

Department of Energy National Laboratories as Resources for Thermoelectrics R&D

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Battelle

**Automotive
Technology**

DOE Laboratory System

- Largest of its kind in the world
- Evolved over 50+ years
- Focused on human and physical resources
- Massive computing capabilities/facilities
- Remote operation capabilities, virtual co-laboratories
- 30+ laboratories (12 large National Laboratories, others more specialized)
- 30,000+ scientific and technical staff (50,000+?)
- \$6+ billion annual R&D
- Assets \$30+ billion replacement value
- GOCO facilities

Comment : Battelle's Role

- Battelle manages or co-manages four of these Laboratories – PNNL, ORNL, BNL, NREL
- Approximately 14,000 staff, including Battelle private resources
- Experienced at structuring multi-lab collaborations (7-Lab Diesel Emissions Reduction Roadmap)

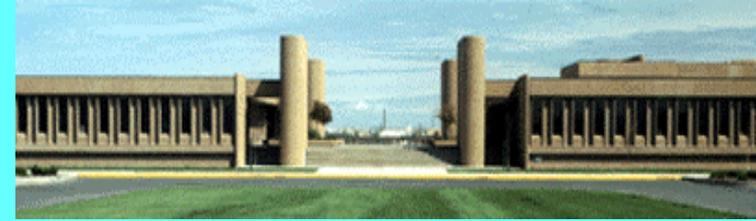
DOE National Laboratories

- Ames National Laboratory
- Argonne National Laboratory
- Brookhaven National Laboratory
- Idaho national Engineering Laboratory
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Lasboratory

DOE National Laboratories (contd)

- Los Alamos National Laboratory
- National Energy Technology Laboratory
- National Renewable Energy Laboratory
- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory
- Sandia National Laboratory

National Laboratories



Pacific Northwest National Laboratories (PNNL)

- Business volume for 2001 was \$535 million.
- Customers include US Dept of Energy and other federal, state and local agencies; universities; and industry sponsors.
- Staff employment in FY2001 was approximately 3,600.
- Staff received 38 domestic and 11 foreign patents for their research in fiscal year 2001. Since PNNL was created in 1965, 926 foreign and domestic patents have been issued for work conducted at the Laboratory.
- In FY 2001, PNNL received four R&D 100 awards, for a total of 58. PNNL also received four Federal Laboratory Consortium awards for a total 48.
- PNNL is operated by Battelle.

National Laboratories



National Renewable Energy Laboratory (NREL)

- NREL's operating budget for FY 2001 was approximately \$216 million.
- Funding comes from DOE's Office of Energy Efficiency and Renewable Energy with the remainder from sources such as grants, cost-shared research with industry and other DOE offices.
- NREL employs approximately 1,110 staff members.
- Since its inception, NREL's research has won 31 R&D 100 awards—the most per staff member of any DOE laboratory.
- NREL is operated by Midwest Research, Battelle and Bechtel National.

National Laboratories

Oak Ridge National Laboratory (ORNL)

- Funding for FY2002 is approximately \$870 million.
- Funding is received from the following: 80% DOE and 20% work for others.
- ORNL has approximately 3,800 staff members.
- Researchers and engineers at the Department of Energy's Oak Ridge National Laboratory (ORNL) have won 104 R&D 100 Awards since the awards began in 1963.
- ORNL is operated by University of Tennessee and Battelle.

National Laboratories



Brookhaven National Laboratory (LANL)

- BNL FY 2002 budget is approximately \$425 million.
- Funding comes from DOE and work for others.
- BNL employs approximately 3,000 scientists, engineers, technicians and support staff and over 4,000 guest researchers annually.
- BNL is operated by the Brookhaven Science Associates for the US DOE.

National Laboratories



Los Alamos National Laboratory (LANL)

- LANL annual budget is approximately \$1.2 billion.
- LANL employs approximately 6,800 University of California employees plus approximately 2,800 contractor personnel.
- LANL is operated by the University of California for the National Nuclear Security Administration of DOE.
- In FY 2001, 40 US patents were issued for Laboratory inventions, 20 commercial licenses were approved, and \$1.56 million in license income was generated.
- LANL is operated by University of California.

National Laboratories



Lawrence Livermore National Laboratory (LLNL)

- LLNL FY 2000 budget is approximately \$1.33 billion.
- LLNL employs approximately 8,000 staff members.
- LLNL is operated by University of California.

National Laboratories

- Lawrence Berkeley National Laboratory - 4,000 staff, managed by the University of California
- Sandia National Laboratories – 8,500 staff, managed by Lockheed Martin
- Idaho National Engineering Laboratory – 8,000 staff, managed by Bechtel
- Argonne National Laboratory – 4,000 staff, \$475 annual budget, operated by the University of Chicago

National Laboratories

- Ames National Laboratory – 400 staff, \$27 million annual budget, operated by Iowa State University
- National Engineering Technology Laboratory – federally operated

“Special” Thermoelectric Resources

- SNL – Albuquerque
 - radioisotope thermoelectric generator (RTG) engineering and testing
 - basic thermoelectric materials research
 - B – C materials research
 - thermoelectric materials synthesis
 - superlattice growth, strained superlattices
- SNL – Livermore
 - thermal and fluids modeling
 - system level second law simulation

“Special” Thermoelectric Resources (contd)

- LLNL

- multi-magnetron sputter deposition (collaboration with HI-Z)

- deposition on heated surfaces

- epitaxial layers

- characterization – XRD, SEM, TEM, scanning TE properties from LN to several hundred degrees C

- device fabrication and testing

“Special” Thermoelectric Resources (contd)

- PNNL

- thin film and multilayer stack coating processes, materials synthesis

- coating process scale up, high rates and large areas

- flat panel display materials

- optical coatings and photonics

- nanotechnology

- surface microchemistry and microstructure

“Special” Thermoelectric Resources (contd)

- ANL
 - modeling and simulation for physical and electronic structure of quantum wells
 - neutron scattering
 - electron microscopy
 - thin film coating processes, including multi-layer structures

“Special” Thermoelectric Resources (contd)

- LANL

- small sample specific heat, thermal conductivity, and electrical resistivity from 0.04K to 300K in magnetic fields to 9T

- thermoelectric power and Hall effect from 1.5K to 300K

- SQUID magnetometry from 2k to 350K and magnetic susceptibility from 0.04k to 300k

- NMR from 0.1K to 300K in fields to 9T

“Special” Thermoelectrics Resources (contd)

- ORNL - HTML Users Center
 - electron microscopy to 0.7Å,
 - thermoelectric/thermophysical properties
 - very high flux “cool” neutron radiography, scattering, diffraction
- NREL
 - heat exchanger/thermoelectrics analysis package to optimize design performance in vehicle exhaust heat recovery. Gives design parameters for hot and cold side temperatures.
 - integrated with Advisor

Collaborative or Funding Mechanisms

- Direct DOE contract
- Work for Others contract
- Funds In CRADA
- CRADA
- User Center User Agreements
- Inter-agency MOU
- Shared or Partitioned Program Scope?
- Inter Agency CRADA?