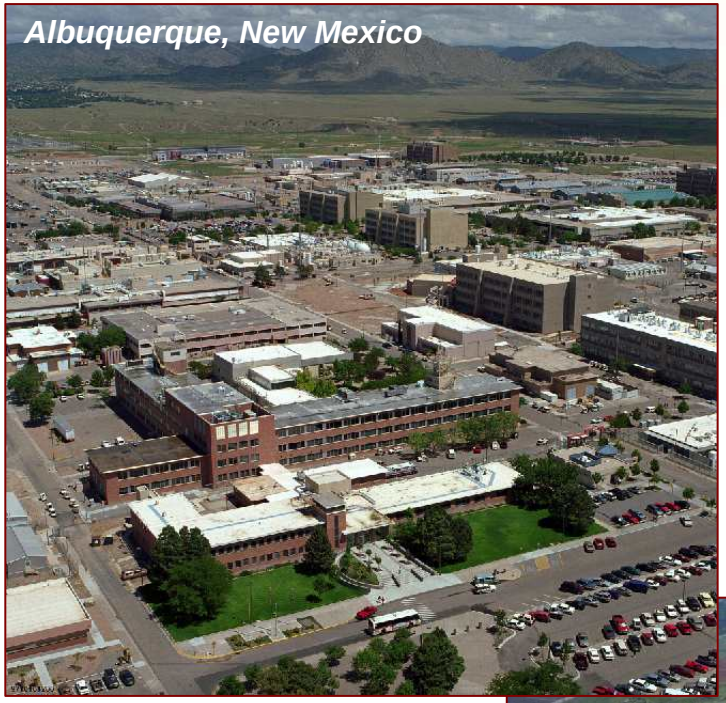
Sandia National Laboratories is Geographically Distributed

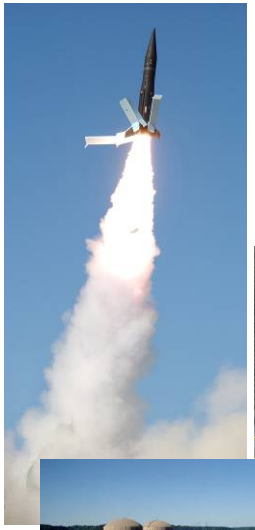


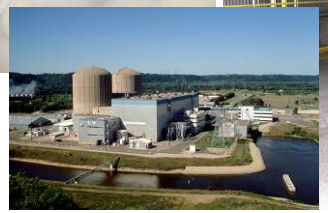


Sandia is Organized into Three Strategic Management Groups

Integrated Technologies and Systems
Three Management Units

- *Energy, Resources, and Nonproliferation*
- *Homeland Security*
- *Defense Systems & Assessments*



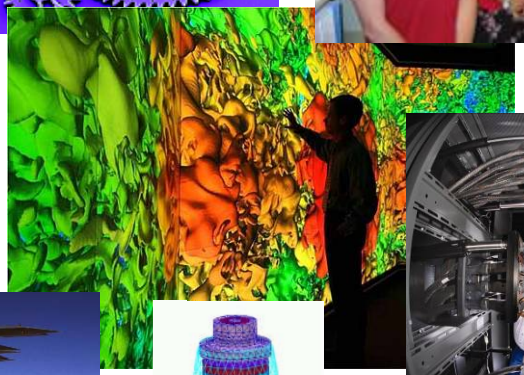
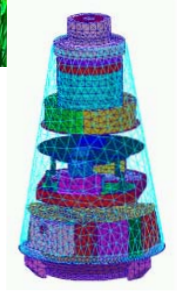
Nuclear Weapons
One Management Unit

- *Nuclear Weapons*




Laboratory Transformation
Two Management Units

- *Integrated Enabling Services*
- *Science, Technology, and Engineering*

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Energy & Infrastructure Future Group

6330
Energy & Infrastructure Future
Rush Robinett

6337
Solar Technologies
Jeff Nelson

6335
Solar Systems Department
Charlie Hanley, Acting

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Wind Energy Technology
Jose Zayas

6331
Geothermal Research
Douglas Blankenship

6336
Energy Infrastructure & DER
John Boyes

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Energy Systems Analysis
Juan Torres

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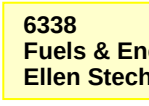
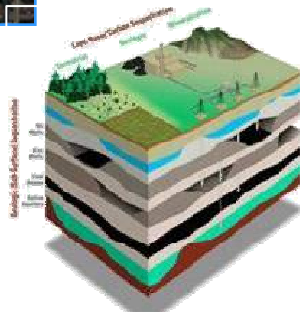
Fuels & Energy Transitions
Ellen Stechel





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Solar Technology

Technologies:

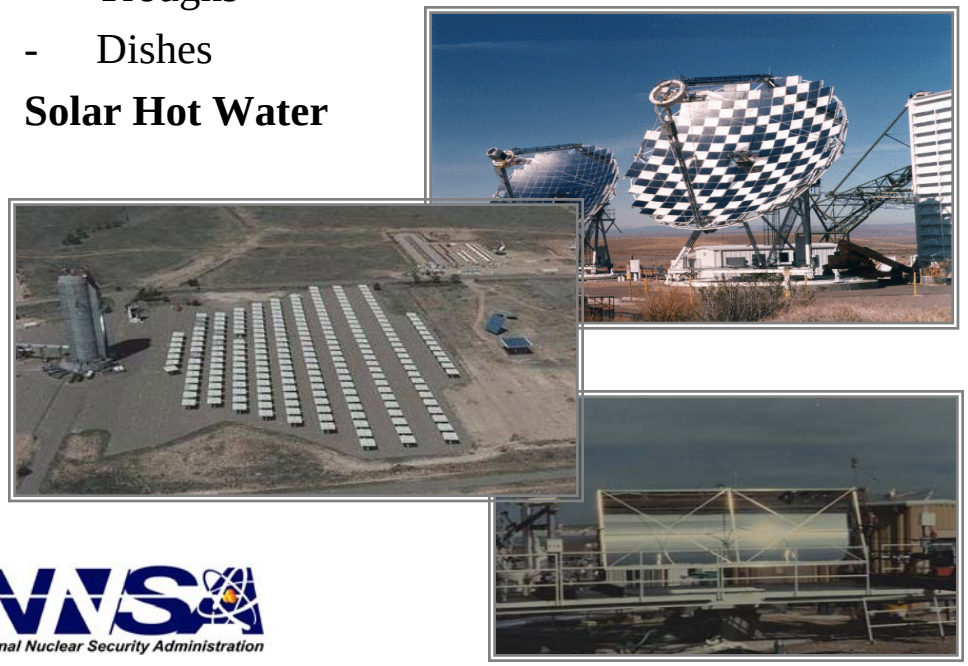
Photovoltaics

- Modules/arrays
- Inverters
- Systems

Concentrating Solar Power

- National Solar Thermal Test Facility (Tower)
- Troughs
- Dishes

Solar Hot Water



National Nuclear Security Administration

Activities:

