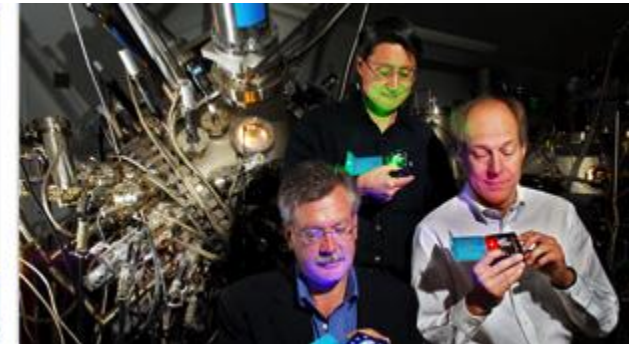


Exceptional service in the national interest



energy.sandia.gov



EERE Program Overview

26 March 2012

<http://energy.sandia.gov>



Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND 2012-3066 P.

History of Sandia Energy Programs

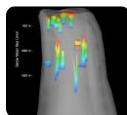


Sandia was born as a nuclear weapons engineering laboratory with deep science and engineering competencies



Energy crisis of the 1970s spawned the beginning of significant energy work

Strategic Petroleum Reserve – geological characterization of salt domes to host oil storage caverns



DOE's Tech Transfer Initiative was established by Congress in 1991



Advent Solar

Energy Policy Act of 2005

Combustion Research Facility (CRF) & Cummins partner on their newest diesel engine



Joint BioEnergy Institute

1950

1960

1970

1980

1990

2000

2007

2010

Vertical axis wind turbine

NRC cask certification studies & core melt studies



Solar Tower opens



CRF opens to researchers



SunCatcher™ partnership with Stirling Energy Systems

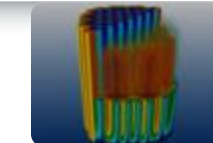
Distributed Energy Technology Laboratory (DETL) to integrate emerging energy technologies into new and existing electricity infrastructures

Power grid reliability study



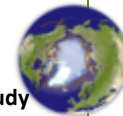
Sunshine to Petrol Pilot Test

Large-scale pool fire tests of liquefied natural gas (LNG) on water



Consortium for Advanced Simulation of Light Water Reactors (CASL)

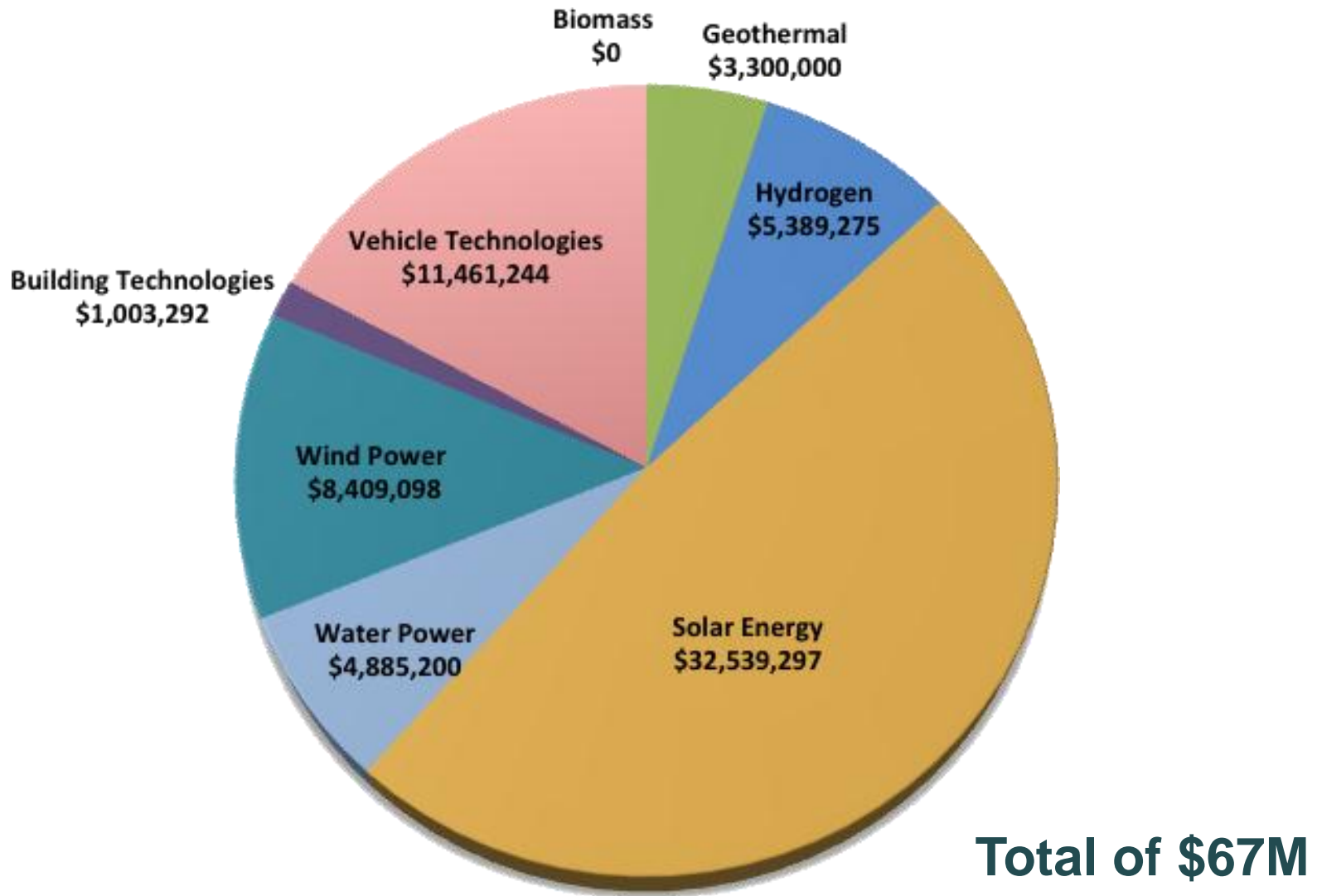
Climate study uncertainties to economies



