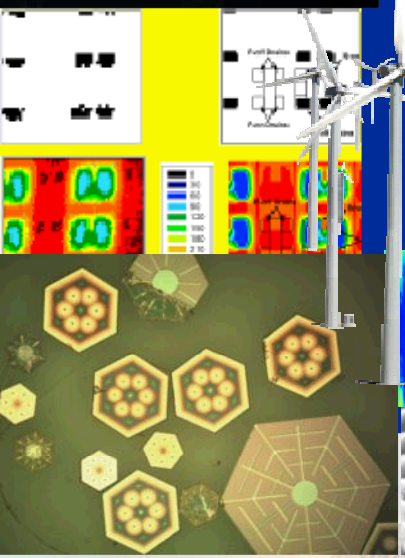
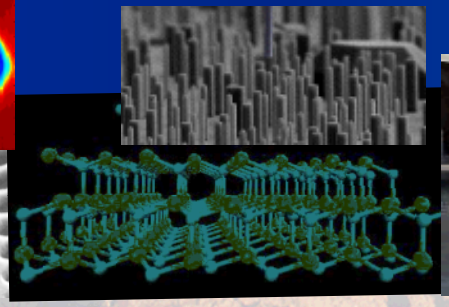
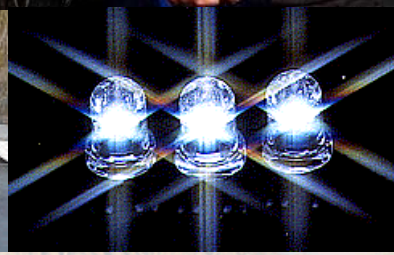
SAND2010-7671P

Sandia National Laboratories

Science and Technology Overview



Dr. Jeffrey S. Nelson, Co-Director
Center For Integrated Nanotechnologies
jsnelso@sandia.gov

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

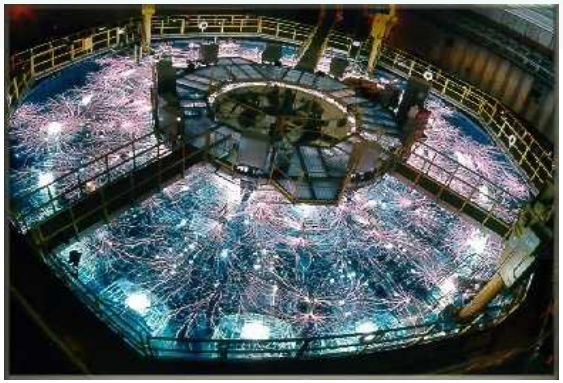
Four National Security Missions for Sandia

Nuclear Weapons	Defense Systems & Assessments	Energy, Climate, & Infrastructure Security	International, Homeland, & Nuclear Security

Science, Technology, and Engineering

Mission Driven Capability Base

Strategic Capabilities

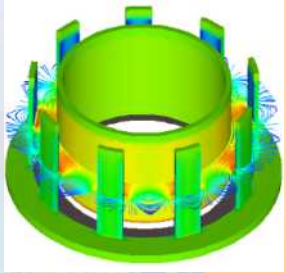


High Performance Computing & Simulation

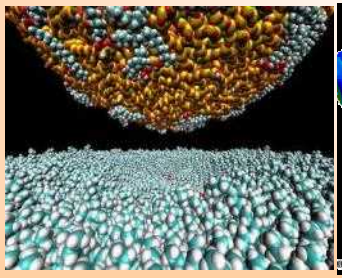
Nanotechnologies and Microsystems

Extreme Environments

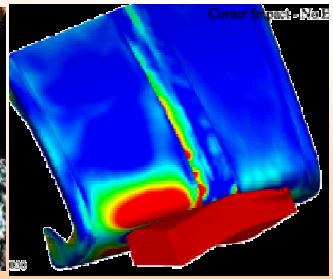
Computer Science



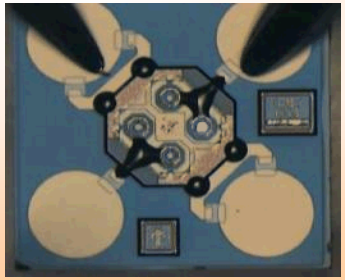
Materials



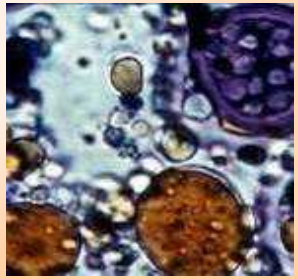
Engineering Sciences



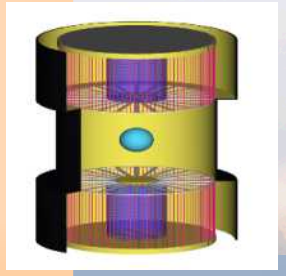
Micro Systems



Bioscience



Pulsed Power



Research Foundations

The Innovation Corridor

Computational Science Research Institute

Ion Beam Laboratory

MESA MicroLab Facility

Integrated Materials Research Laboratory

Center for Integrated Nanotechnologies

MESA Fabrication Facility

Red Storm HPC Facility

Joint Computation and Engineering Laboratory

MESA Weapons Integration Facility

We use our Users Facilities extensively to engage researchers internationally

Center for Integrated Nanotechnologies (CINT):

- Provides access to tools and expertise for the research of nanoscience integration
  - 162 user's projects in FY08
  - Current number of users > 200
  - 50% of the users are foreign nationals

Combustion Research Facility (CRF):

- Worldwide recognized R&D facility for combustion chemistry and turbulent flame research
- Develop applied science supporting industry

Computer Science Research Institute (CSRI):

- On-site joint research in computer science, computational science and mathematics
  - 48% of visitors are foreign nationals

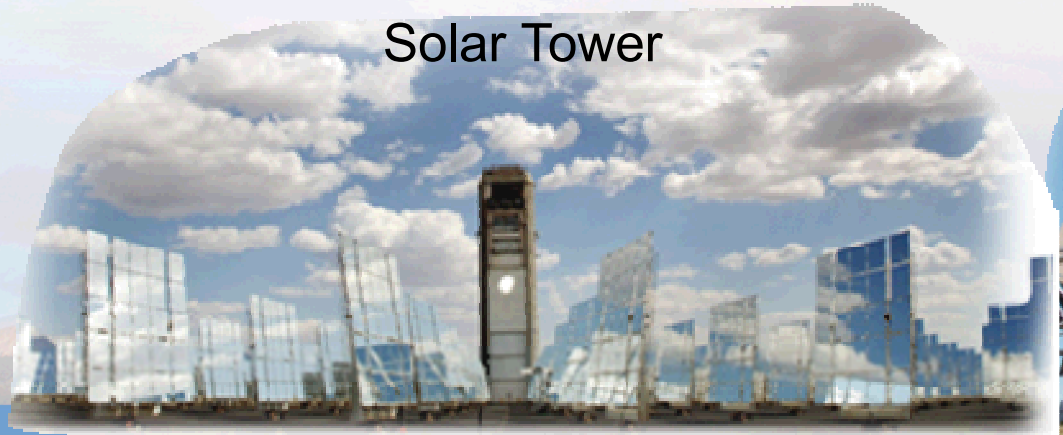
Sandia National Laboratories

National Solar Thermal Test Facility

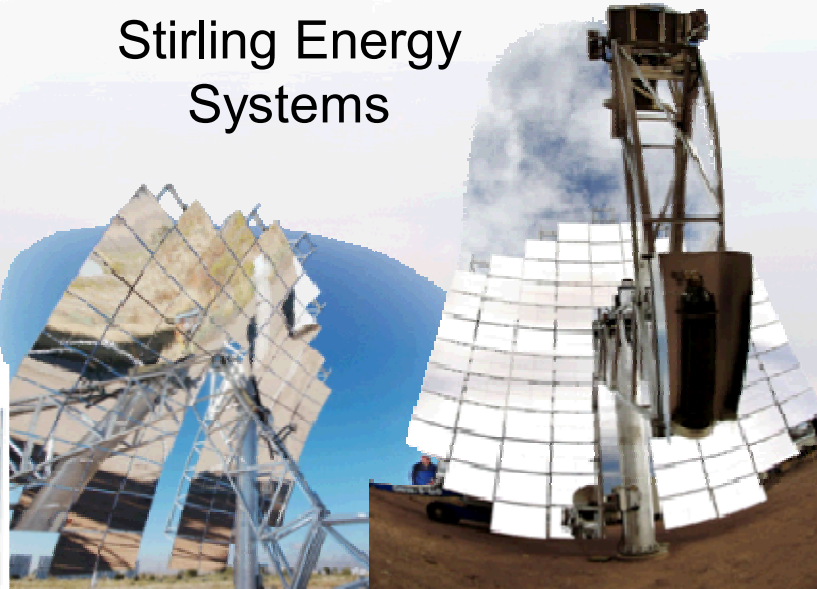
Photovoltaics

Solar Trough

Stirling Energy Systems



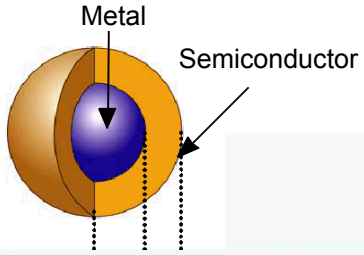
Solar Tower



Center for Integrated NanoTechnology

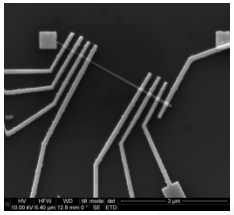
Assembling diverse nanoscale materials across length scales to design and achieve new properties and functionality.

Bifunctional materials



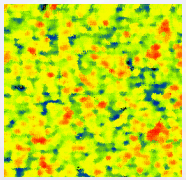
Combining ferromagnetic & semiconducting behavior

Fabrication & Assembly

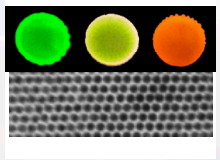


Nanowire devices

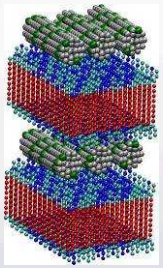
Nanocomposite materials



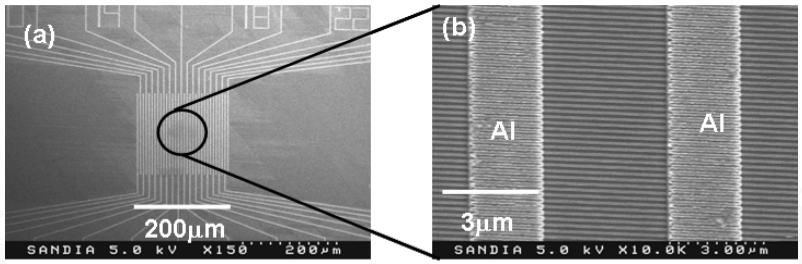
Nanoscale inhomgeneities



Engineered nanocomposites

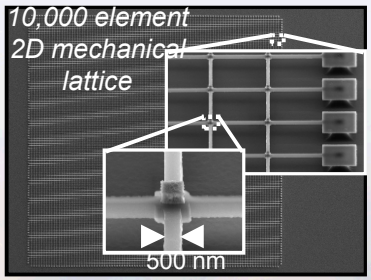


Active nanosystems



Nanowire arrays

Switchable metamaterials



Nanomechanical arrays

Length scale

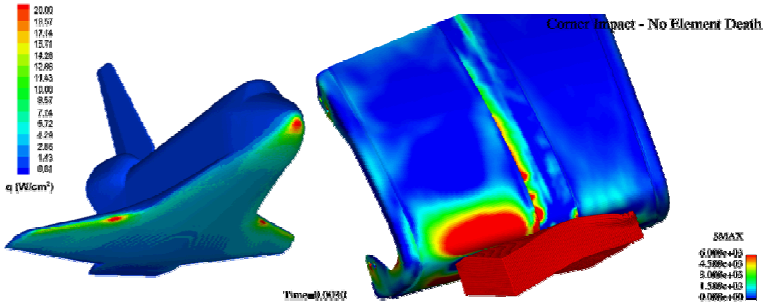
Nano **Micro**

Sandia National Laboratories

DHS / IC / DOE – Critical Energy Infrastructure
LNG International Transport

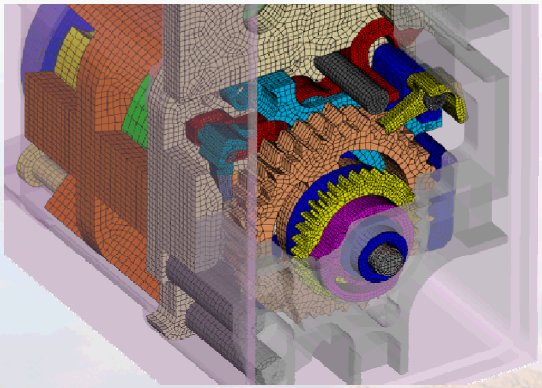
Mike Hightower, 6332
Sheldon Tieszen,1532
and Company
and ESH …