Advanced R&D

- New systems integrations
- Hydrogen production
- New “smarts”: controls, communications, power conversion

Modeling – performance prediction

Reliability engineering

Evaluations/characterizations of new components/products

Barrier removal: codes, standards, certification, design assistance, technical support

Solar Energy Customers & Partnerships

- **Customers and Partnership Success**

PV Module & System Integrators

- Sunpower
- Powerlight
- Sharp
- Sanyo
- BP
- Global Solar
- Kyocera
- Advent
- Emcore
- Amonix
- First Solar
- United Solar

Inverters & BOS

- Xantrex
- GrennRay
- SMA
- Fronious
- General Electric
- PVPowered
- Ballard

Utilities

- Tucson Electric Power
- California Energy Commission
- Arizona Public Service
- Southern California Edison
- Pacific Gas & Electric

Concentrating Solar Power

- Acciona
- Stiling Energy Systems
- Florida Power & Light
- Boeing

Other Agencies

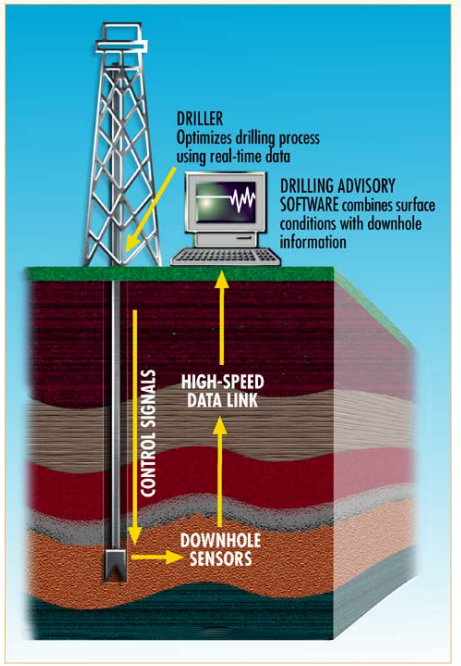
- Underwriters Laboratory (UL)
- NASA
- Airforce/DOD
- USDA-Rural Utility Service
- DARPA

*** Work with Solar industry to develop new components-systems.**
*** Develop innovative technology solutions through partnering.**
*** Perform comprehensive systems analysis-benchmarking of current and future systems (lab and field).**

Geothermal Research

Drilling and Monitoring in Harsh Environments

- **Geothermal Well Construction**
  - **High-Temperature Electronics**
  - **Diagnostics-While-Drilling**
  - **Rock Reduction Technologies**
  - **Wellbore Integrity and Lost Circulation**
  - **Drilling Dynamics Modeling and Simulation**
  - **Vibration Mitigation**



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Competencies Developed in Geothermal Program Benefit Others

- **Diverse technology impact areas from breaking rock to electronic systems that operate at 300 °C.**
- **Industry assistance and cooperation from technology transfer to "mom & pop" industries to catalyzing a $1.5B/yr PDC bit industry that today drills ~ 60% of world footage.**
- **Geothermal program competencies have strong synergies with oil & gas drilling (getting deeper and hotter), environmental drilling and remediation, unconventional fossil fuel recovery, drilling for the military, high-temperature/high-reliability electronics for the automotive/aerospace industry and more…**
- **Three R&D 100 Awards + DOE Energy 100 Award for work in PDC bits.**

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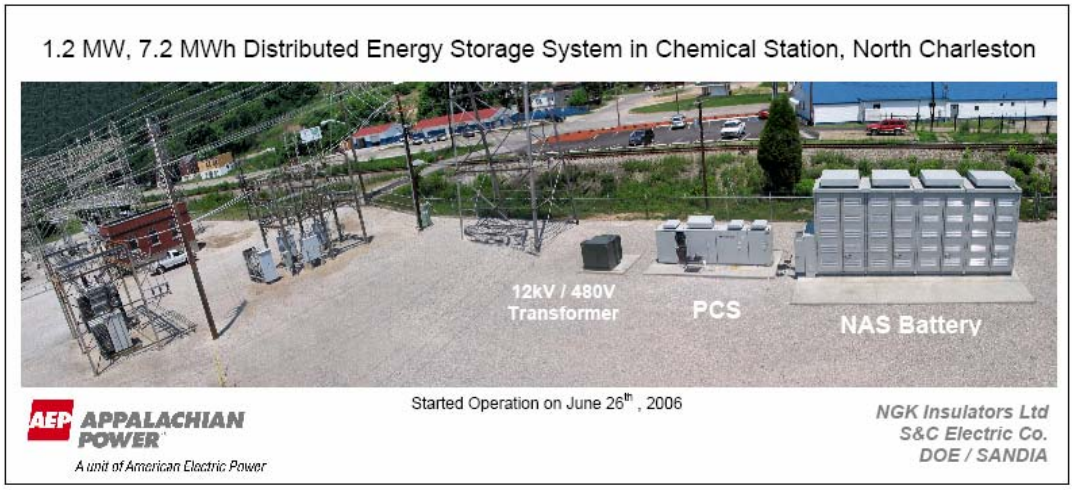
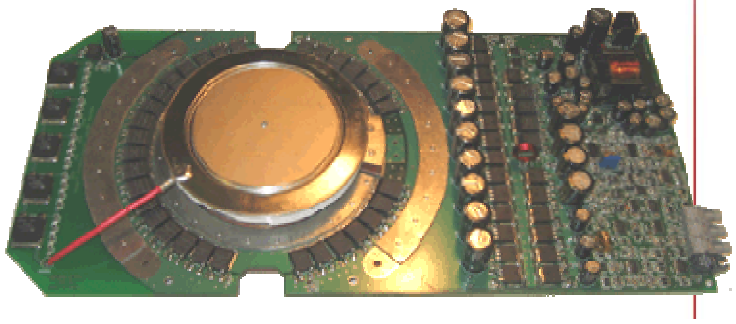
Energy Infrastructure and Distributed Energy Resources