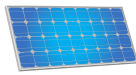
Combustion Research Computation and Visualization (CRCV) opens

Our core NW competencies enabled us to take on additional large national security challenges

FY11 EERE Investments in Sandia



Note: Office of Science investments in JBEI and CRF not shown here.



Photovoltaics & Distributed Systems

UNIQUE CAPABILITIES

- Comprehensive systems characterization and optimization
 - components -> grid interconnect
 - predictive models -> field reliability
- New power electronics to enable “smart grid” enhancements
- Distributed Energy Technologies Laboratory (DETL)

KEY INDUSTRY PROJECTS

- Managing two PV “Regional Test Centers” – ABQ and Florida
- PV Modeling Collaborative
- Chair working groups for new utility-scale PV models/interconnects
- Supporting PV Manufacturing Initiative
- CRADAs with EPRI, SunPower, NVEnergy

CURRENT WORK

- Advanced tools for large-scale grid integration
 - PV, storage, and controls
 - Solar Energy Grid Integration Systems (SEGIS) – new inverters for enhanced capabilities (2011 R&D100 Award)
- PV Systems Reliability – new manufacturing capabilities for a US industry
- PV for DOD sites: outreach and technical analysis



pv.sandia.gov

Concentrating Solar Program

UNIQUE CAPABILITIES

- Only major power tower test facility (heliostat field and solar tower - 6 MWt) available for customer testing in western hemisphere
- Solar furnace, high-flow-rate molten salt test loop, rotating platform (trough) and top quality experts in CSP

KEY INDUSTRY PROJECTS

- Molten salt power towers with Gemasolar in Spain, Solar Reserve in Nevada).
- Dish engine technology with Infinia
- Nitrate salt thermal storage in parabolic troughs
- Perform testing for Abengoa, Solar Reserve, NASA, Nooter/Eriksen, 3M, BP, eSolar

CURRENT WORK

- Extending temperature range of CSP (>600C) to meet SunShot Goals of 6¢/kWh
- Developing key systems to reduce cost of CSP including heliostats, power block (advanced thermodynamic cycles), heat transfer fluid, storage materials, receiver