Computing now enables unprecedented analysis and prediction for science and engineering

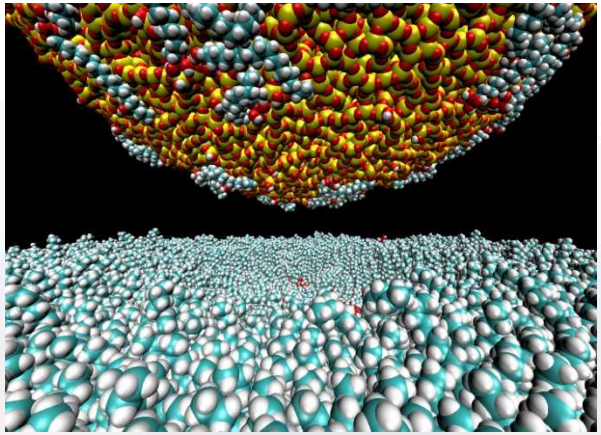


Columbia

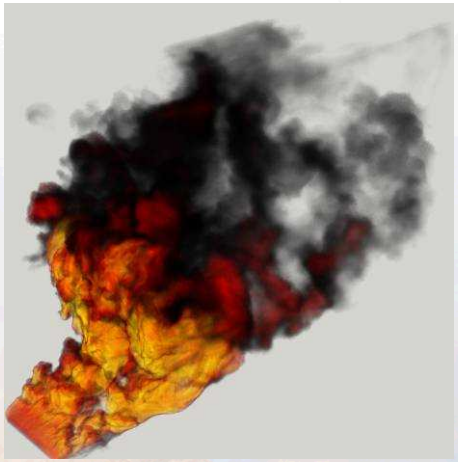
Industry



Safety & Security



Science



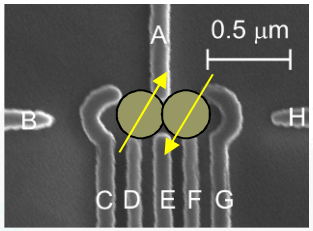
Extreme environments

Laboratory Directed Research & Development investment for the future

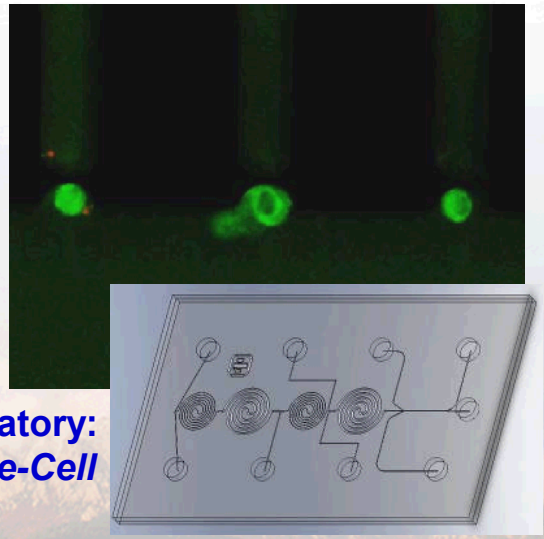
6.7% of operating budget
~$160M

LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

- Cultivate core capabilities
- "Seed Corn" for future mission technologies
- Anticipate and respond to national needs



Physical Qubit & Native Gate Set



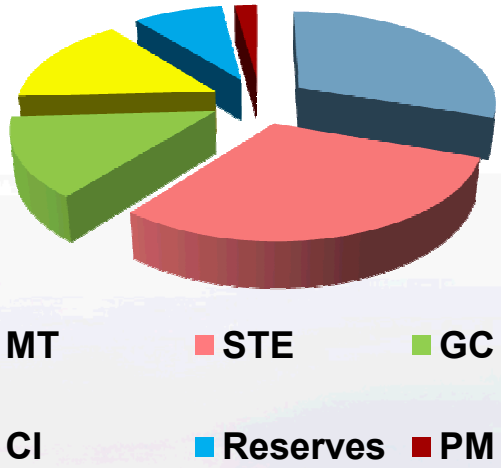
Microscale Immune Studies Laboratory: *Studying Cell Signaling with Single-Cell Resolution*

Sandia National Laboratories

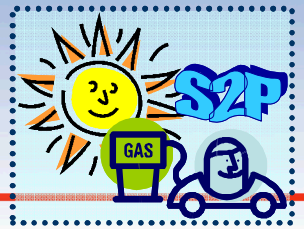
LDRD Invests in Four Major Areas that Support our DOE and WFO Missions.

- **Mission Technologies (MT, $50.3M)**
  - directly supporting NNSA, DOE, and WFO missions and their S&T needs
- **Science, Technology and Engineering (STE, $50.3M)**
  - anticipating future ST&E needs and capabilities, with critical support to all mission needs
- **Grand Challenges (GC, $22.5M)**
  - bold, high-risk ideas with enormous potential impact to national security
- **Corporate Investments (CI, $25.2M)**
  - collaborations with academia, support of high risk, leading edge R&D, and early career R&D ($10-15M)

FY10 LDRD Budget
$166M



Grand Challenge:
Solar Fuels: Sunshine to Petrol



Vision: To directly, efficiently, and cost effectively produce infrastructure compatible liquid fuels employing the same resources as nature (Sunlight, CO_2 and H_2O).

$$\text{Sunlight} + CO_2 + H_2O = \text{Fuel} + O_2$$

$$\text{Sunlight} + CO_2 + 2H_2O \rightarrow CO + 2H_2 + (3/2)O_2 \rightarrow CH_3OH \text{ (Methanol)}$$

Target

>10x sunlight to fuel efficiency than biomass

Sandia National Laboratories

Sandia receives 6 R&D100 Awards in 2009

High-Temperature Silicon Carbide Power Module (Stan Atcitty)
- is the world's first high-temperature – 250°C – silicon carbide-based power electronics module

Catamount N-Way (CNW) Lightweight Kernel (Ron Brightwell)
- operating system exploits existing features of multi-core processors to deliver significant improvements in data access performance

NanoCoral Dendritic Platinum Nanostructures (John Shelnutt)
- significantly reduce platinum metal usage and thus the cost of platinum catalysts for use in fuel cells, solar cells, and other applications

Ultralow-Power Silicon Microphotonic Communications Platform (Michael Watts)
- addresses the bandwidth and power consumption limitations of future microelectronic inter-chip networks

Hyperspectral Confocal Fluorescence Microscope System (Dave Haaland)
- with its associated multivariate analysis software, is used to discover and quantify individual fluorescing species in 3D

Artificial Retina (Kurt Wessendorf)
- uses a compact video camera and image processor to trigger nerves to help the blind see

ECIS SMU Vision

Enhance the nation's security and prosperity through sustainable, transformative approaches to our most challenging energy, climate and infrastructure problems.

Partnerships on a Global Scale

- Carbon Capture and Storage
- Low-Carbon Technologies
- Photovoltaics
- Climate Change
- Smart Grid
- Nuclear Energy
- Energy Efficiency
- Renewable Technologies
- Energy and Water Relationships
- Nanoelectronics and Nanomaterials
- Computational Materials Sciences
- Basic Research

Alternative Fuels Research

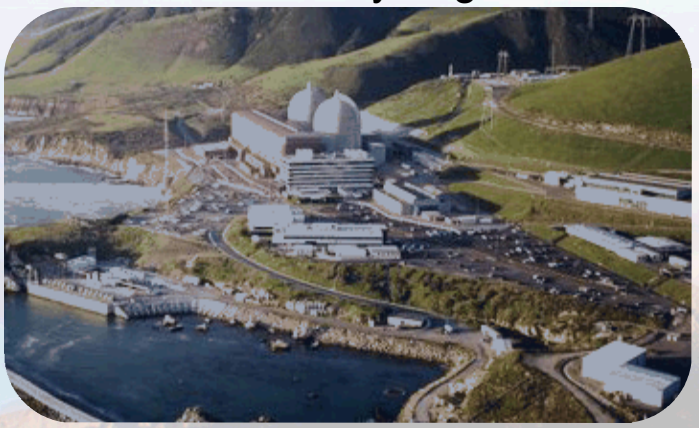
Joint BioEnergy Institute (JBEI)