S&C Purewave UPS System

- **Distributed energy resources**
- **Power electronics**
  - New base program in FY08
- **Energy storage**
- **Energy Surety Microgrid**



Application of Energy Storage



R&D 100: ETO High Power Switch

Energy Storage and Surety Microgrid Customers

- **Current Customers/Partners**
  - US DOE Office of Electricity
  - US Coast Guard
  - US Army Civil Engineering Construction Laboratory
  - Kauai Island Utility Co-Op
- **Past Partnership Success**
  - S&C Electric Co. Purewave UPS
  - GNB Absolyte II VRLA Battery

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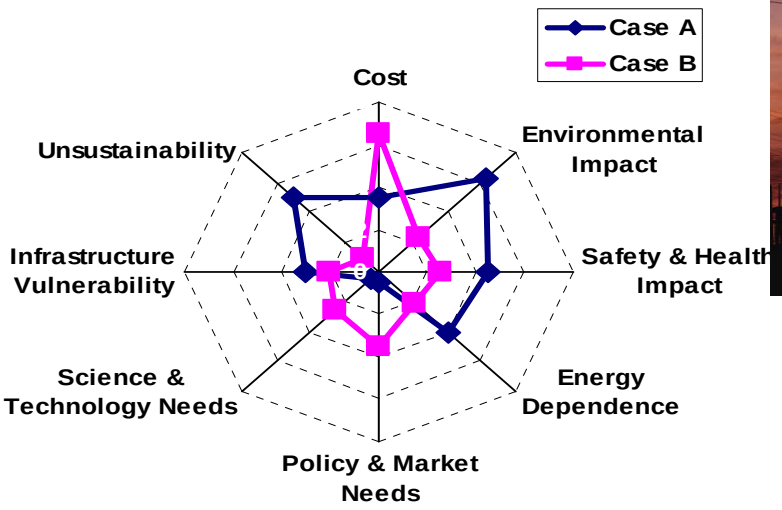
Energy Systems Analysis

- **Competencies:**
  - **Power grid (generation, transmission, distribution) operations, modeling**
  - **Energy transport security (pipelines, power grid, marine, railways)**
  - **SCADA and control systems analysis and security**
  - **Energy system vulnerability, safety, and risk assessment**
  - **Energy system modeling and simulation**
  - **Energy systems analysis**
  - **Energy-Water Nexus issues**



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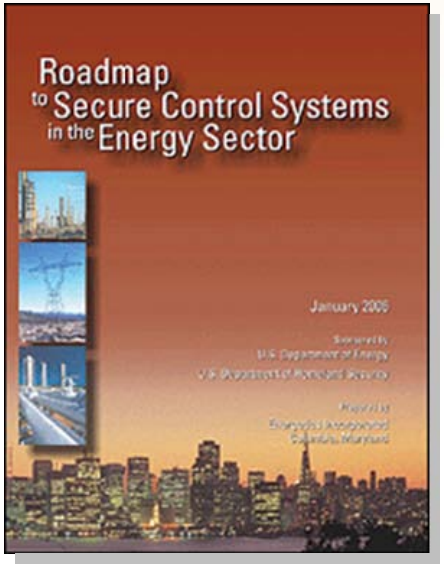
SCADA Security Program
Industry Customers & Partnerships

- **Current and Former Customers**
  - Southern California Edison (Power Grid Assessment)
  - Detroit Edison (Power Grid Assessment)
  - California ISO

- **Partnership Success**
  - ABB (Product Security)
  - Chevron (Pipeline Security)
  - American Gas Association (Standards)
  - Gas Technology Institute (Standards)
  - American Petroleum Institute (Standards)
  - Cisco (Product Security)
  - Williams Natural Gas Pipelines (Pipeline Security)
  - Numerous cyber security vendors



- **Industry-driven synthesis of public and private sector input**
- **Identifies energy sector's most critical control system security challenges and R&D needs**
- **Provides strategic framework to align public-private investments timely and efficient manner**

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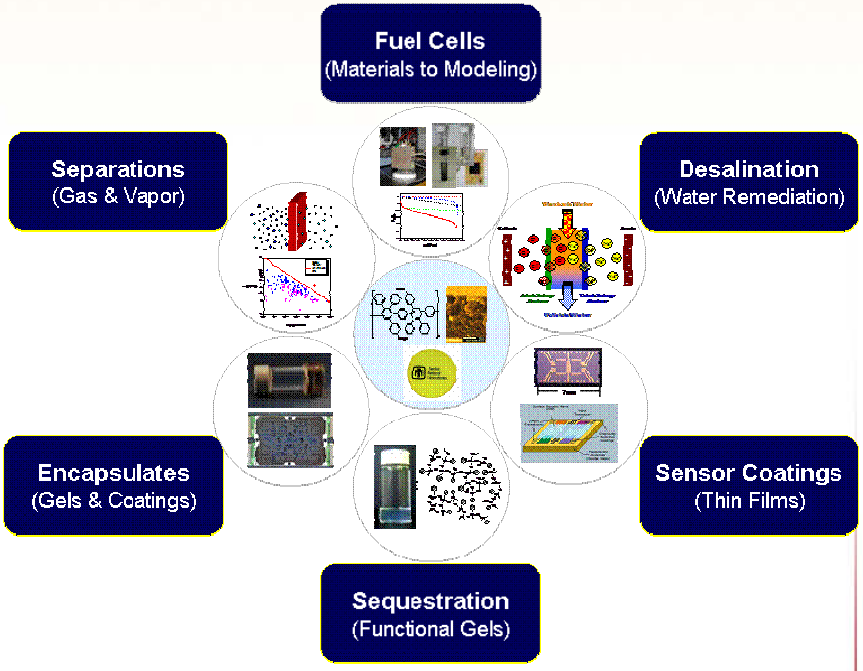
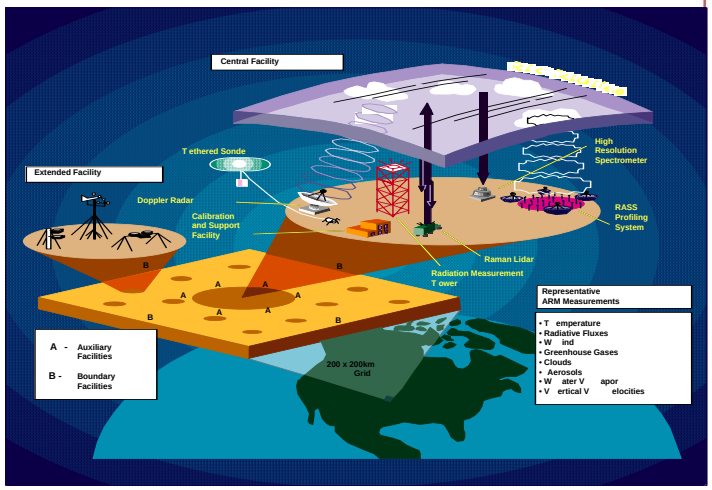
The Fuels & Energy Transitions