Wind Program

UNIQUE CAPABILITIES

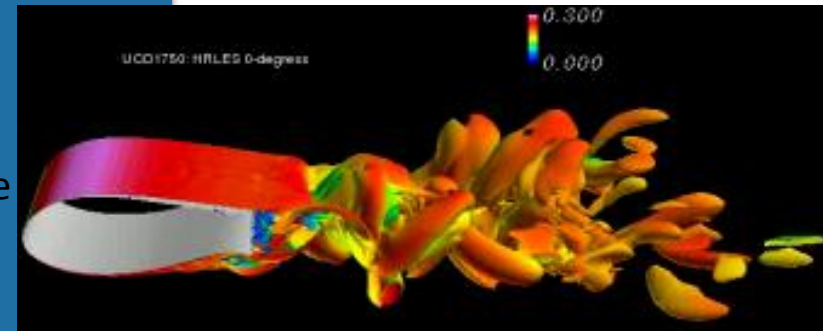
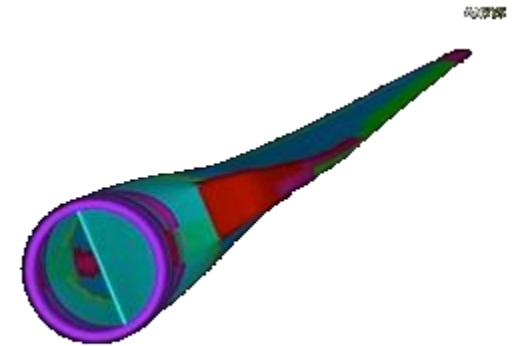
- SNL specializes in wind-turbine blade design, blade tools & models, and wind system reliability (CREW)
- SNL has unique test facilities for scaled blade testing and turbine-to-turbine interaction studies (SWIFT wind test site)

KEY INDUSTRY PROJECTS

- GE – active controls, reliability
- Vestas – active controls, testing
- Montana State University – blade material testing
- Texas Tech University – wind testing
- NREL – systems engineering, wind farm planning, blade testing

CURRENT WORK

- Test and evaluation of methods for mitigating turbine interference with radars
- Reliability data base and analysis
- SWIFT test site development at TTU
- Development of tools for wind turbine design & modeling
- Blade testing and materials analysis





Water Energy Program

UNIQUE CAPABILITIES

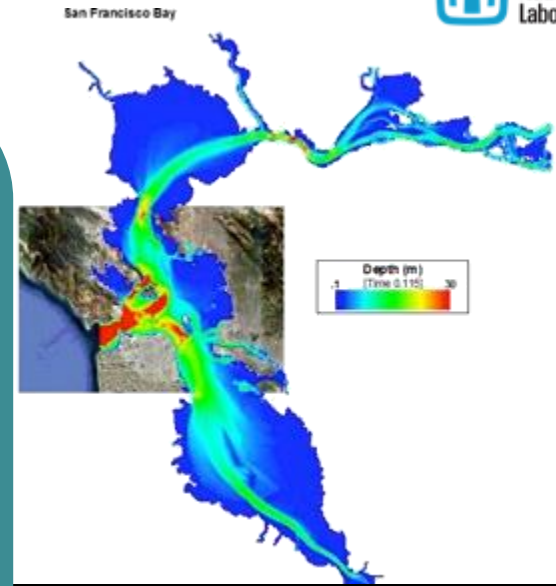
- SEAWOLF laboratory/field oscillatory-flow sediment transport testing
- Sandia Lake Facility – TRL 6 appropriate for wave testing
- MHK-capable environmental circulation and performance code (SNL-FEDC)

KEY INDUSTRY PROJECTS

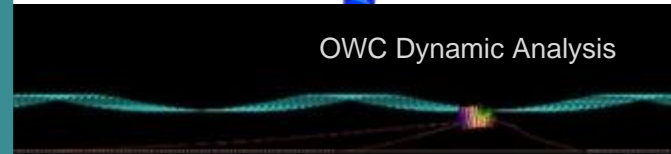
- Technical Industry FOA Support
 - Ocean Renewable Power Company, Ocean Power Technologies, Snohomish PUD
- SNL-EFDC Technology Transfer to
 - Free Flow Power, NOAA, FERC, BOEM, Verdant, ORPC

CURRENT WORK

- Reference Model generation and evaluation to set industry COE baselines and cost reduction pathways
- Renewable-appropriate composite structural materials and anti-biofouling coatings evaluation
- Fundamental code development for current and wave devices
- Water turbine acoustic signature prediction and measurement



OWC Dynamic Analysis



Sandia Lake Facility

Geothermal Program

UNIQUE CAPABILITIES

- Drilling Dynamics Simulator - real world drilling dynamics in the laboratory
- Rotary head and coil tubing test machines
- Electronics fabrication and facilities for high-temperature testing and evaluation
- Dynamometer test stand
- Facilities for testing energetic materials