Sunshine to Petrol

Combustion Research Facility

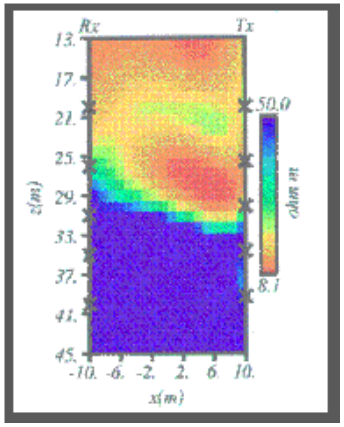
Southwestern Biofuels Association

Nuclear Hydrogen

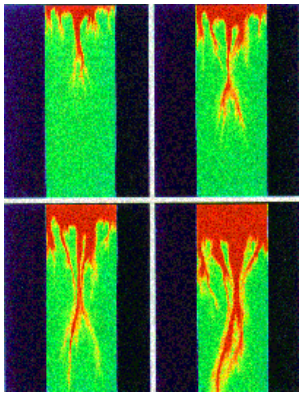


Sandia National Laboratories

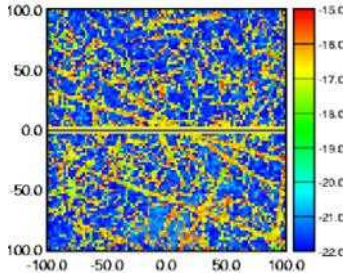
Earth Science Capabilities



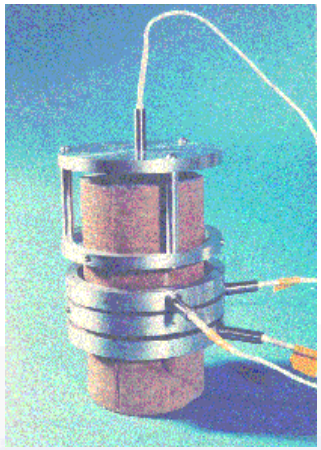
Geophysics



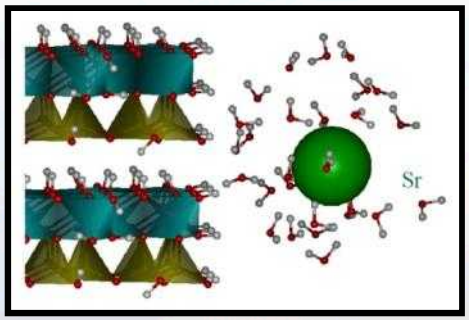
Geohydrology



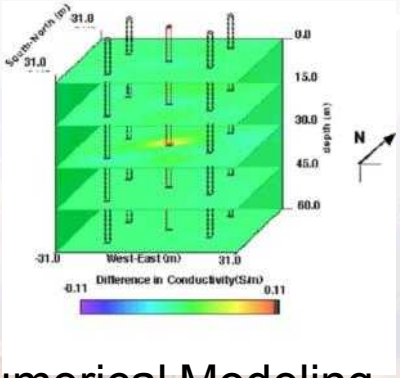
Geostatistics



Geomechanics



Geochemistry

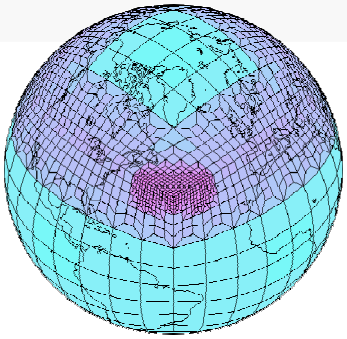


Numerical Modeling

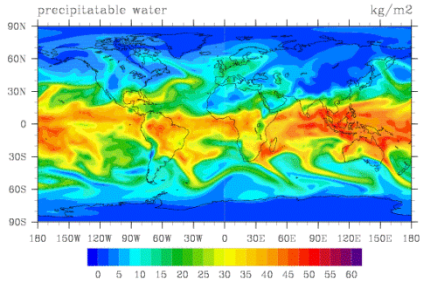
Geotechnology

Climate Research Spans Modeling, Monitoring and Decision Support

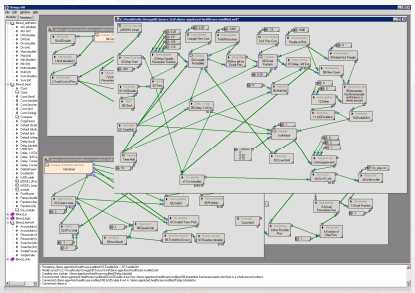
- **In partnership with ORNL and LANL, provides the Community Climate System Model (CCSM) with state-of-the art atmospheric numerical models.**
- **Expertise and resources associated with the Arctic region.**
  - Manages Alaska North face DOE ARM facility
- **Systems-dynamics, agent-based, discrete-event modeling capabilities for decision support.**
- **Built and launched more than 100 satellites with unique diagnostic & data analysis capabilities (e.g. MTI)**
- **Expertise in development and deployment of microsensors**



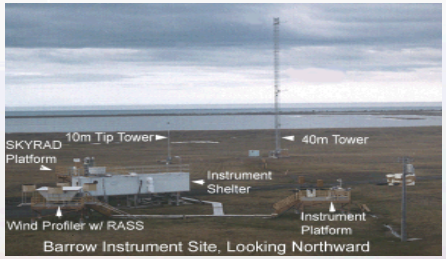
State-of-the-art scalable dynamical-core atmospheric model for CCSM



HOMME earth simulation with 100km model on 96k cores (ORNL Jaguar)



Omega-AB: Discrete event modeling tool



Alaska North face DOE ARM facility managed by SNL

Sandia National Laboratories

The Sandia Water Initiative Objectives And Program Areas

- Increase the safety, security and sustainability of water infrastructure through the development of advanced technologies that create new water supplies.

- Decrease demand through water-use efficiency.

- Provide decision-informing tools to the institutions responsible for balancing supply and demand.

Treatment Technologies

Modeling & Management

Security Systems

Energy-Water

Sandia National Laboratories

Center for Integrated Nanotechnology:

U.S. Dept. of Energy Nanoscale Science Research Center

CINT has two facilities with extensive capabilities

Characterization Wing

- TEM, SEM
- Low Temp Transport
- Scanning Probe Microscopy
- Ultra-fast Spectroscopy

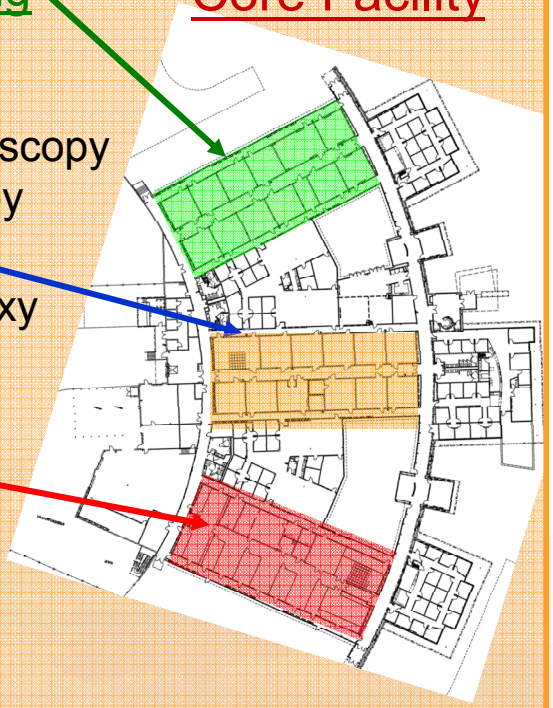
Synthesis Wing

- Molecular Beam Epitaxy
- Chem & Bio labs
- Molecular films

Integration Lab

- E-beam lithography
- Photolithography
- Deposition & Etch
- SEM / FIB

Core Facility



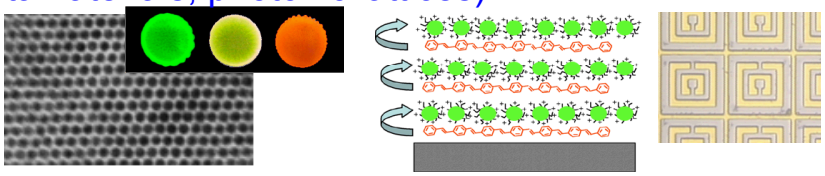
Gateway to Los Alamos Facility

- Biomaterials & Chem synthesis
- XRD, SEM
- UV-vis, ellipsometry
- Nano-indentation
- Nanoscale optical probes
- Microscopies
- Physical Synthesis
- Pulsed Laser Deposition
- Ultra-fast Spectroscopy
- Computer Cluster
- Visualization Lab

CINT Scientists are grouped by Science Thrust

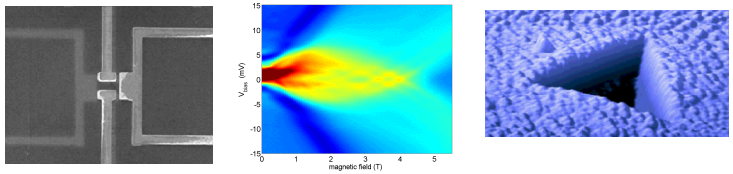
Nanophotonics & Optical Nanomaterials (NPON)

Synthesis, excitation and energy transformations of optically active nanomaterials and collective or emergent electromagnetic phenomena (plasmonics, metamaterials, photonic lattices)



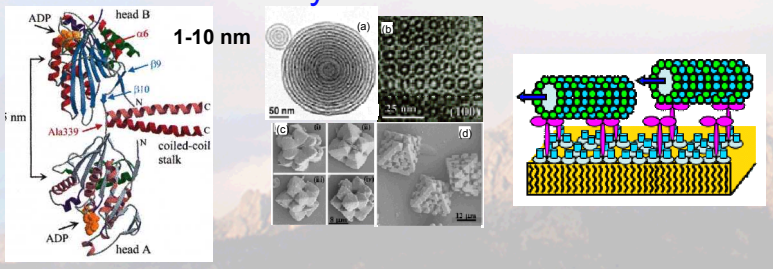
Nanoscale Electronics, & Mechanics (NEM)

Control of electronic transport and wavefunctions, and mechanical coupling and properties using nanomaterials and integrated nanosystems



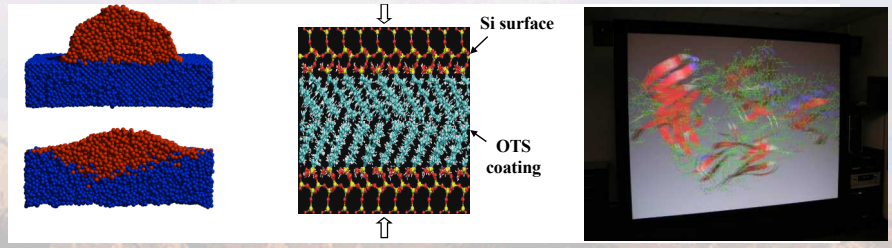
Soft, Biological, & Composite Nanomaterials (SBCN)

Solution-based materials synthesis and assembly of soft, composite and artificial bio-mimetic nanosystems

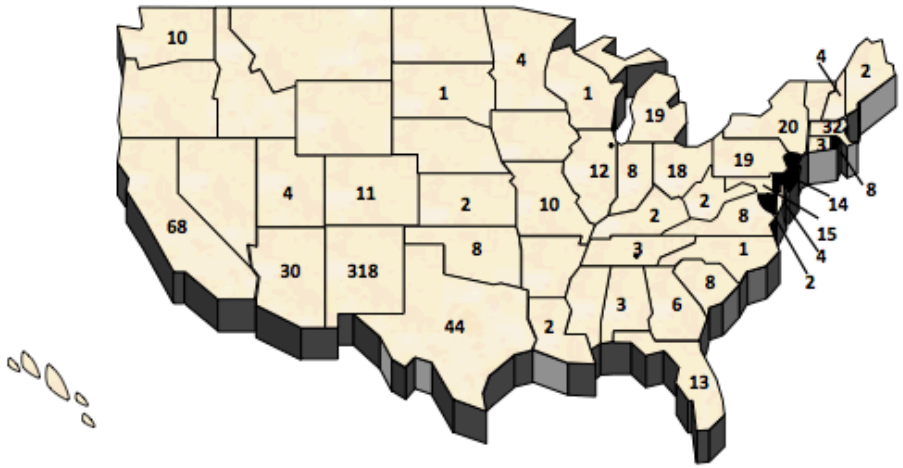


Theory & Simulation of Nanoscale Phenomena (TS)

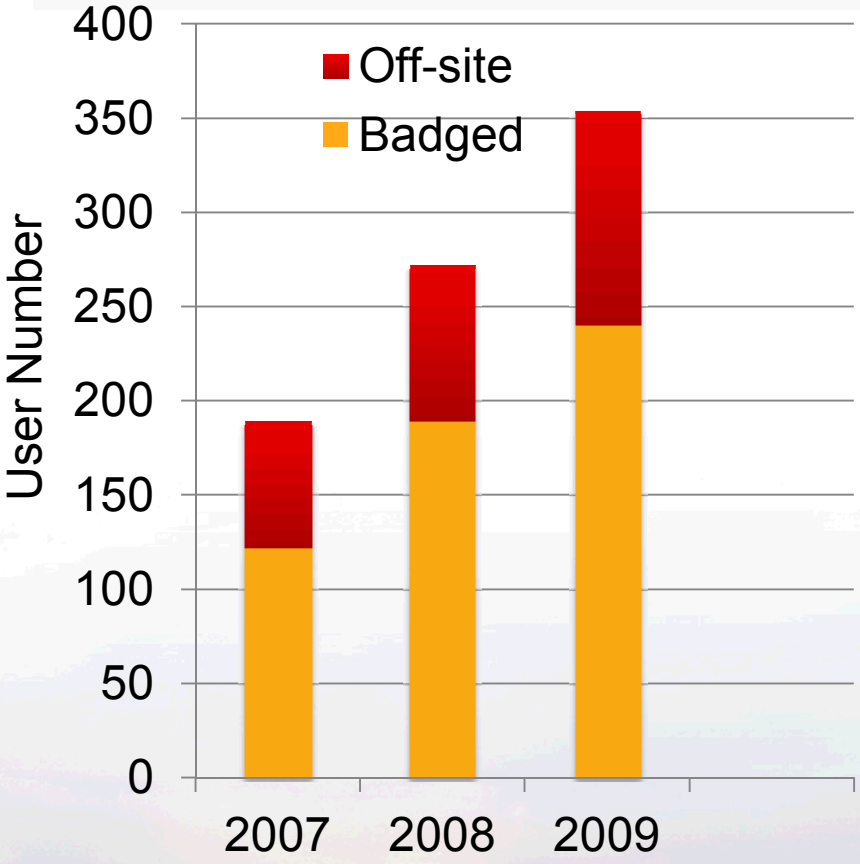
Assembly, interfacial interactions, and emergent properties of nanoscale systems, including their electronic, magnetic, and optical properties