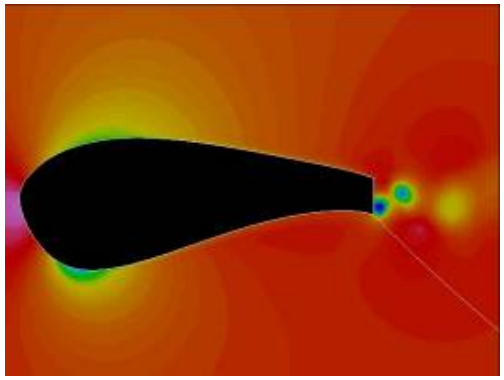
- **Materials Membranes & Coatings**
  - **Synthesis & Characterization**
    - Inorganic
      - **Ceramics, Glasses, Metals**
    - Organics
      - **Synthetic & Natural Polymers**
    - Hybrids
    - Nanomaterials
  - **Wide Range of Applications**
- **Assembly & Testing**
  - **Fuel Cells**
    - System Level including Modeling
  - **Desalination**
- **Atmospheric Radiation Monitoring**
  - **DOE Facility on the North Slope of Alaska**

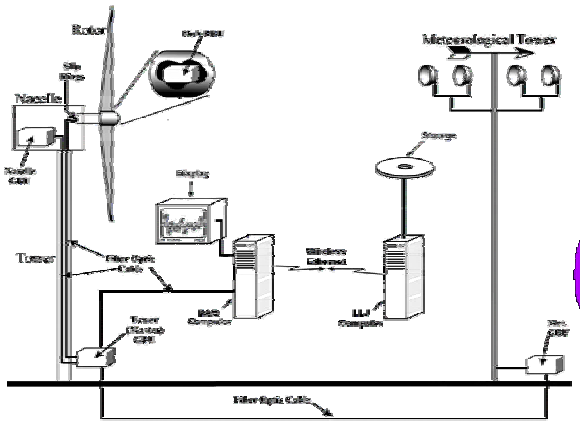


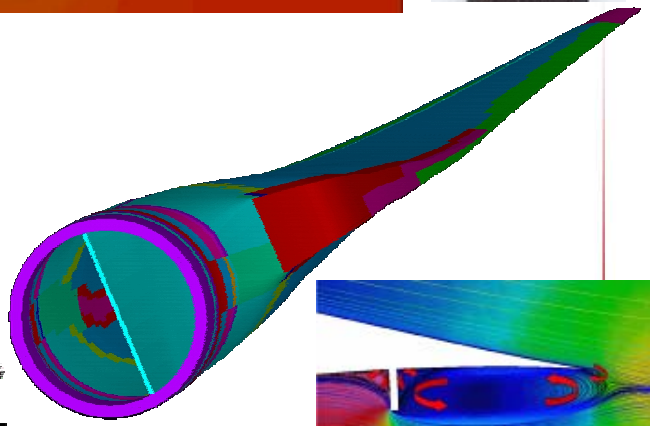


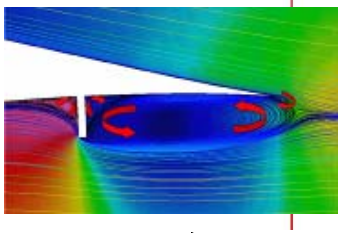
Wind Energy Technology

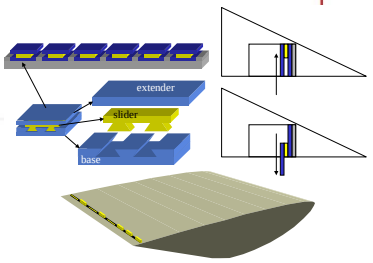
- **Blade Technology**
  - **Materials and Manufacturing**
  - **Structural, Aerodynamic, and Full System Modeling**
  - **Lab - Field Testing and Data Acquisition**
  - **Sensors and Structural Health Monitoring**
  - **Advanced Blade Concepts**
- **System Reliability**
  - **Industry Data Collection**
  - **Improve reliability of the existing technology and future designs**