KEY INDUSTRY PROJECTS

- Partnered with Atlas Copco in the development of down-the-hole hammers for geothermal applications
- Working with GE in the testing of SiC microelectronics and evaluation of optical fiber performance in high-temperature H₂ rich environments
- Demonstration and evaluation of advanced PDC bits with US Navy and NOV Reed Hycalog

CURRENT WORK

- Advanced drilling systems and well completion technologies
- Evaluation and development of high-temperature tools and devices for downhole applications
- Application of environmentally friendly energetics for reservoir stimulation
- Engineered Geothermal Systems – systems analyses combining physics and economics





Vehicles Program

UNIQUE CAPABILITIES

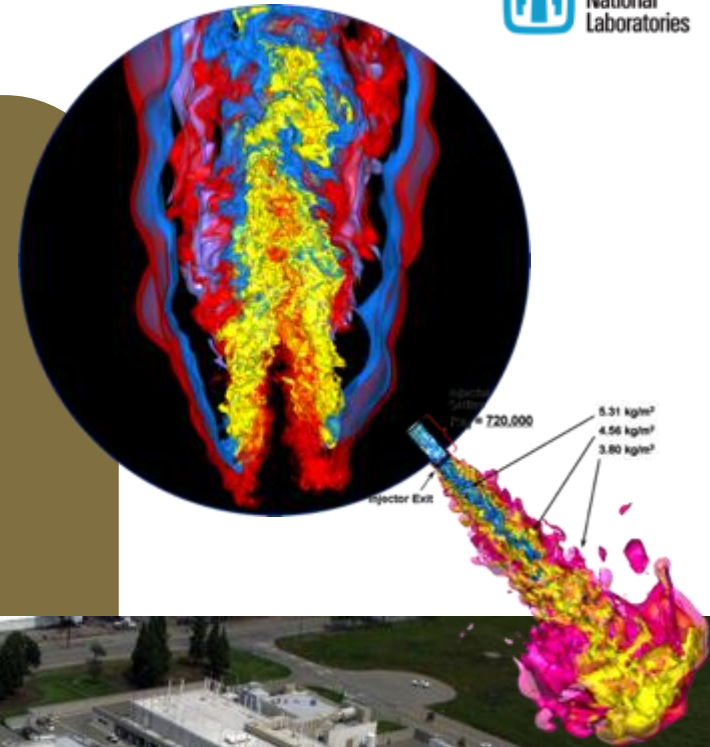
- 36 highly specialized labs
- Multiple cluster computers including a 5000 core, 50 teraflop system
- Over 100 resident researchers

KEY PARTNERSHIPS

- Ford, GM, Detroit Diesel, Caterpillar, John Deere, Cummins, Chrysler, Mack
- ConocoPhillips, ExxonMobil, Chevron, BP, Shell
- Multiple universities
- International collaborators (China)
- Several National Laboratories
- Over 100 visiting collaborators each year

CURRENT WORK

- Engine performance and emissions studies
- Experimental and computational work
- Pioneering of laser-based diagnostics to understand combustion science
- Co-evolution of advanced biofuels and engines
- Conceptual designs of new engine-fuel combinations





Biomass Program

UNIQUE CAPABILITIES

- SNL specializes in advanced multi-spectral imaging for the analysis of plant cell walls in dynamic environments
- SNL has unique capabilities at the Combustion Research Facility for the analysis of advanced biofuel combustion

KEY PARTNERSHIPS

- LBNL – advanced biofuels through synthetic biology
- GE – lifecycle analysis and testing of advanced biofuels
- Lockheed Martin – thermochemical conversion of biomass
- Novozymes – enzyme production
- Arizona State University – algal biofuels
- Montana State University – endophytic fungi

CURRENT WORK

- DOE Joint BioEnergy Institute
- Advanced biomass pretreatments based on ionic liquids
- Development of enzyme mixtures that are stable at high temperatures
- Co-evolution of advanced biofuels and engines
- Algal biofuels



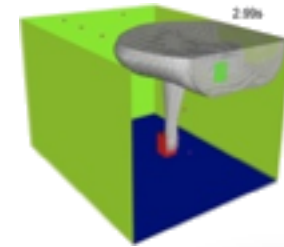
Hydrogen Program

UNIQUE CAPABILITIES

- 50 years of experience in H₂ S&T
- SNL has unique facilities for understanding H₂ effects in materials, components, and systems
- Risk-informed framework for the development of science-based safety requirements and standards