CINT's Growing User Community



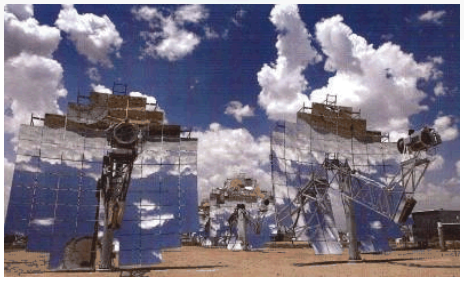
BES User Category	2007	2008	2009
Badged	122	189	240
Off-Site	67	83	114
Total	**189**	**272**	**354**



354 users, 610 researchers involved in 258 active projects, representing 36 States and 14 Foreign Countries

Strong User & CINT Science

Energy & Infrastructure Future Group



6330
Energy & Infrastructure Future
Rush Robinett

6337
Concentrating Solar Technologies
Joe Tillerson

6335
Photovoltaics & Grid Integration
Charlie Hanley

6333
Wind & Water Power Technologies
Jose Zayas

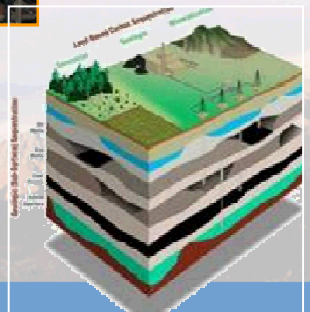
6331
Geothermal Research
Douglas Blankenship

6336
Energy Infrastructure & DER
John Boyes

6332
Energy Systems Analysis
Juan Torres

6338
Materials, Devices & Energy Tech
Jeff Nelson

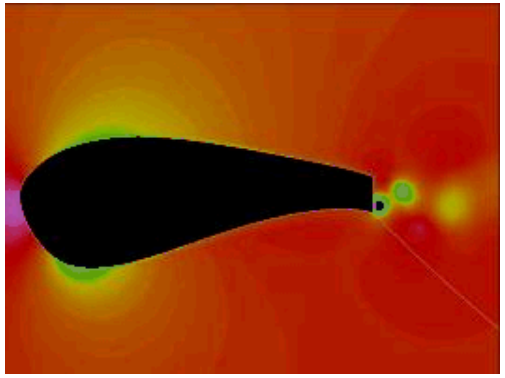
6339
Energy, Climate & Atmospheric Mgt
Ellen Stechel

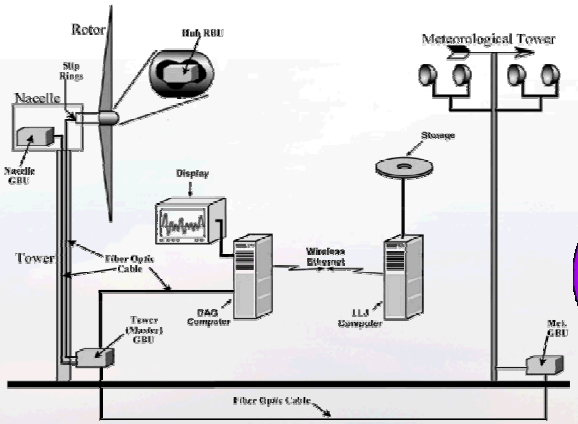


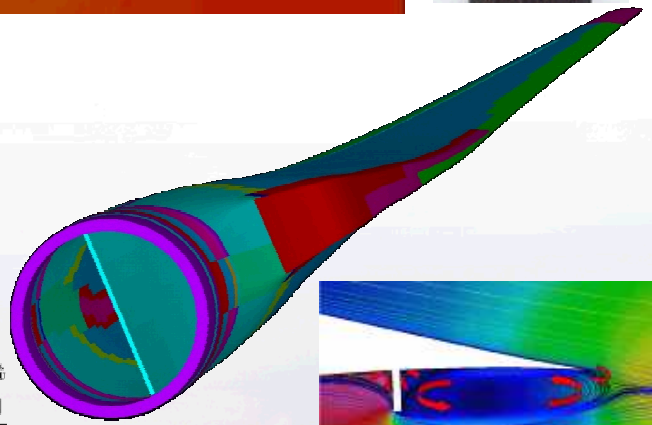
Sandia National Laboratories

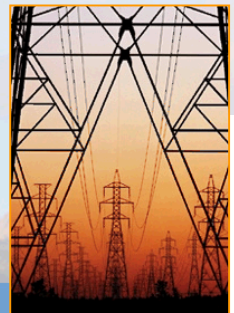
Wind Energy Technology

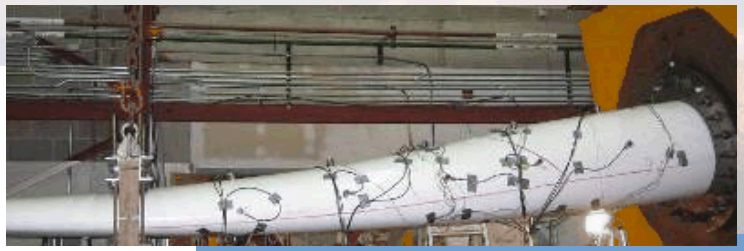
- **Blade Technology**
  - Materials and Manufacturing
  - Structural, Aerodynamic, and Full System Modeling
  - Lab - Field Testing and Data Acquisition
  - Sensors and Structural Health Monitoring
  - Advanced Blade Concepts
- **System Reliability**
  - Industry Data Collection
  - Improve reliability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

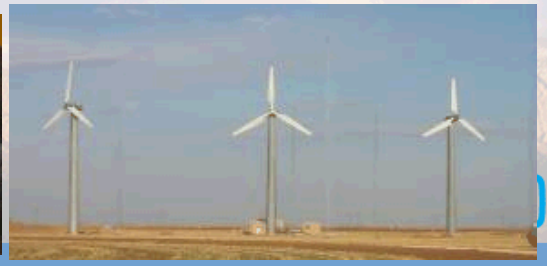


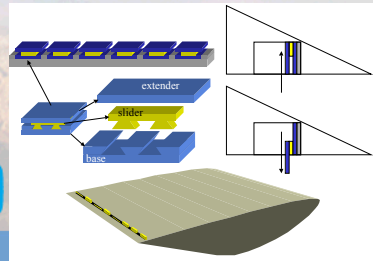






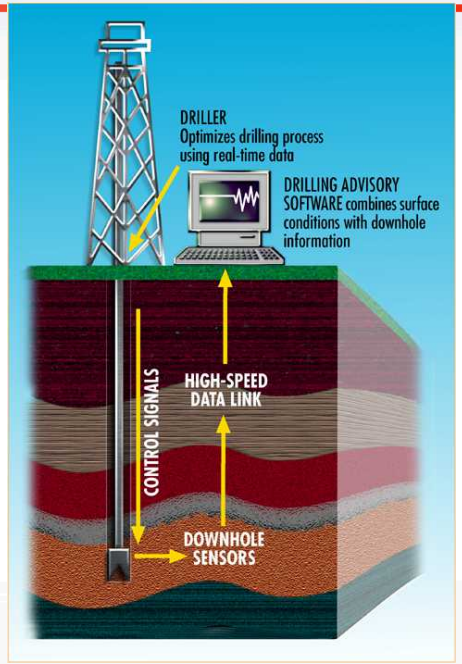






Geothermal Research
Drilling and Monitoring in Harsh Environments

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

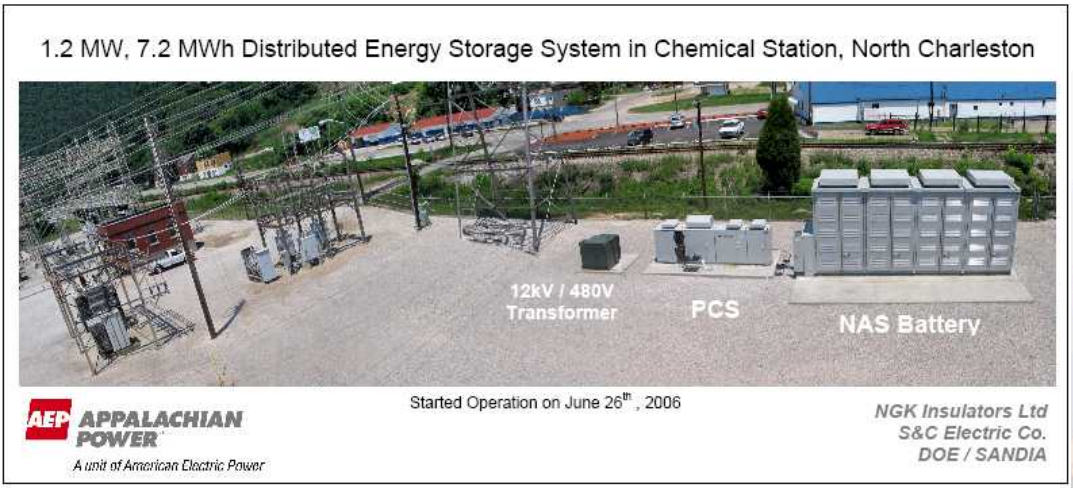


Sandia National Laboratories

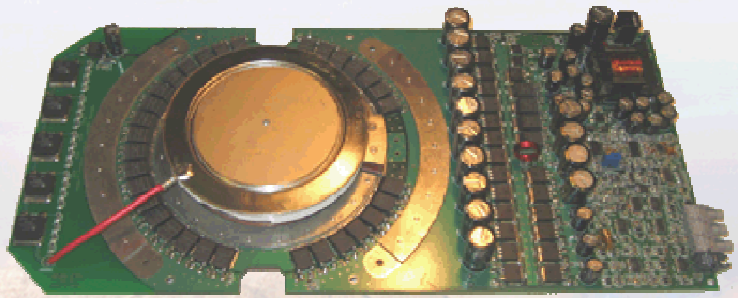
Energy Infrastructure and Distributed Energy Resources