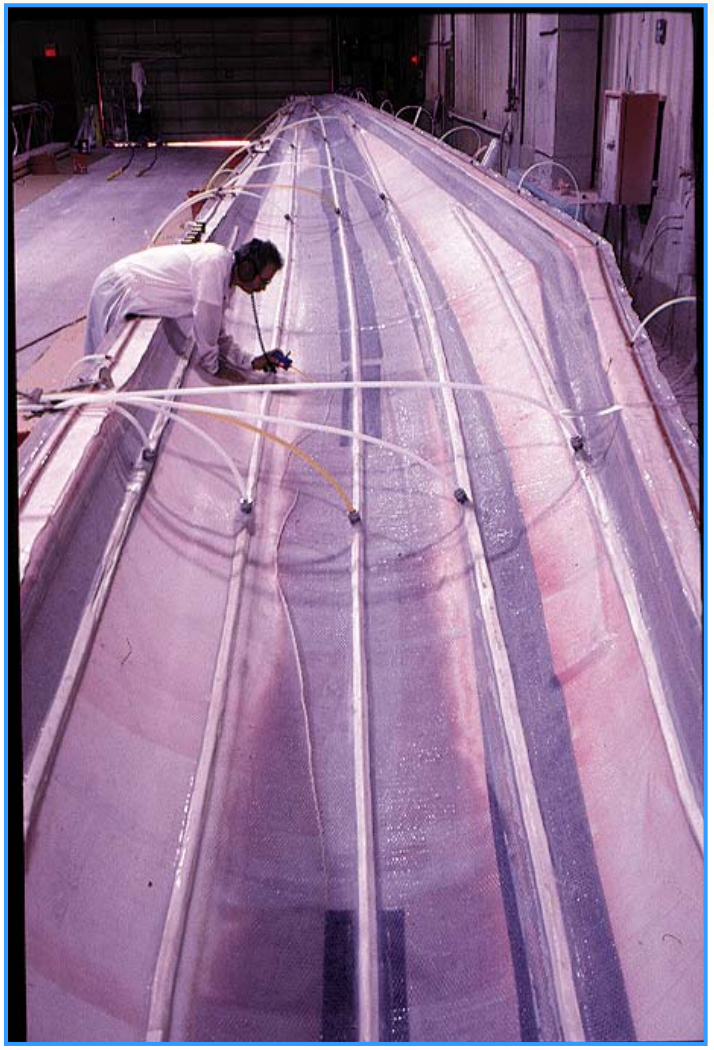






Wind Energy Customers & Partnerships

- **Current Customers**
  - Texas Tech (DAS & Field Testing)
  - 3TEX (Field testing)
  - Aither (Sensors)
  - NASA (Sensors)
  - Acellent (Sensors)
  - Owens Corning (Materials)
  - Clipper Wind (Manufacturer)
- **Past Partnership Success**
  - TPI Composites
    - TPI and Mitsubishi have a joint venture – Vienteck in Juarez, Mexico
    - Manufacturing blades for 1-2 MW Mitsubishi machines
    - 40m long blade now being tested
    - TPI patented SCRIMP® technology



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Energy Surety Microgrids

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Elements of Energy Surety

Energy System is:

	If it:
Safe	Safely supplies energy to end user
Secure	Maintains power in a malevolent environment
Reliable	Maintains power when and where needed
Sustainable	It can be maintained indefinitely
Cost Effective	Produces energy at lowest predictable cost

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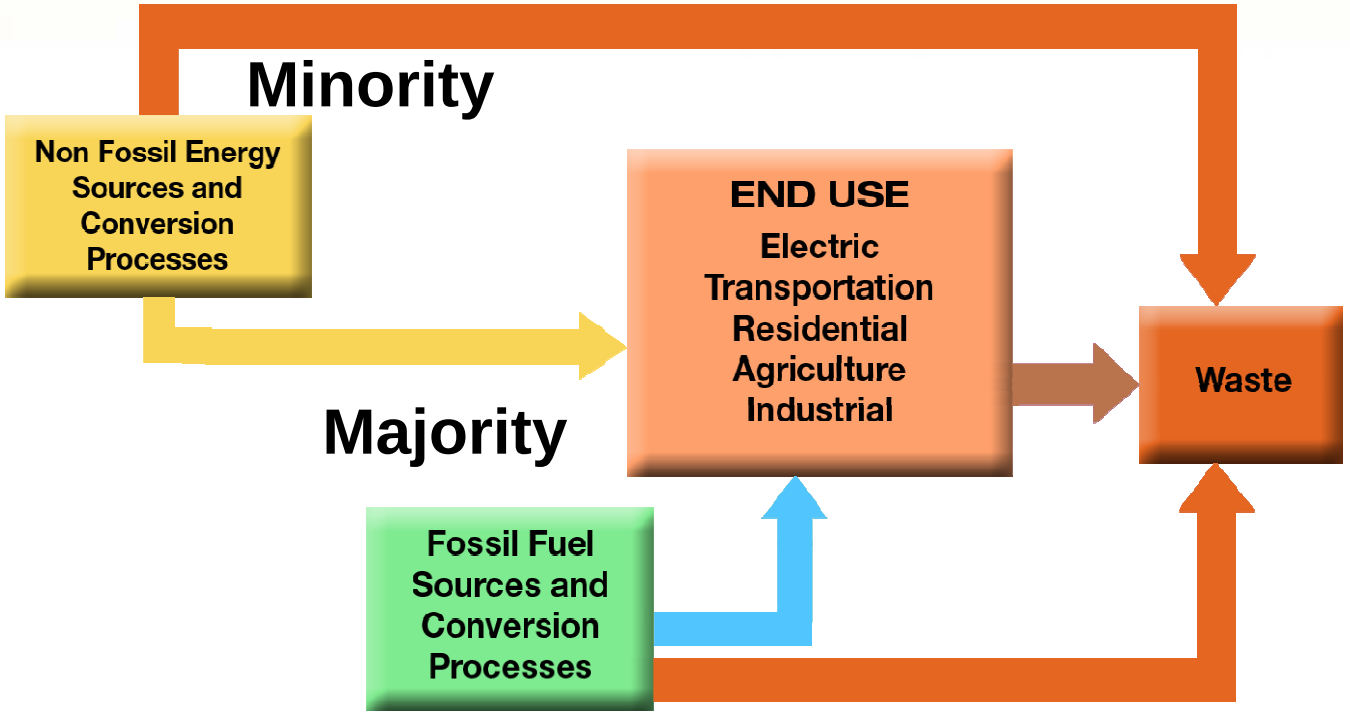
The Current Energy System is Full of Losses, an Open Cycle, and Highly Vulnerable

- Fossil Fuel dominated infrastructure.
- Over 50% of US energy resources lost in conversion and transport.
- Diversity of energy resources difficult to accommodate.
- Reliance on nature to absorb waste by-products.
- Infrastructure capacity, flexibility, and reliability is limited.
- Resource competition with India and China.
- Unpredictable and volatile energy prices.



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Military and Civilian Energy Interruptions can Have Catastrophic Impacts

Military
Energy Interruption

- **Ft. Huachuca, AZ, served by two feeders**
- **May 2002 fire takes out both feeders**
- **Base down for 16 hours**
  - ***Est. cost $3M***
  - ***Loss of mission capability***

Civilian
Energy Interruption

- **Philips Semiconductor, Albuquerque, NM, served by two feeders**
- **Fire takes out both feeders**
- **Chip fab shuts down for 3 months**
  - ***Company loses important customers***
  - ***Plant shuts down permanently***