KEY PARTNERSHIPS

- University of Colorado - STCH
- I²CNER - hydrogen effects in materials
- AIST - Tank standards harmonization
- SAE, CSA, ASME, ISO – Standards level
- H2CAN - H₂ Safety research
- Lincoln composites – Tank research
- Swagelok – H₂ compatible materials
- NREL - Data collection for risk analysis



CURRENT WORK

- Solar Thermal Hydrogen Production (STCH)
- Storage tank behavior research
- H₂ effects in components and pipelines
- Risk assessments of hydrogen installations
- Geologic storage assessments
- Development/validation of advanced infrastructure and storage technologies
- Market Transformation



Building Technologies Program

UNIQUE CAPABILITIES

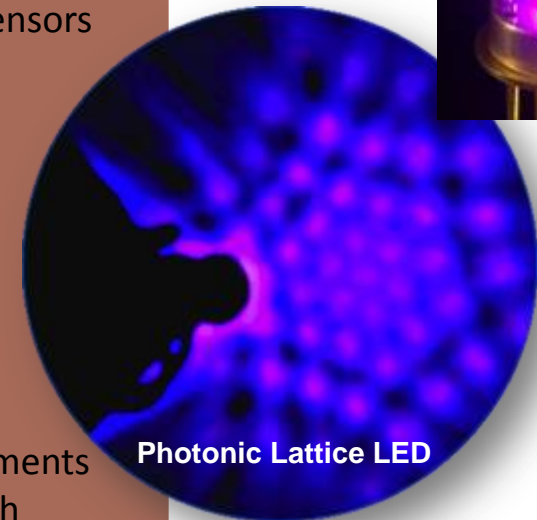
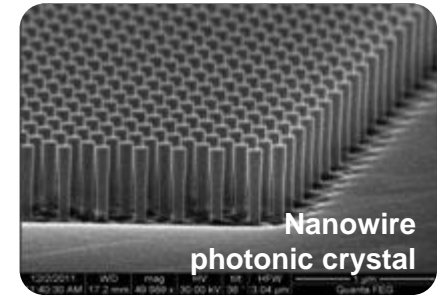
- SNL is recognized as a world leader in solid-state lighting research
- SNL has unique semiconductor growth, processing, and characterization equipment in MESA
- MESA is the world's largest government investment in semiconductor facilities

KEY INDUSTRY PROJECTS

- Veeco – semiconductor growth reactor design, modeling, and sensors
- Philips – measurement of LED defect densities and locations
- Applied Materials – novel substrates
- RPI – fundamental mechanisms of LED efficiency droop at high currents
- Corning – lasers for lighting

CURRENT WORK

- III-V semiconductor materials for enhanced LED efficiency
- Research on quantum dots as rare-earth-free phosphor replacements
- Design of advanced growth reactors to lower costs of LED growth
- Lasers for lighting
- Thermotropic materials in solar thermal collectors





Energy Storage Program

UNIQUE CAPABILITIES

- 1 MW Energy Storage Test Pad
- Energy Storage Analysis Laboratory
- Over 3 decades of leadership and experience to DOE/OE ESSP
- Cradle-to-grave responsibility for all power sources for DOE defense programs

KEY INDUSTRY PROJECTS

- Demo projects with NYSERDA & CEC
- Development of electrical energy storage metrics and market structures
- Development of high-temp power electronics
- ARRA energy storage demo: PNM Prosperity Project
- R&D 100 Awards
 - 2011 Ultra-high-voltage Silicon Carbide (SiC) Thyristor
 - 2009 High-Temperature SiC Power Module
 - 2003 Emitter Turn-Off Thyristor
 - 2003 Fiber-Optic Electrical Current and Temperature Transducer



CURRENT WORK

Research: Redox flow, Sodium based, Lithium-ion and Advanced lead-acid batteries; Compressed air energy storage; Flywheel storage

Demonstrations/deployments: 16 ARRA; State Energy Agency Support; Energy Surety Microgrids; Hawaii Clean Energy

Systems analysis: Impact Assessments; Market Design studies; Cost Modeling; Codes and Standards



KEY EERE FACILITIES @ SANDIA

National Solar Thermal Test Facility (NSTTF)

UNIQUE CAPABILITIES

The NSTTF is the only central receiver test facility in the U.S. with over 700 man-years of staff experience to support CSP R&D including the solar furnace, molten salt test loop, and rotating platform.