S&C Purewave UPS System

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



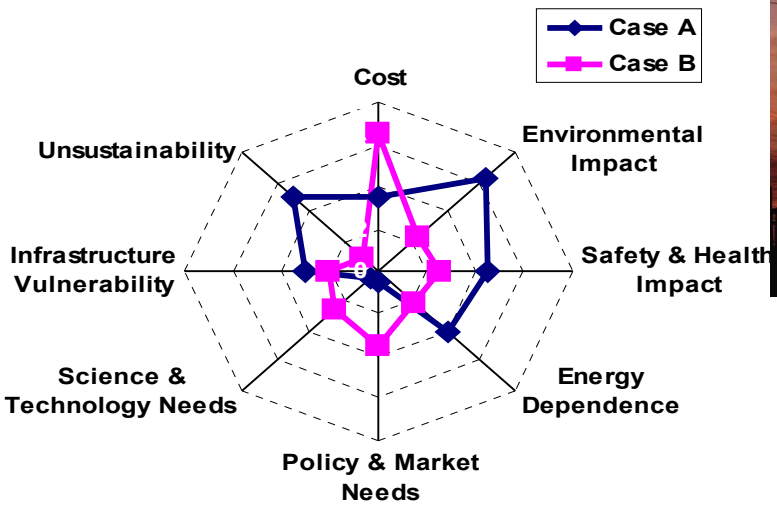
Application of Energy Storage



R&D 100: ETO High Power Switch

Energy Systems Analysis

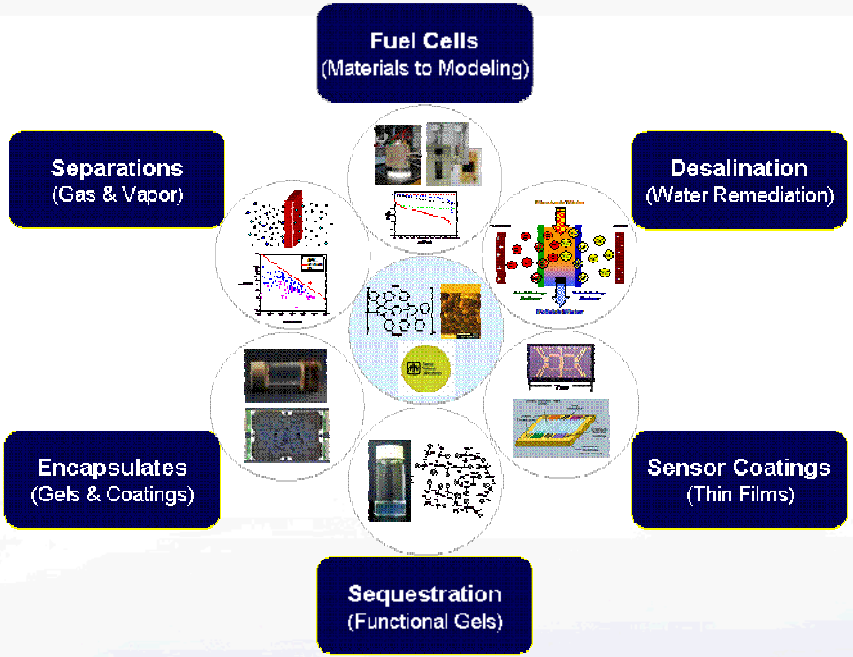
- **Competencies:**
  - Power grid (generation, transmission, distribution) operations, modeling
  - Energy transport security (pipelines, power grid, marine, railways)
  - SCADA and control systems analysis and security
  - Energy system vulnerability, safety, and risk assessment
  - Energy system modeling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

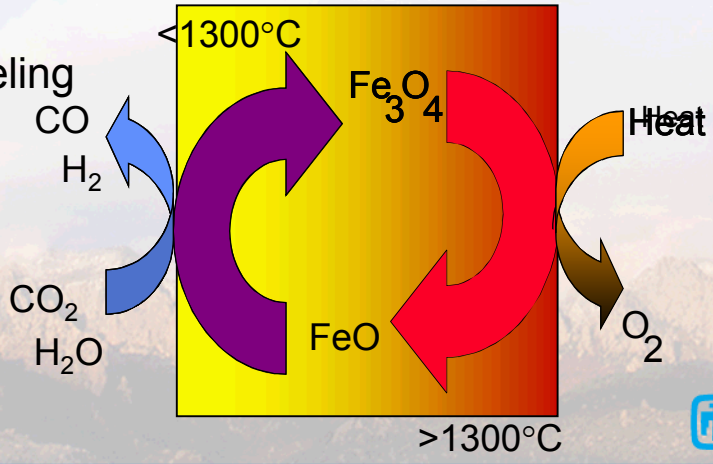


Sandia National Laboratories

Material, Devices, and Energy Technologies

- **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
- **Fuel Cells**
- **Solar Fuels**
- **CO2 Capture and Reuse**





Sandia National Laboratories

Solar Technology

Technologies:

Photovoltaics

- Cells/Modules/Arrays
- Inverters/BOS
- Controls/Communication
- Systems

Concentrating Solar Power

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

Solar Hot Water

Activities:

Advanced R&D

- New systems integrations
- Hydrogen production
- New "smarts": controls, communications, power conversion, energy management

Modeling – performance prediction

Reliability engineering*

Evaluations/characterizations of new components/products

In field performance evaluation

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

Market Transformation

Customers:

DOE/EERE/OE …

DOD

Industry

NASA

National Nuclear Security Administration

Sandia National Laboratories

The Distributed Energy Technology Laboratory

Grid

Center for Control System Security

480V Microgrid

Other Remote DER sites

Various Loads

Distributed Energy Resources

al Laboratories

SEGIS - Solar Energy Grid Integration Systems

SEGIS focus is to develop the intelligent hardware that interconnects PV to the evolving "Smarter" electrical grid

Ward Bower, 6338
Scott Kuszmual, 6335
Sig Gonzalez, 6335

Sandia National Laboratories

Concentrating Solar Power Activities at Sandia

Concentrating Solar Power (CSP) is also referred to as Solar Thermal Electric Power.

Joe Tillerson, Manager
Tom Mancini, Program Manager

Sandia National Laboratories

Sandia National Laboratories
National Solar Thermal Test Facility

What is CSP?

CSP systems ……..

- convert the sun's energy to heat and use that heat to power and engine/generator.
- are utility-scale solar power (> 100 MW).
- comprise three generic technologies: parabolic trough, power tower, and dish Stirling.
- have more than 140 plant-years of commercial operation (9 plants, 354 MW) in California desert.
- can provide dispatchable power for peaking and intermediate loads (with storage or hybridization).
- mostly utilize commodity items for manufacture (glass, steel, aluminum, piping, controls, etc.).

CSP Markets in the US are Growing Rapidly

Announced CSP Plant Construction in the US

Installation Name and Technology Developer	Technology Type	Output (MW)	Status
Solel SEGS	Trough	353.8	Operational
Acciona Nevada Solar One	Trough	64	Operational
Solargenix Saguaro APS Plant	Trough	1	Operational
Stirling Energy SDG&E Plant	Dish-Engine	300	Feasibility
Ausra & PG&E Plant	LFR	177	Feasibility
BrightSource Energy - Ivanpha 1	Tower	100	Feasibility
Victorville Hybrid Gas-Solar Plant	Trough	50	Feasibility
Sopogy Demonstration Plant	MicroCSP	1	Feasibility
Solel PG&E Plant	Trough	553	Planning
Stirling Energy Systems SCE Plant	Dish-Engine	500	Planning
Stirling Energy Systems SCE Plant Exp.	Dish-Engine	350	Planning
Ausra & Florida Power & Light Plant	LFR	300	Planning
Stirling Energy SDG&E Plant Exp 1	Dish-Engine	300	Planning
Stirling Energy SDG&E Plant Exp 2	Dish-Engine	300	Planning
Harper Lake Solar Plant	Trough	250	Planning
Arizona Public Services/ Abengoa	Trough	280	Planning
BrightSource Energy - Ivanpha 2 and 3	Tower	300	Planning
Emcore/SunPeak Power	Lens CPV	200	Planning
Palmdale Hybrid Gas Solar Plant	Trough	50	Planning
Future U.S. CSP contract potential		**4,430 MW**	

Source: Prometheus Institute, Sorin Grama

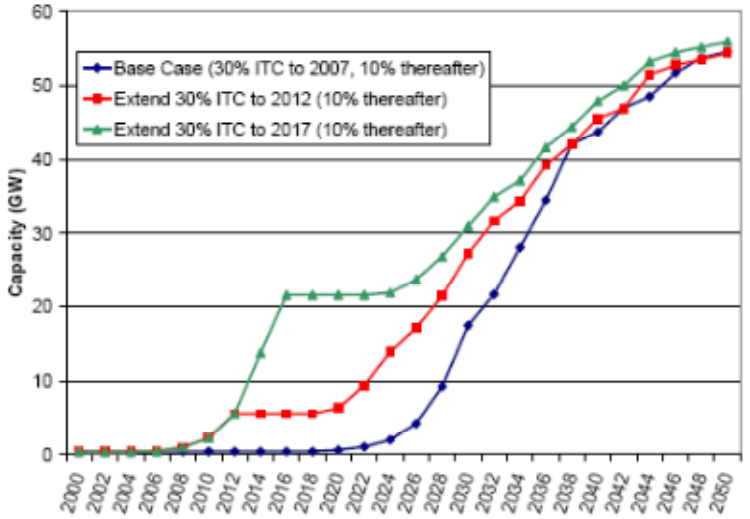


Figure 1-5. Investment Tax Credit Impact on CSP Capacity

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Parabolic Troughs

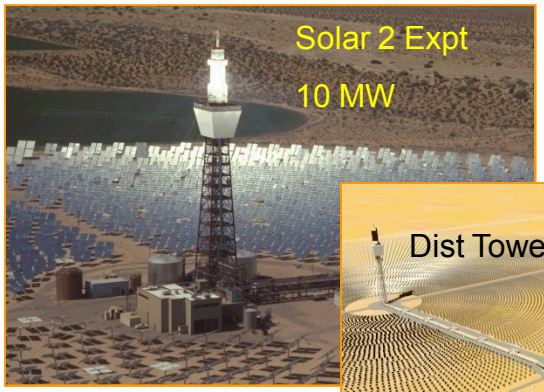
* Line-focus technologies
- State-of-the-art (SOA) is parabolic trough
- Total annual average solar-to-elect efficiency at 12 - 14%.
- No thermal Storage
- Capacity ~ 29%
- Could be hybrid with NG

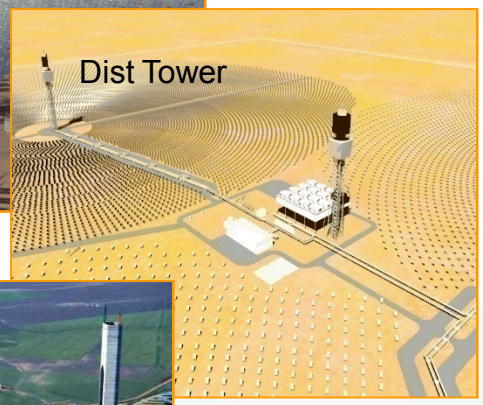
* R&D Efforts
  - Thermal storage
  - In field Optical Alignment
  - Higher Temperature Operation
  - New low-cost designs

Key elements: Concentrator and Receiver Tube

Sandia National Laboratories

Power Towers





* Point-focus technology
- SOA is water/steam system
- Total annual average solar-to-electric efficiency ~ 12%.
- Inherent Thermal Storage Capability Capacity Factor ~ 30%

- R&D Efforts
- Higher Temperature, molten salt operating fluid
- Integrated MS Thermal storage
- Higher Efficiency ~ 18 – 20%

Key element: Heliostats and Central Receiver

Sandia National Laboratories

Dish Stirling Systems

Point-focus technology

SOA 25 kW Dish Stirling

- Total annual average solar-to-electric efficiency ~ 22%.
- Does not accommodate thermal Storage
- Capacity ~ 30%

R&D Efforts

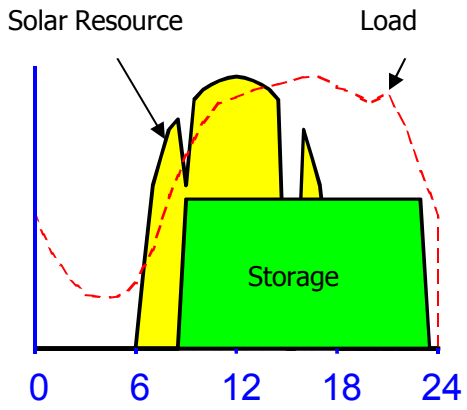
Alternative engines in development

Limited mass production of engines required to reduce cost

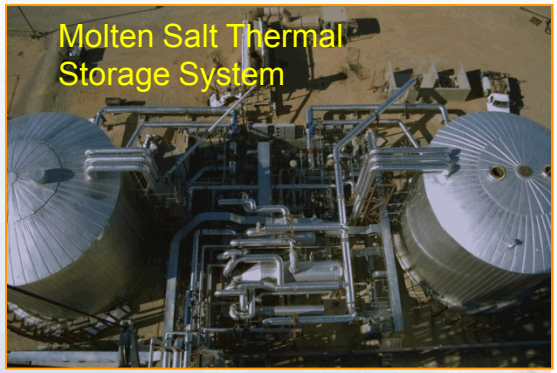
Key element: Stirling engine and dish concentrator

Sandia National Laboratories

The Value of Storage: Dispatchable Power



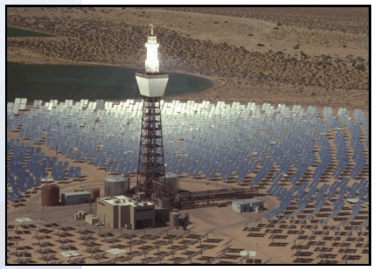
- **Thermal Storage**
  - uncouples solar energy collection and generation.
  - produces higher value electricity because power production can better match utility time-of-day needs.
  - is high efficiency (~98% roundtrip)



Molten salt power towers utilize the salt as the working fluid and storage. Two trough systems are under construction in Spain to use the salt as storage.