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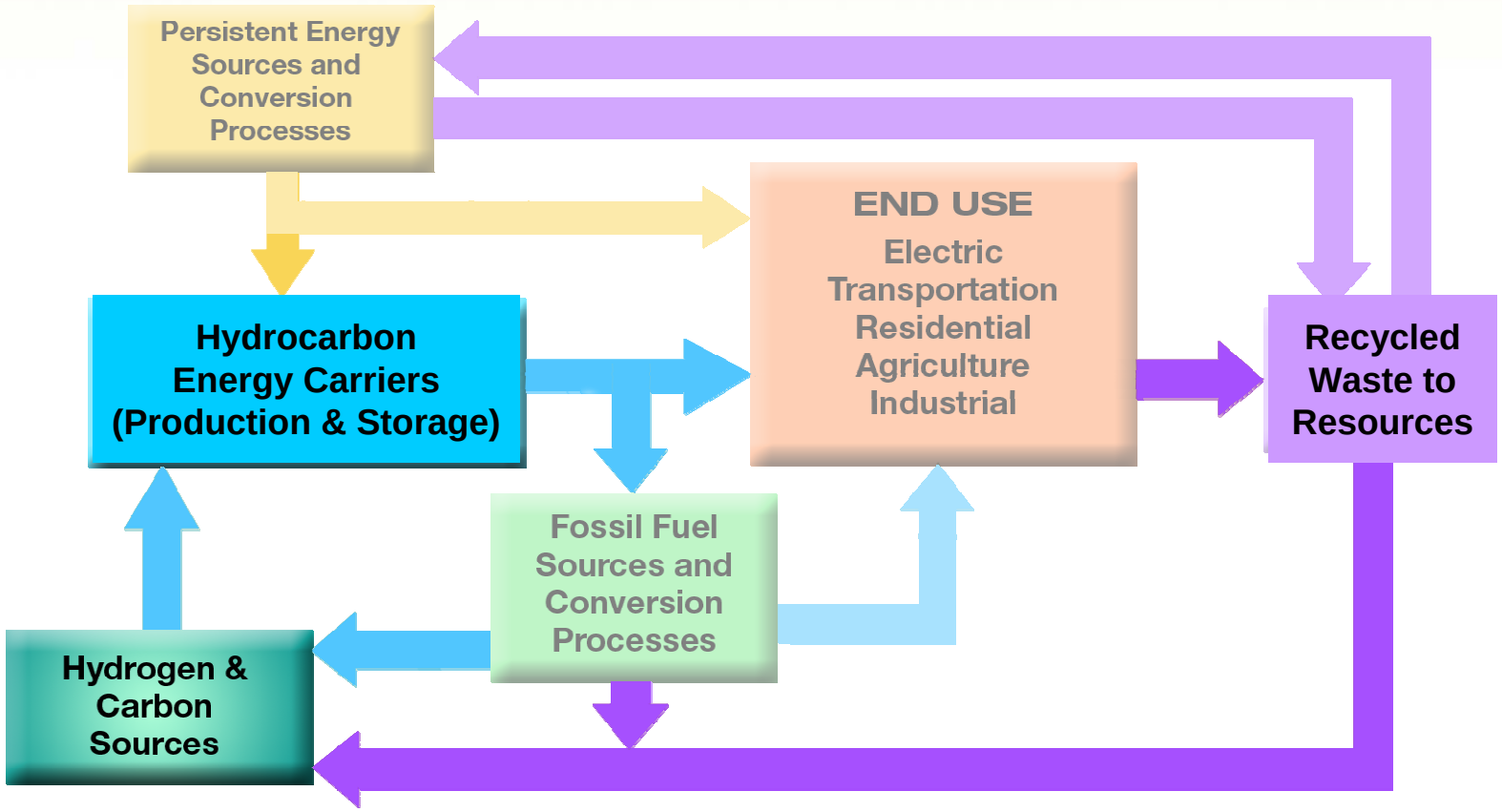
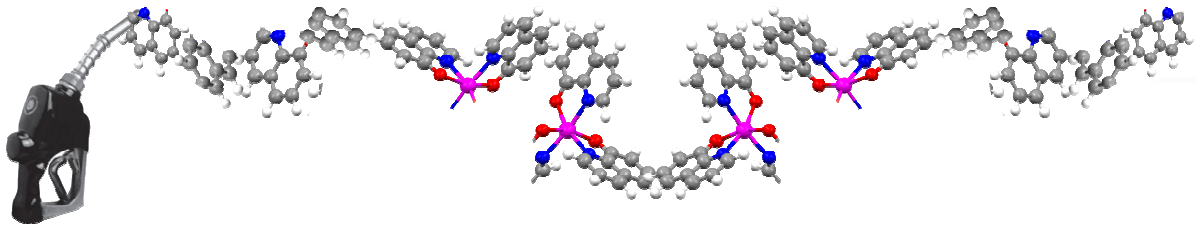
A Flexible, Adaptive Energy Infrastructure, with a Hydrocarbon "Core" Offers a Path Forward





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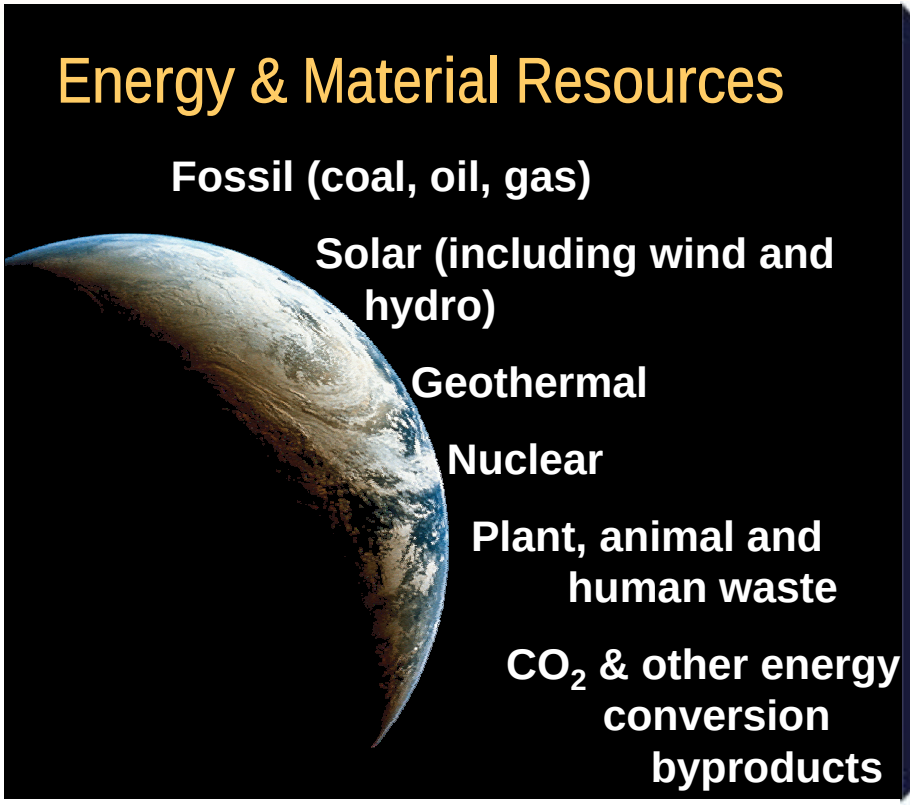
Energy Challenge - Harvest, Transform, and Control Delivery of Available Energy



Energy Processing

Harvest, transform, and deliver exergy* at the necessary amount and rate.