NATIONAL VALUE

NSTTF is the only facility in the U.S. that:

- Provides large scale, high flux material testing
- Tests large scale molten salt components (pumps, valves, etc.)
- Provides a target for long range heliostat beam evaluation
- Tests Solar Central Receivers

Also, one of 3 facilities in the U.S. that has been selected as a PV Regional Test Facility.

RESEARCH IMPACT

- **NASA** – Ablator testing, Shuttle Tile testing, Hypersonic vehicle material testing
- **Solar Reserve** – Heliostat evaluation
- **Areva Solar** – Compact Linear Fresnel Reflector Technology utilizing molten salt (under negotiation)
- **PWR** – Solar Receiver Tube/Shroud testing (under negotiation)
- **Sierra Nevada Corporation** – Solar Air Receiver
- **Nooter Eriksen** – Solar Receiver Shroud Test
- **Aerojet** – Material sample testing
- **Boeing** – Material testing
- **Infinia** – Evaluating Dishes and Stirling Engines
- **SunPower** – Concentrating PV
- **Department of Energy (DOE)**



UNIQUE CAPABILITIES

PSEL is a multi-user, multi-sponsor facility that conducts research in PV cells, modules, and arrays and performs detailed, comprehensive analysis in PV systems design, optimization, and characterization in real-world scenarios.

NATIONAL VALUE

- DOE User Facility for cell-to-system measurements of new PV technologies
- Develop predictive performance models
- Working with industry to better address reliability/lifetime concerns
- New, standard characterization methods reduce risk and improve bankability of PV projects
- Partnerships span the U.S. PV industry

RESEARCH IMPACT

Cell/Module Companies

- Abound
- Amonix (RIP)
- Applied Materials
- BP Solar (RIP)
- Concentrix (now part of Soitec)
- Dow Solar
- Emcore
- enXco
- First Solar
- Gratings Solar
- Greenray
- Greenvolts
- Miasole
- NanoSolar
- Prism Solar
- Semprius
- Sharp
- Sierra Solar
- Skyline
- Solaria
- SolFocus
- Soliant
- SoloPower
- SunPower
- Unisolar

Government/National Labs

- DOE
- GSA
- NREL
- SNL (MEPV, etc)



Private Labs

- CFV
- Fraunhofer - CSE
- TUV/PTL

Integrators/Project Developers

- enXco
- Recurrent Energy

Universities

- FSEC
- NMSU
- UVM



UNIQUE CAPABILITIES

DETL conducts research with industry and academic partners to integrate emerging energy technologies into new and existing electricity infrastructures.

NATIONAL VALUE

- DOE User Facility for new smart grid technologies in an integrated, fully functioning environment
 - New photovoltaic inverters and energy management systems
 - Integrated storage and new controls
 - Demand-side management and utility interactions
- Provides lab evaluations prior to field installations

RESEARCH IMPACT

- Electric Power Research Institute (EPRI)
- Department of Defense
- PNM (NM utility)
- GreenSmith
- GreenRay
- Enphase
- Petra AMPT
- Princeton
- AE (PVPowered)
- StatCon
- SMA
- Fronius
- Xantrex (Schneider)
- Aurora



Scaled Wind Farm Technology Center (SWIFT)



U.S. DEPARTMENT OF
ENERGY

Sandia
National
Laboratories

UNIQUE CAPABILITIES

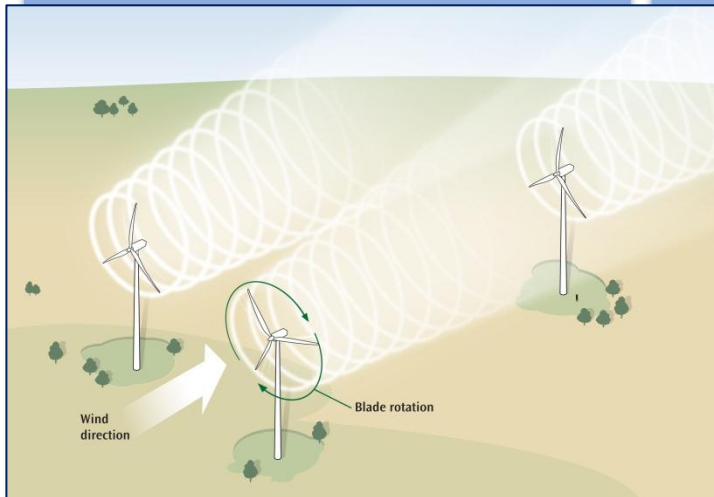
- 1st facility in the world to specifically study wind farm wakes and their interaction with wind turbines
- Highest category wind class, with average winds of 17 mph (7.5 m/s) directly from the South
- Scaled research turbines (Vestas model V27) allow for rapid technology development at ~1/20th the experimental cost