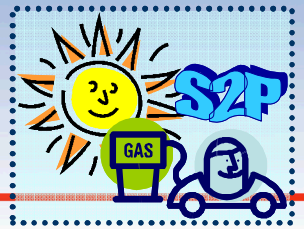
Molten-Salt Power Towers Have Low-Cost Storage

Energy collection is uncoupled from power production



Challenge: Transition of Molten-Salt Technology to Troughs

Solar Fuels: Sunshine to Petrol



Vision: To directly, efficiently, and cost effectively produce infrastructure compatible liquid fuels employing the same resources as nature (Sunlight, CO_2 and H_2O).

$$\text{Sunlight} + CO_2 + H_2O = \text{Fuel} + O_2$$

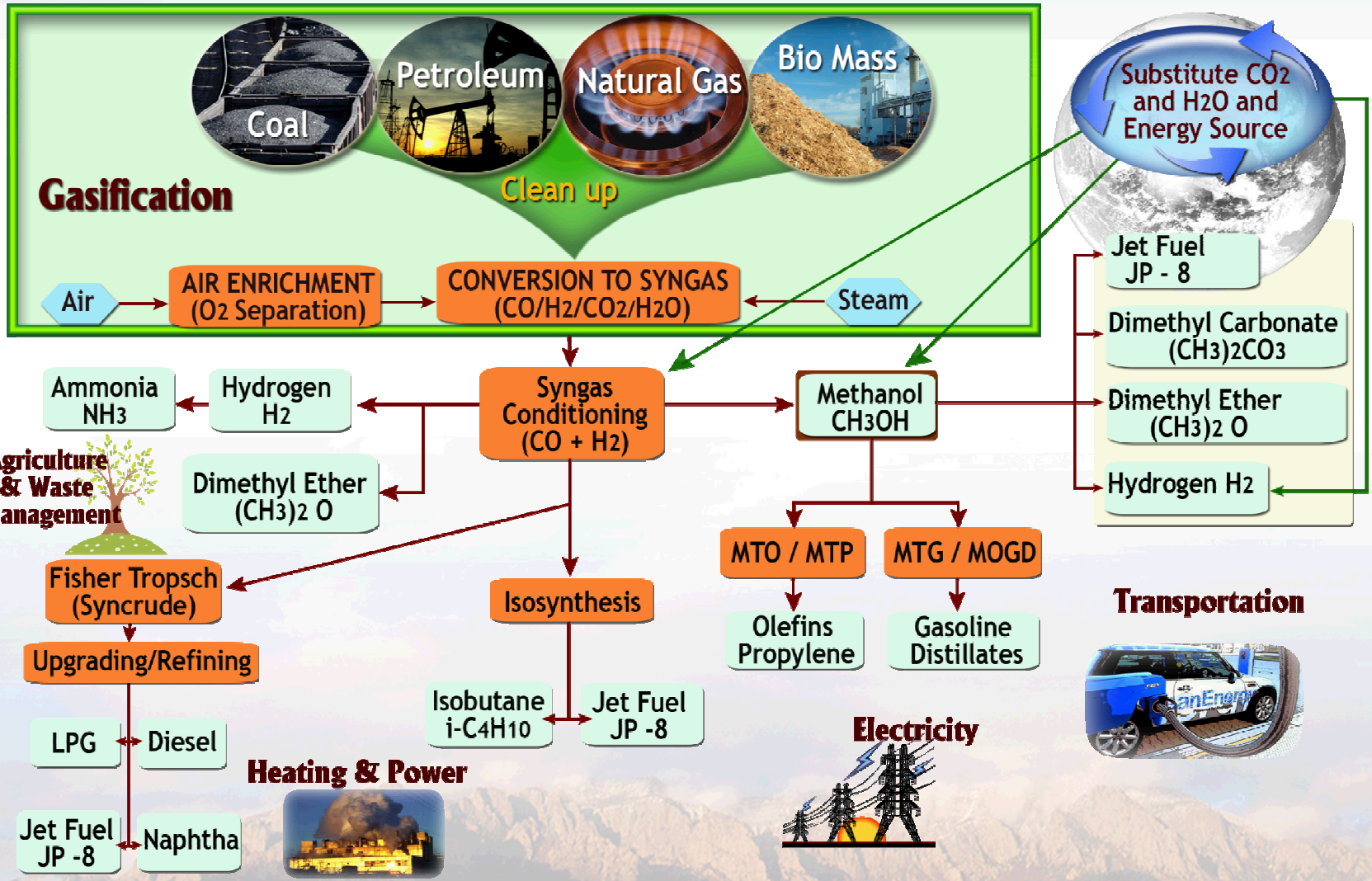
$$\text{Sunlight} + CO_2 + 2H_2O \rightarrow CO + 2H_2 + (3/2)O_2 \rightarrow CH_3OH \text{ (Methanol)}$$

Target

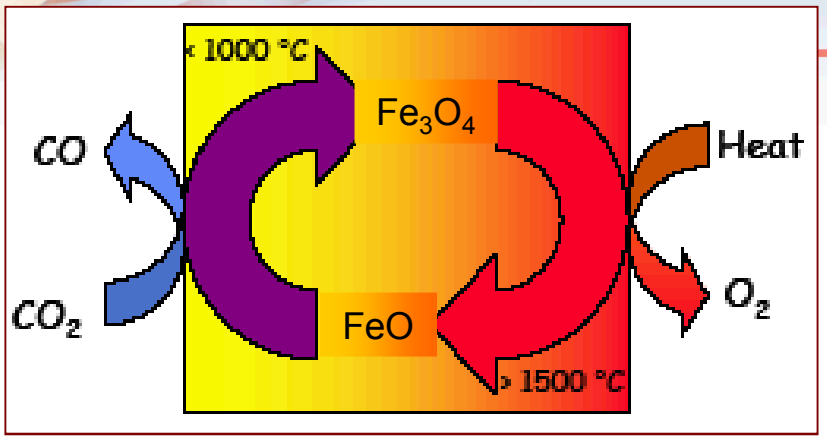
>10x sunlight to fuel efficiency than biomass

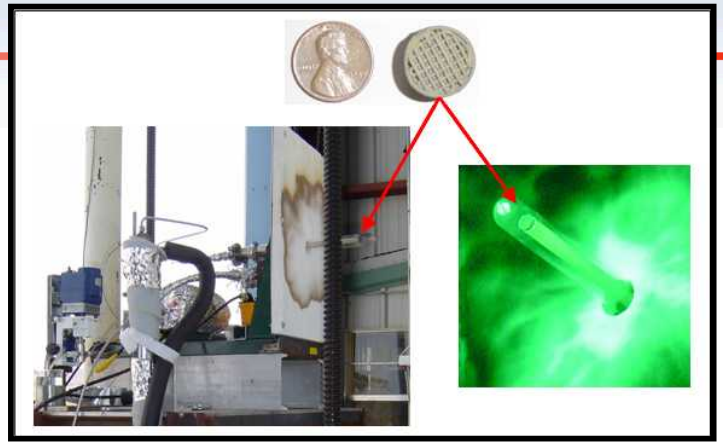
Sandia National Laboratories

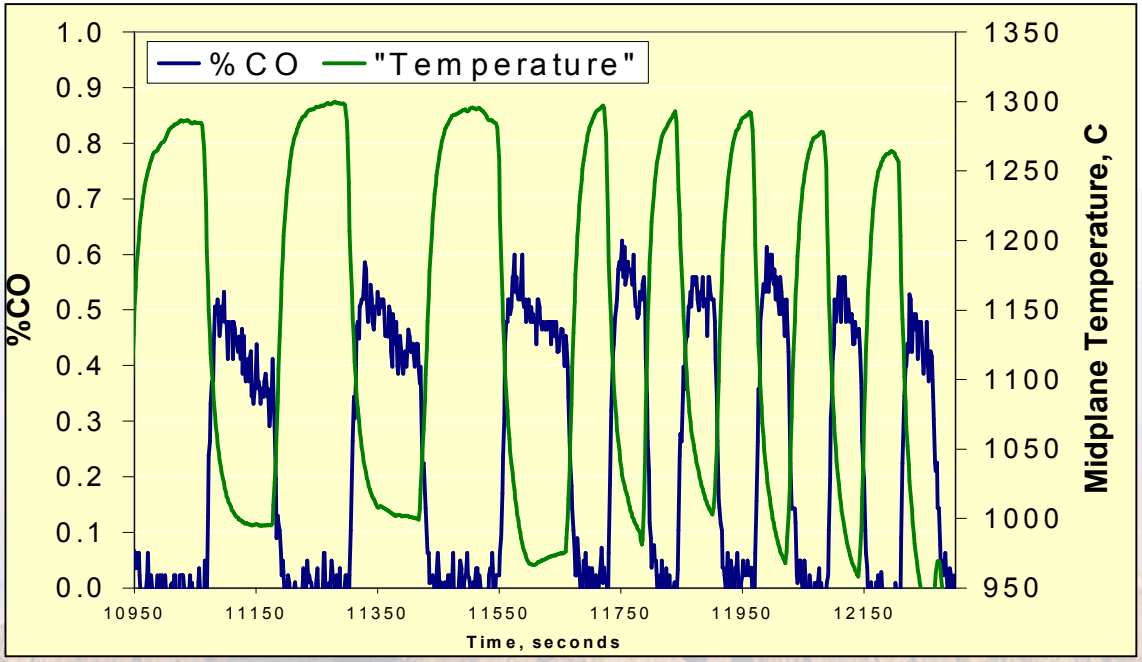
Solar Fuels Vision



CO2 Splitting at the NSTTF

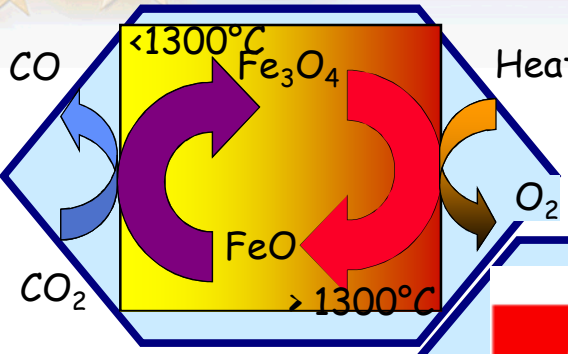


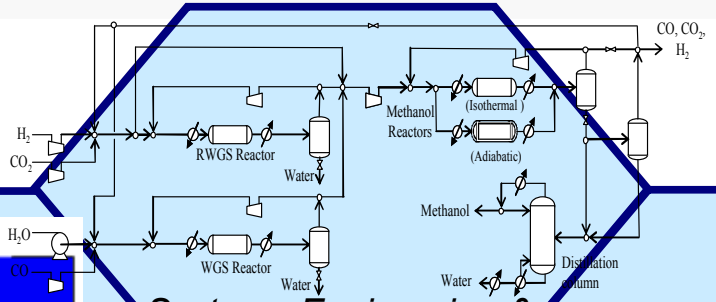




Sandia National Laboratories

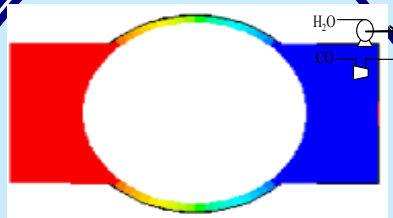
We Have Assembled a Multi-Disciplinary Team Necessary for Success (Grand Challenge LDRD)