Energy Needs or Services

- Electricity
- Fuel
- Heat
- Cooling
- Chemicals (such as lubricants)
- Clean Water

*EXERGY = AVAILABLE ENERGY = useful portion of energy that allows one to do work and perform energy services

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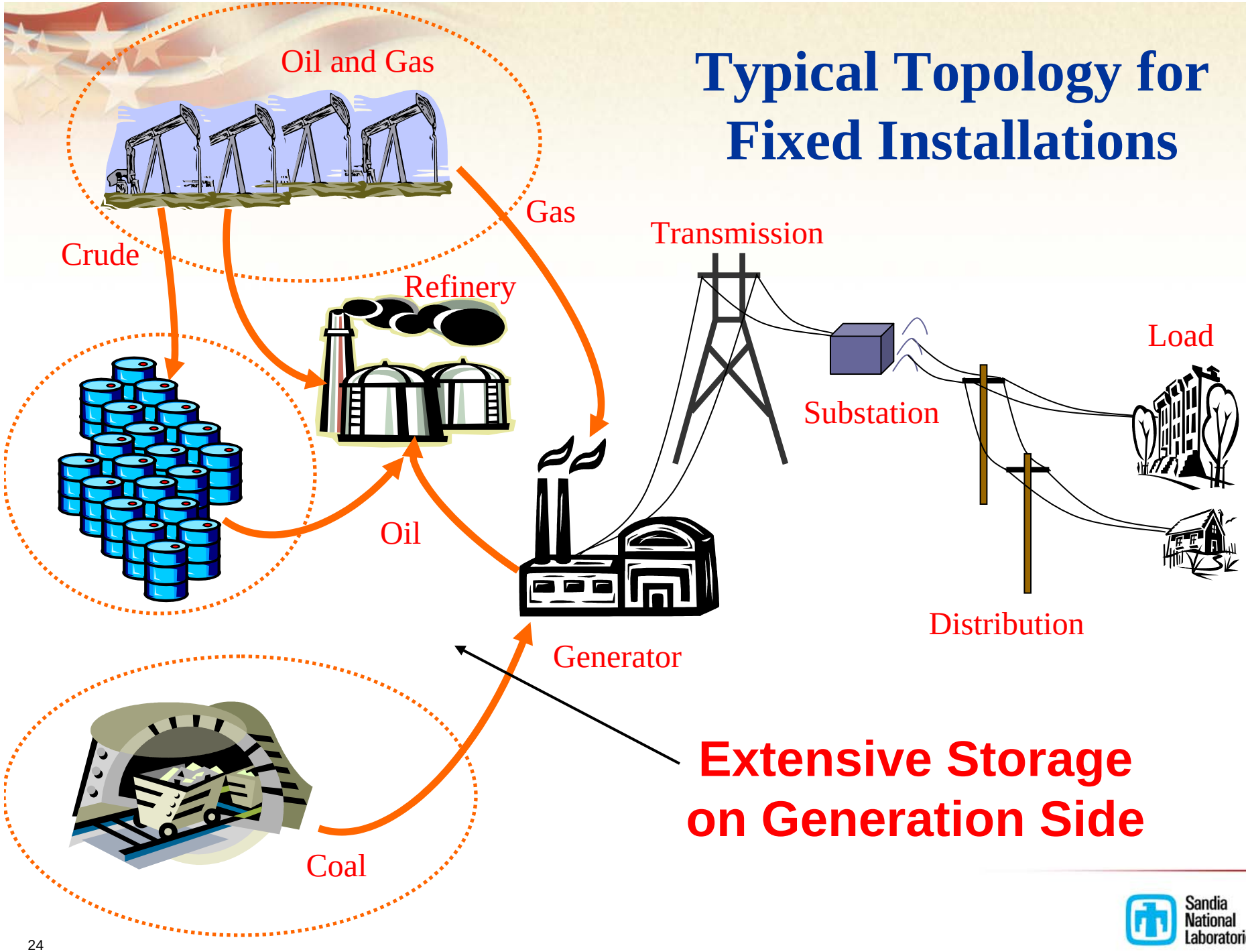
Typical Topology for Fixed Installations



Extensive Storage on Generation Side

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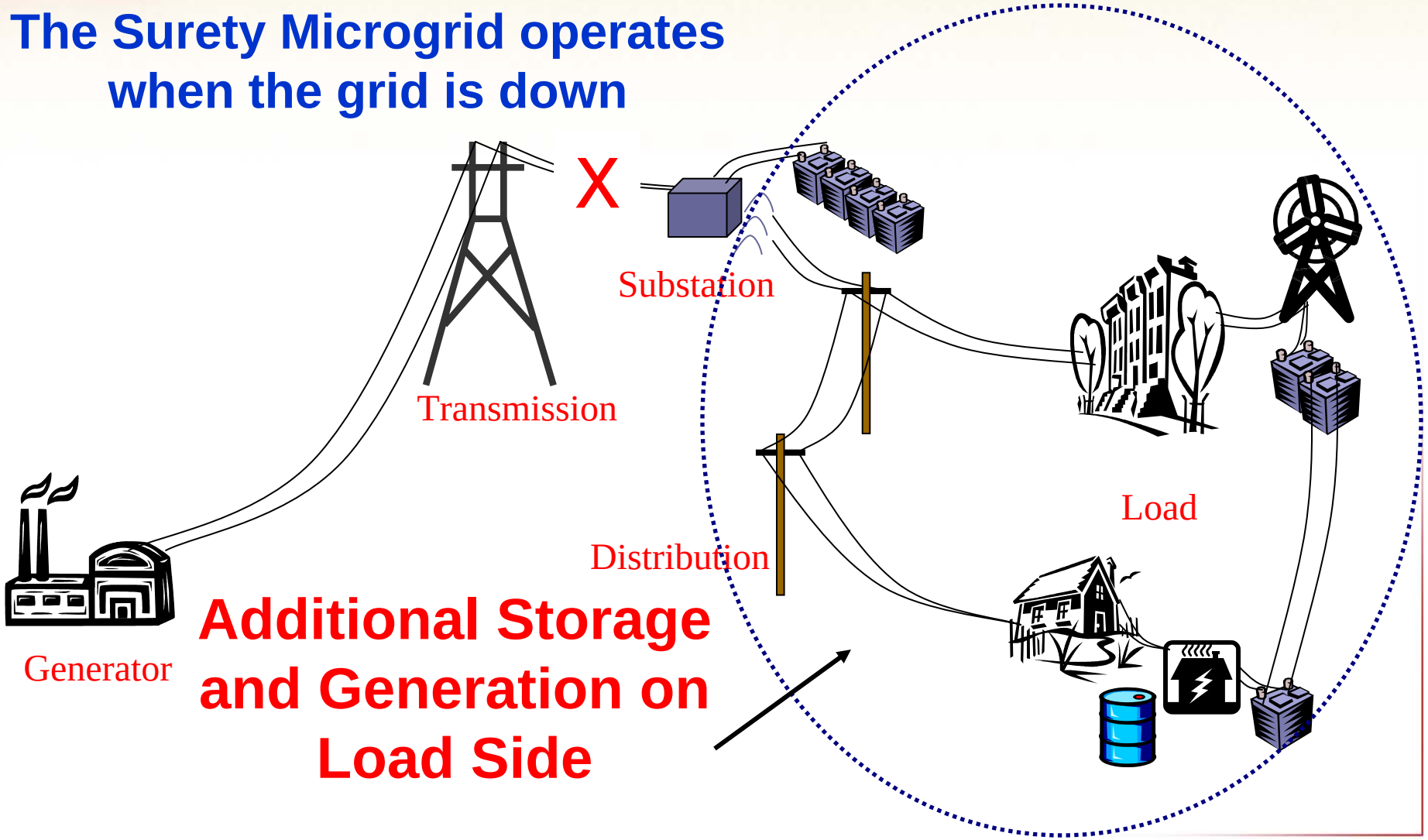
Emergence of a Surety Grid