NATIONAL VALUE

- Reduce performance losses and maintenance costs from turbine-turbine interaction
- Develop advanced wind turbine rotors for increased energy capture and improved reliability
- Turbine models and data are being developed as a public open-source research asset to aid the entire wind energy community

RESEARCH IMPACTS

- Vestas Research and Development, the world's largest wind turbine manufacturer, is installing its own V27 turbine to perform both cooperative and proprietary research.
- Texas Tech University has partnered to develop the test facility, which will be used to foster academic research and wind energy education.
- Currently finalizing NDA's to perform research testing at the facility for General Electric Wind Energy, Gamesa Wind, and Alstom Wind.



Lake Test Facility

UNIQUE CAPABILITIES

The Lake Test facility is the only test facility of its kind with a large surface area and 15 m depth and infrastructure to support full scale hydrokinetic equipment equipped with instrumentation and data analysis.

NATIONAL VALUE

- With a wave making modification, this would be the largest controlled test capability in the world
- Would be the only test capability to test fully operational wave energy devices in the world
- Preliminary US Testing Needs assessment for MHK development shows this potential capability is a major gap

RESEARCH IMPACT

- CTD, Inc.
- General Power Associates
- Resolute Marine
- Columbia Power Technologies
- Wave Energy Technology
- Ecomerit
- Straumekraft AS
- OPT



Combustion Research Facility

An Office of Science Collaborative Research Facility dedicated to energy science and technology for the 21st century

Essentially every modern vehicle on the road today is cleaner and more efficient due to CRF collaborative work.

ONGOING WORK

- Target combustion strategies:
 - Low temperature, clean combustion (e.g., homogenous charge compression ignition)
 - Advanced lean-burn gasoline engines
 - Advanced diesel combustion (e.g., high exhaust gas recirculation)
 - Alternative fuels (biofuels, natural gas, etc.)
- Next-gen diagnostics and computational tools

The most direct path to reduced dependence on foreign oil is increased vehicle efficiency and use of alternative fuels

- 82,000-square-foot office and lab facility at Livermore Valley Open Campus
- 36 highly specialized labs
 - Laser-based diagnostics
 - Combustible and toxic gas handling
 - Computer-controlled safety system
- New 8000 square-foot computational laboratory
- Co-sponsored by EERE and BES



Battery Abuse Testing Lab (BatLab)

UNIQUE CAPABILITIES

The BatLab is at the forefront of testing the limits of what batteries can safely handle and provides critical data for developing the next generation of batteries—doing everything imaginable to batteries (e.g., crushing, piercing with nails, heating to boiling) in the lab to make sure that once a battery is in commercial use, it will be safe and reliable.

NATIONAL VALUE

- The nation's leading experts in battery safety research and unique facilities for battery abuse testing for DOE and industry
- The world's largest and most comprehensive battery calorimetry laboratory
- DOE's largest lithium-ion cell prototyping facility
- State-of-the-art battery abuse testing facilities to perform a variety of electrical, thermal, and mechanical abuse tests
- Materials to full system test capabilities
- Access to Sandia's Power Source Technology Group and other advanced Sandia capabilities/facilities

RESEARCH IMPACT



UNIQUE CAPABILITIES

The geothermal research laboratory designs, tests and analyzes field deployment downhole tools for operation in high-temperature, high-pressure environments coupling research and development with practical applications.