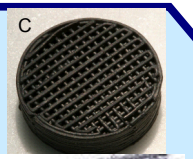


Systems Engineering & Economics

Materials Engineering & Fabrication

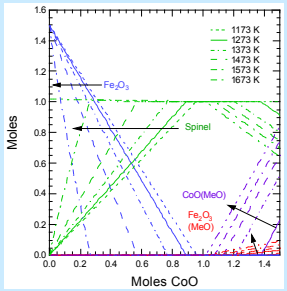


Multi-scale Rxn & Transport Modeling

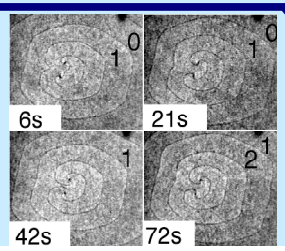


Engine Design & Build

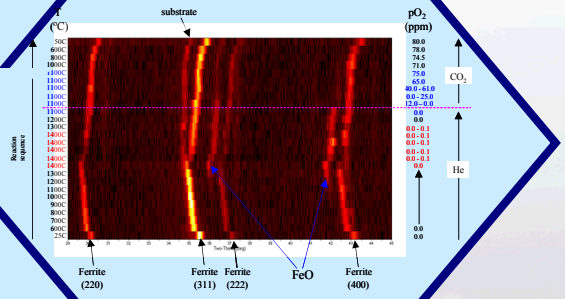
Solar Engineering



Thermodynamics & Kinetics



Basic Science



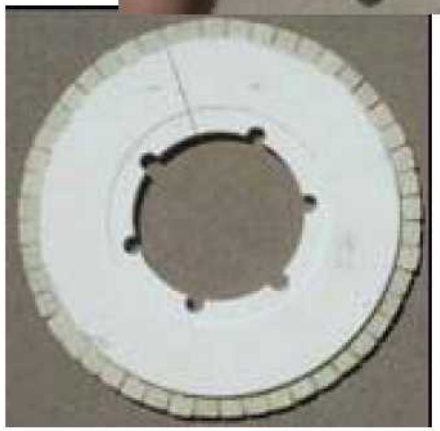
Materials Science

Sandia National Laboratories

Sunshine to Petrol

The Prototype is Assembled: Initial Tests on Sun

- Two Material Classes demonstrated split both CO_2 and H_2O
- Continuous, fast, repeated cycles, without loss of activity demonstrated
- Initial testing of CR5* prototype completed, assembly and redesign of reactive structures in progress



14 rings
~9 kWth
Full Scale
~75 kWth

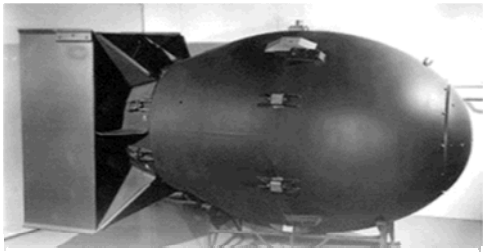
*Counter-Rotating-Ring Receiver/Reactor/Recuperator

The End

Questions and Discussions

Sandia's History

"Exceptional service in the national interest"



THE WHITE HOUSE
WASHINGTON

May 13, 1949

Dear Mr. Wilson:

I am informed that the Atomic Energy Commission intends to ask that the Bell Telephone Laboratories accept under contract the direction of the Sandia Laboratory at Albuquerque, New Mexico.

This operation, which is a vital segment of the atomic weapons program, is of extreme importance and urgency in the national defense, and should have the best possible technical direction.

I hope that after you have heard more in detail from the Atomic Energy Commission, your organization will find it possible to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.

I am writing a similar note direct to Dr. C. E. Buckley.

Very sincerely yours,

Harry Truman

Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.

Sandia's Sites

Albuquerque,
New Mexico

Livermore,
California

Yucca Mountain,
Nevada

WIPP,
New Mexico

Kauai,
Hawaii

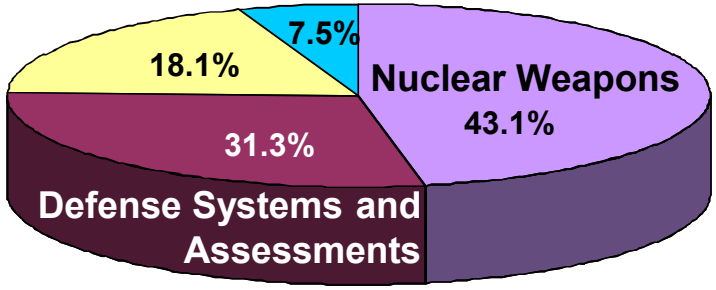
Pantex, Texas

Tonopah, Nevada

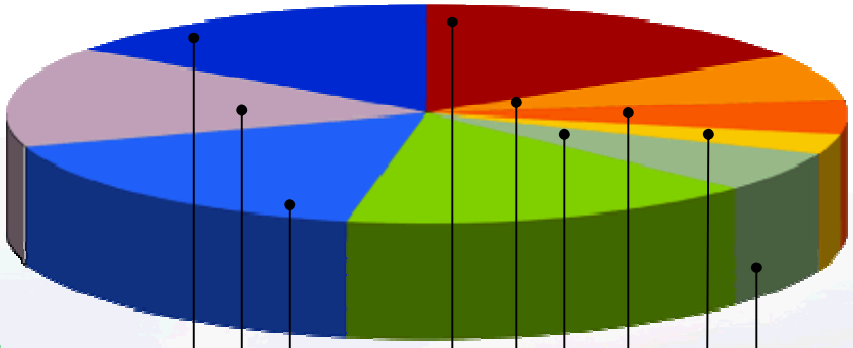
People and Budget

- On-site workforce: 11,200
- Permanent workforce: 8,400
- Gross payroll ~ $890M
- Budget ~ $2.3B

Operating Revenue
$2.3 B

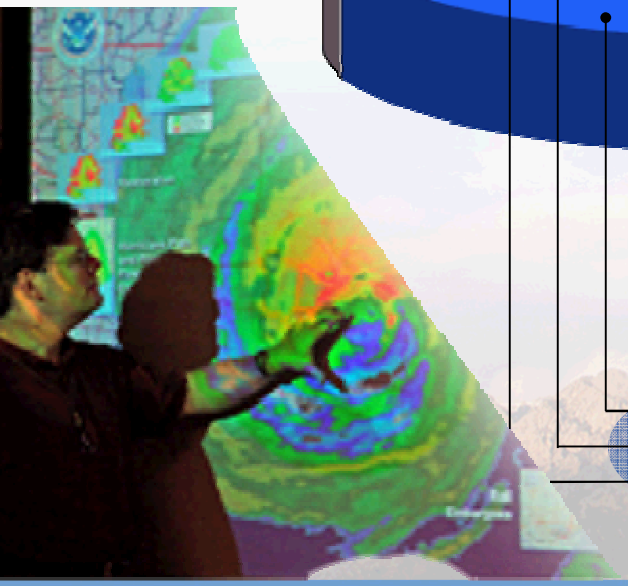


Technical Staff (3,844) by Degree
(End of FY08)



- Energy and Non-proliferation
- Homeland Security

- Computing 16%
- Math 2%
- Chemistry 4%
- Physics 6%
- Other Science 4%
- Other Fields 17%
- Electrical Engineering 19%
- Mechanical Engineering 16%
- Other Engineering 15%



Sandia National Laboratories

Sandia's Nuclear Weapons Core Products

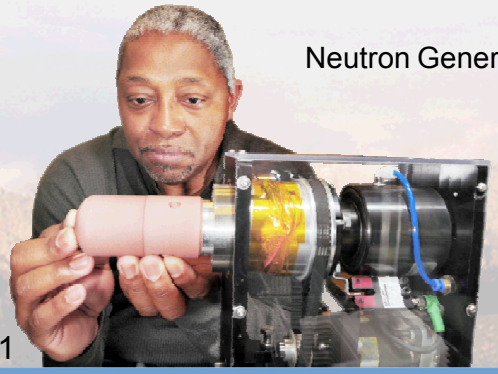
At the core of Sandia's Nuclear Weapons Program are those products that represent key elements of weaponization, including:

- Integrated, Engineered Warhead Systems,
- Arming, Fuzing, and Firing Systems,
- Neutron Generators,
- Gas Transfer Systems, and
- Surety Systems.

The science foundations and development, qualification, and production activities that support these products are at the center of Sandia's Nuclear Weapons Program.

Integrated, Engineered Warhead Systems

Neutron Generators

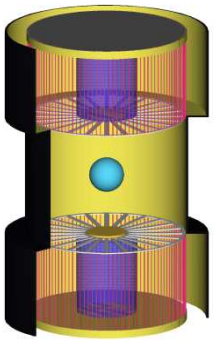


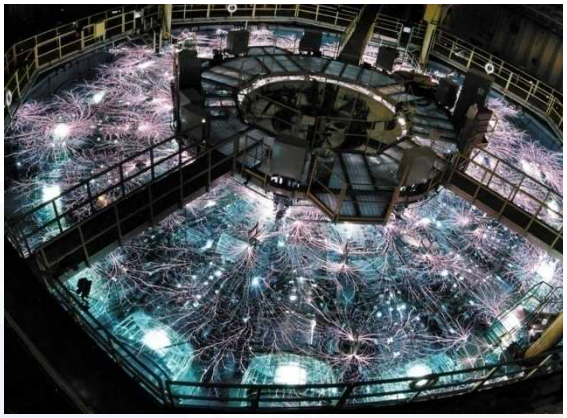
Sandia National Laboratories

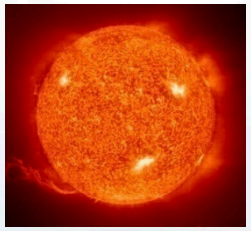
Pulsed Power: The Z Facility

– *The Most Powerful X-ray Source in the World* –

Concentrate electrical energy in *space* and *time* in order to create and understand high energy density environments







Provide fundamental understanding for mitigating shaped-charge weapons

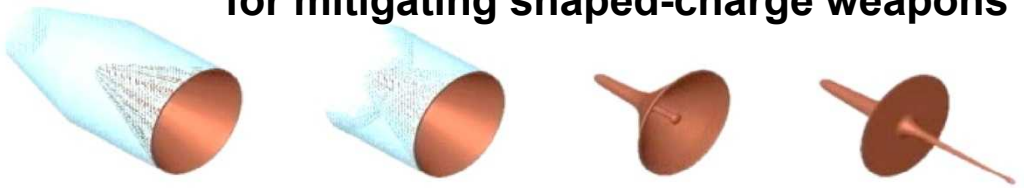


Figure 1: Formation of a shaped charge jet – Explosive (transparent blue) creates a jet of material as it squeezes a cone-shaped copper liner. (Courtesy Dr. Paul Berning, ARL)

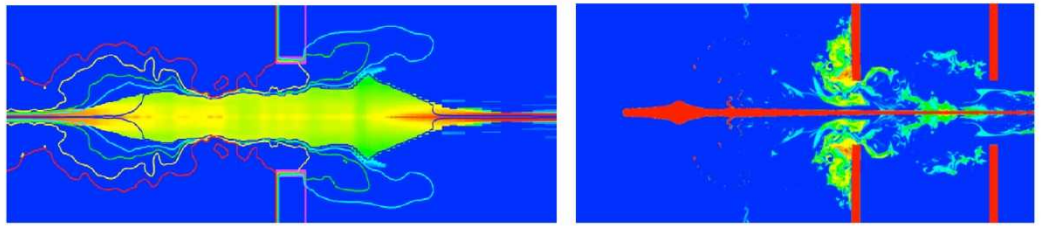


Figure 2: Electromagnetic armor: two example calculations of a shaped charge jet passing between two charged plates with holes. (left): plot of electric current streamlines and material densities for a high-current configuration. (right): plot of electrical conductivities for a low-current configuration.