The Surety Microgrid operates when the grid is down



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Why Sandia?

- **Sandia has conducted two power grid studies for Kauai Utility; we are therefore familiar with the Kauai power grid. The studies were focused on the use of energy storage to improve grid stability.**
- **Extensive experience and expertise with distributed generation and microgrids.**
- **Manage the energy storage program for DOE OE.**
- **Will co-lead the new power electronics program for DOE in FY08.**
- **Co-lead for National SCADA Test Bed under DOE OE.**
- **Developed the Energy Surety Microgrid concept.**

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The Distributed Energy Technology Laboratory

Grid

Center for Control System Security

480V Microgrid

Various Loads

Other Remote DER sites

Distributed Energy Resources

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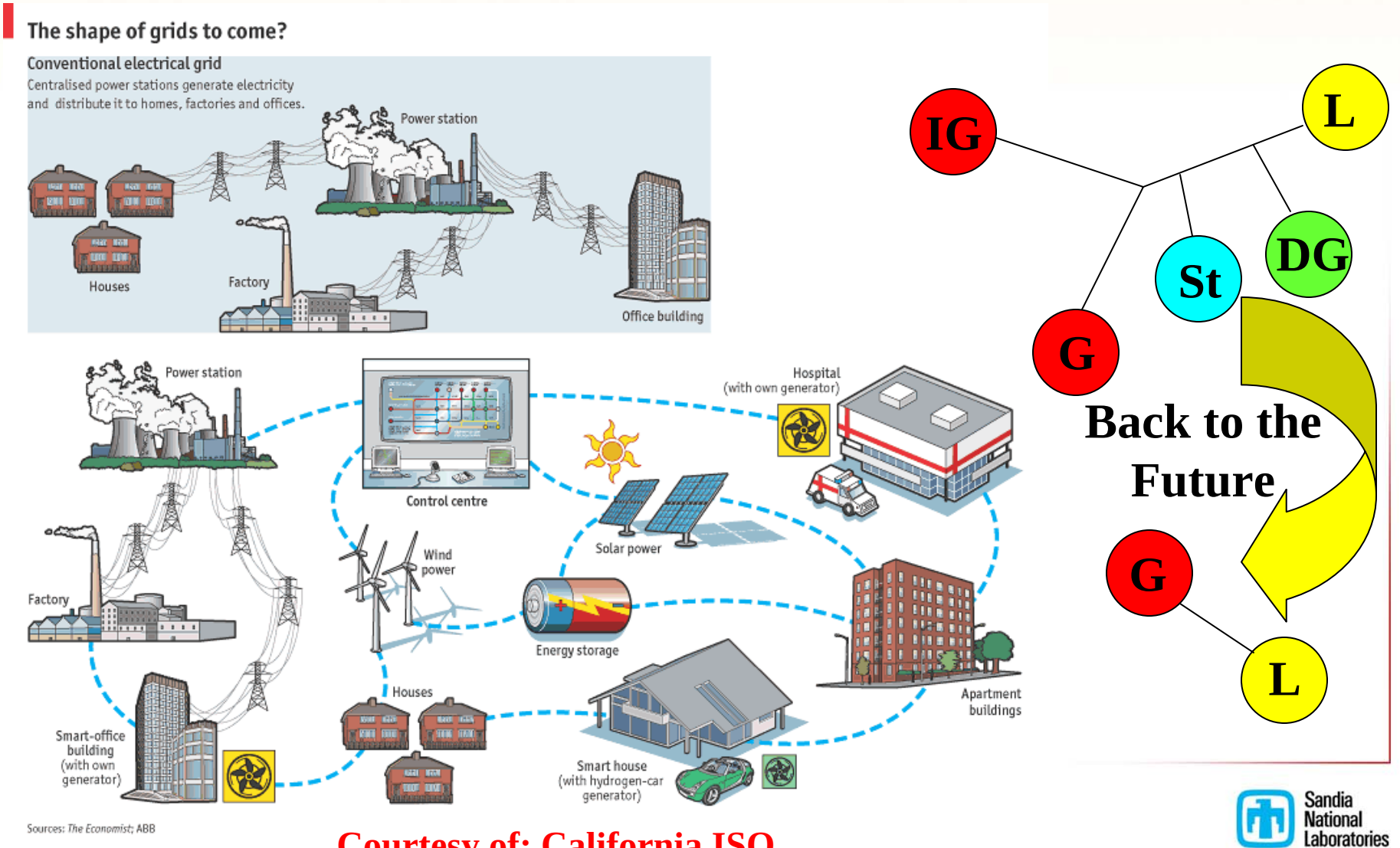
Potential Future Energy Grid



Courtesy of: California ISO

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