NATIONAL VALUE

- A unique national resource for the development and testing of well construction systems in harsh environments
- Over 35 years of continuous effort supporting the advancement of well construction technologies



RESEARCH IMPACT

- DOE Downhole
- DOD - DARPA • US Synthetic
- CDC - NIOSH • Numa
- Other Federal • Security DBS
Agencies • Draka
- GE Global Cableteq
Research • MagiQ
- Atlas Copco
- NOV



- Hard-rock drilling facility to support testing of rock cutting materials, bits and downhole tools with active control through a drilling dynamics simulator.
- Dynamometer test stand for evaluation of drilling tool power
- Instrumented test rigs for down-the-hole-hammer evaluation
- Component fabrication facilities and test equipment for development of high-temperature electronics, electromechanical and optical fiber based equipment.
- Environmental test systems (ovens, furnaces, pressure vessels, shakers) for component evaluation and testing of high-temperature systems and components



LABORATORY DIRECTED RESEARCH & DEVELOPMENT

LDRD INVESTMENTS



Highly Leveraged Investments

- “Grand Challenge” and leading LDRDs
 - Solar fuels - \$14M (five years), completed in FY11
 - Renewables grid integration - \$11M (three years), completing in FY13
 - Microsystems enabled PV - \$10M (three years), completing in FY15
- Office of Science
 - Center for Integrated Nanoscience Technology - \$11M in FY11
 - <http://cint.lanl.gov/>
 - Joint Bioenergy Institute - \$5M in FY11
 - <http://www.jbei.org/>
 - Combustion Research Center - \$10M in FY11
 - <http://crf.sandia.gov/>
- DOE OE Energy Storage and Transmission
 - Research, Development and Deployment Analytics

Sunshine to Petrol (S2P)

Producing Drop-In Fuels

UNIQUE CAPABILITIES

- Sandia is uniquely capable in concentrating solar, materials development, systems engineering, and computing to develop reactors, high-temperature metal oxide chemistry, and balance of systems efficiencies, cost, and cost-driver analysis.

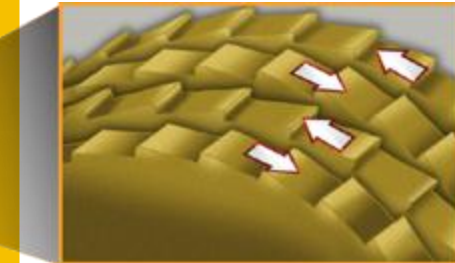
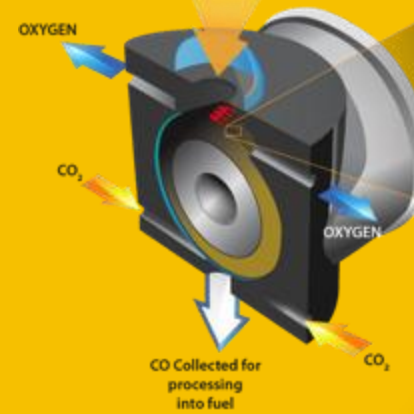
KEY PARTNERSHIPS

- Sandia's internal Grand Challenge investment (\$14M/5 years)
- BP, Solar Fuels Alliance



CURRENT WORK

- A concentrating solar-driven thermochemical heat engine to convert CO_2 and H_2O to SynGas – a flexible and established precursor to gasoline, jet fuel, diesel, and chemical components.
- With biofuels, S2P balances the national research portfolio in alternative transportation fuels.



Alternate discs rotate in opposite directions



Solar Glitter

A Microsystem-Enabled PV Concept

GOAL

To develop advanced solar technologies and systems that will provide the US industry with a competitive advantage worldwide in delivering solar electricity at less than 10 cents per kWhr.

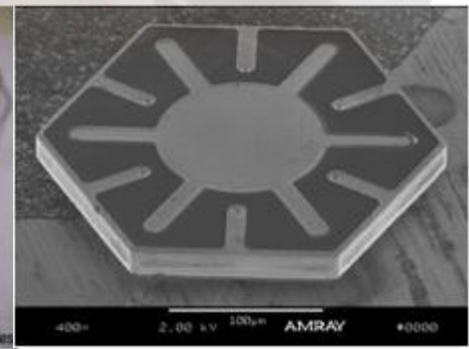
MOTIVATION

Double the efficiency and half the cost of conventional PV systems:

- high efficiency (*cell level >50%, system level >40%*)
- reduced cost (module cost of $\sim \$0.5/\text{Watt}_{\text{peak}}$, system cost of $2\text{-}3/\text{Watt}_{\text{peak}}$).



Flexible
PV Modules



Thin PV Cells