The Z facility provides extreme experimental environments:

- **Temperatures higher than *the center of the sun* (>10,000,000 K)**
- **Pressures higher than *the center of the earth* (>20,000,000 atm)**

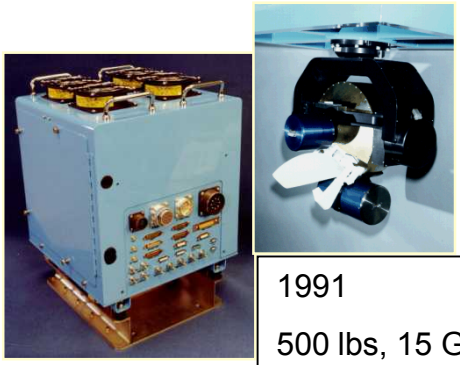
Sandia National Laboratories

Defense Systems & Assessments Programs

- Science & Technology Products
- Surveillance & Reconnaissance
- Integrated Military Systems
- Remote Sensing and Verification
- Information Operations
- Proliferation Assessment

Sandia Miniature SAR Evolution

- **Sandia has been Improving Performance and Shrinking SAR Size for Over Two Decades**
  - Sandia systems known for fine resolution, high image quality, real-time processing
  - Mini-SAR is the next major step in this evolution.
  - Next Generation SAR: MESA SAR

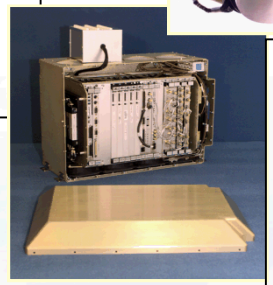


1991

500 lbs, 15 GHz

6-in resolution

16 km range



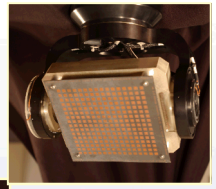
1998

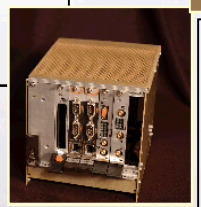
120 lbs, 16.7 GHz

4 -in resolution

35 km range

CCD & GMTI



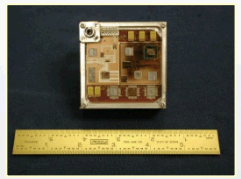


2005

25 lbs, 16.7 GHz

4-in resolution

15 km range



2009

~10 lbs, 16.7 GHz

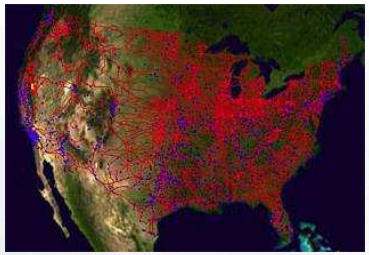
4-in resolution

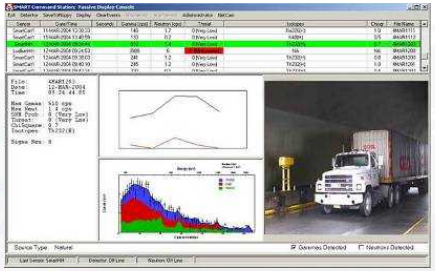
~10 km range

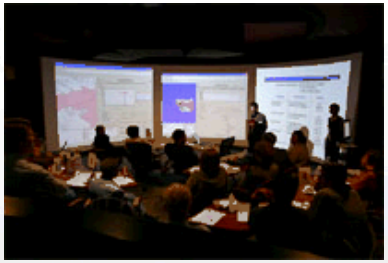
International, Homeland, & Nuclear Security

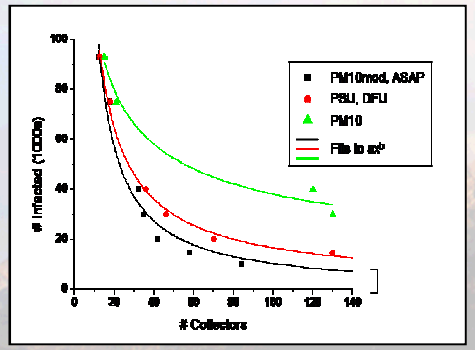
We explore solutions throughout the threat spectrum

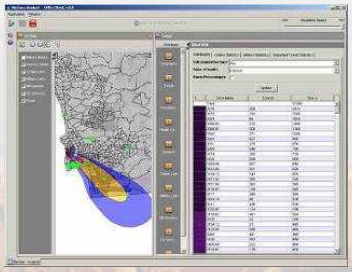
Anticipate	Prevent	Protect	Respond	Recover
• Reference scenarios for bioterrorism • Motivation and intent analysis • Infrastructure failure analysis	• Nat'l architectures for bio-detection • Explosive detection technologies • Countermeasures Test Bed		• Modeling of operations • Simulated experiences • Red-team assessments	• Decontamination technologies • Forensics







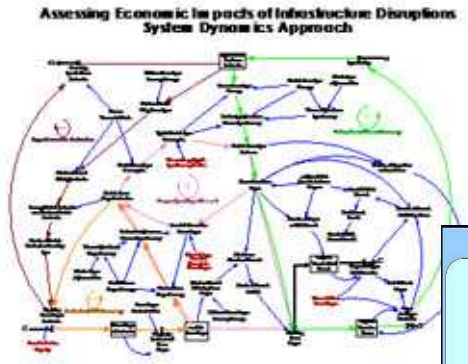


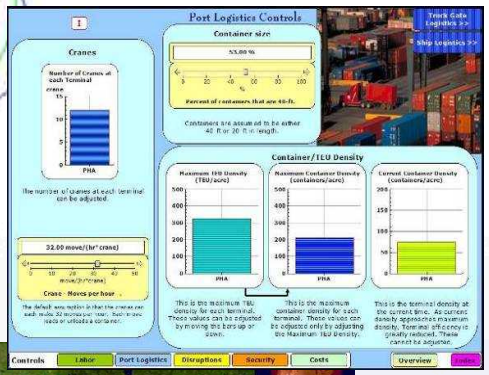


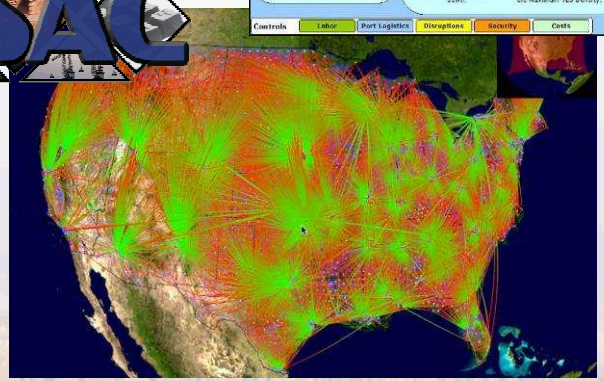
Sandia National Laboratories

Sandia's approach aims to prevent cascading failure of critical infrastructure

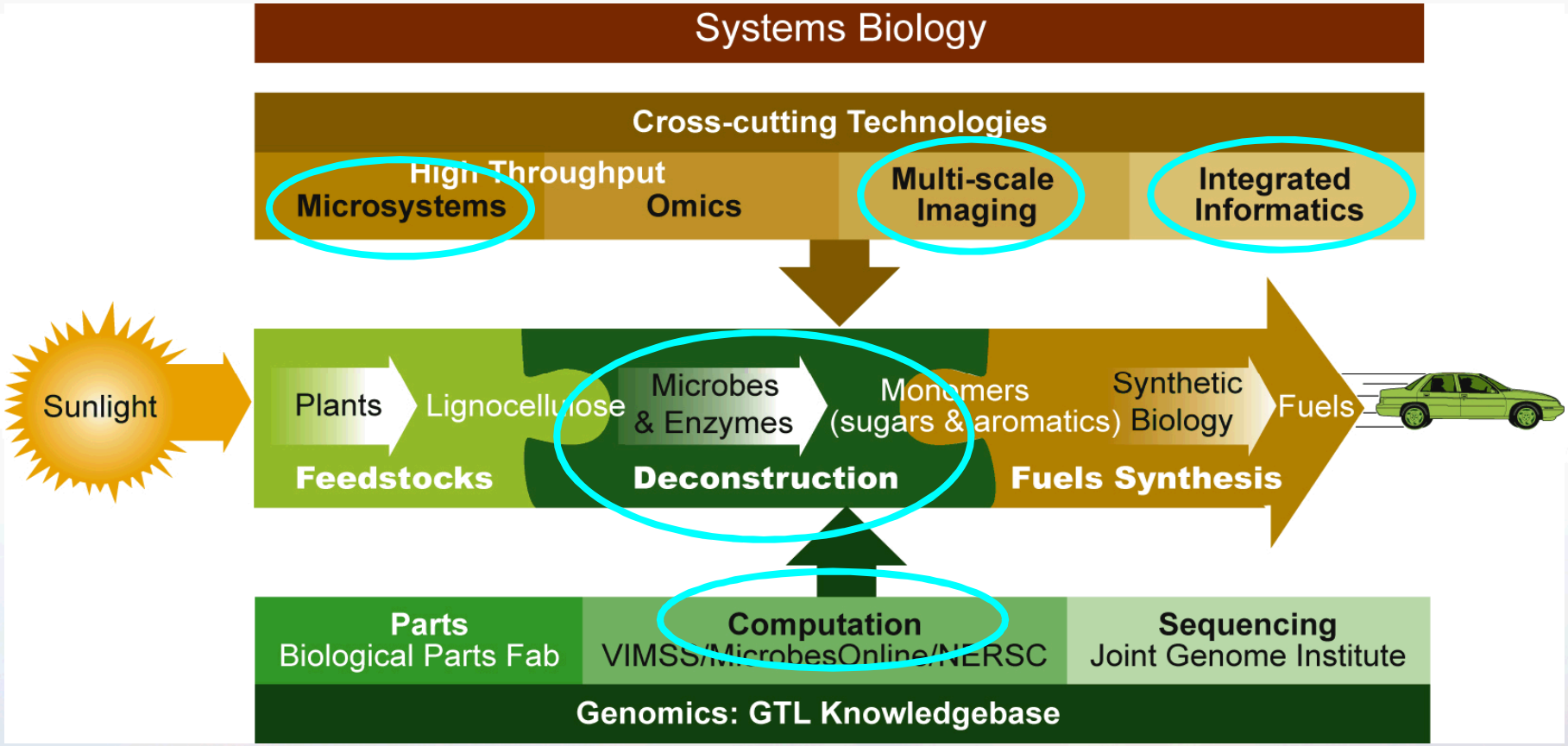
- National Infrastructure Simulation and Analysis Center
- Advanced simulation studies and tools
- Next-generation Internet security tools
- Information Operations Red Team







Joint BioEnergy Institute (JBEI) Leverages Sandia's Key Capabilities



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